International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 04 | April - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Exam Management System: A Full-Stack Multi-Tenant Web-Based Adaptive Learning and Exam Conduction System

[1]*Harsh Ileshbhai Patel,B.Tech Student, Department of Computer Science and Engineering, Parul University*
[2]Dhrumil Patel,*B.Tech Student, Department of Computer Science and Engineering, Parul University*
[3]Rahul Choudhary,*B.Tech Student, Department of Computer Science and Engineering, Parul University*
[4]Keshvi Sharma,*B.Tech Student, Department of Computer Science and Engineering, Parul University*
[5]Vishal Rathwa,*B.Tech Student, Department of Computer Science and Engineering, Parul University*

Abstract—The Exam Management System is a full-stack web application designed to overcome the limitations of traditional, static online quiz and assessment systems. This paper presents the comprehensive design, architecture, and implementation of a platform that integrates adaptive scoring, multi-format question support (MCQ, passage-based MCQ, and descriptive), gamification mechanics, AI-driven answer evaluation, a multi-tenant Organization Admin module, and a certificate generation system. Built on the MERN stack (MongoDB, Express.js, React.js, Node.js) with Tailwind CSS for the frontend, the system dynamically adjusts question weightage based on individual user performance, ensuring fair and personalized assessment. A central architectural contribution of this work is the introduction of a three-tier Role-Based Access Control (RBAC) model comprising Super Admin, Organization Admin, and User roles, which transforms the platform into a scalable multi-tenant exam conduction system. Organizations such as colleges, coaching institutes, and corporations can independently manage their own exams, question banks, participants, and certificates within isolated tenants on the same platform instance. Evaluation results demonstrate improved learner engagement, assessment fairness, and administrative efficiency compared to conventional systems.

Index Terms—Adaptive Learning, Exam Conduction System, Full-Stack Web Development, Gamification, Multi-Tenant Architecture, Quiz Platform, Role-Based Access Control.

I. INTRODUCTION

The rapid expansion of digital education has accelerated demand for scalable, intelligent assessment platforms. Online learning environments have grown significantly since the COVID-19 pandemic, pushing institutions to adopt digital tools for evaluation and knowledge testing. However, most existing online quiz systems remain fundamentally static: they deliver the same questions at the same difficulty to all users, irrespective of individual ability or prior performance [1]. This results in poor personalization, learner disengagement, and inaccurate ability measurement.

A second, equally significant limitation is architectural. Most quiz platforms are designed for a single institution managed by a central administrator. In practice, multiple independent organizations—universities, coaching centers, corporate HR departments—frequently require the ability to create and manage their own examinations independently, with strict separation of data. Forcing each organization to maintain a separate deployment is costly, operationally complex, and does not scale. A true multi-tenant architecture is the only viable path toward serving such diverse organizational needs on a shared infrastructure.

A third gap concerns question format diversity. Real-world assessment demands extend beyond multiple-choice questions to include passage-based comprehension testing and open-ended descriptive responses. Automated

VIII. ORGANIZATION ADMIN: EXAM CONDUCTION SYSTEM

The Organization Admin module is the most significant architectural contribution of this work. It transforms the platform from a single-institution quiz application into a true multi-tenant exam conduction system capable of simultaneously serving independent institutions with full data segregation and administrative autonomy.

A. Design Goals

The module is designed around three foundational principles. First, data isolation: each organization's exams, questions, participant records, results, and certificates are fully segregated at the database layer via organizationId filtering, making cross-tenant data leakage architecturally impossible under normal API operation. Second, administrative independence: once an Organization Admin account is provisioned by the Super Admin, the organization self-manages all aspects of its exam lifecycle without requiring further Super Admin intervention. Third, infrastructure sharing: multiple organizations share the same deployed platform instance, eliminating per-organization server costs and maintenance overhead while benefiting from platform-wide feature upgrades simultaneously.

B. Organization Admin Workflow

The complete exam conduction workflow proceeds through eight stages: (1) The Organization Admin

evaluation of free-text answers has historically been a barrier to fully automated exam pipelines; however, recent advances in Large Language Models (LLMs) have made AI-driven descriptive evaluation both practical and cost-effective.

The Adaptive General Quiz Platform is proposed as a comprehensive solution to all three challenges. It is a MERN-stack web application that combines adaptive scoring, gamification, AI evaluation, multi-tenant organization management, and certificate generation into a unified, production-ready system. This paper describes the motivation, design, architecture, features, and implementation of the platform in detail.

The remainder of this paper is organized as follows: Section II reviews related work. Section III presents the problem statement. Section IV defines the project objectives. Section V describes the system architecture. Section VI details the role-based access control model. Section VII presents core platform features. Section VIII describes the Organization Admin and exam conduction system. Section IX covers the certificate generation system. Section X presents the database design. Section XI explains the adaptive scoring logic. Section XII details the system flow. Section XIII presents results. Section XIV discusses limitations. Section XV outlines future scope. Section XVI concludes the paper.

II. RELATED WORK

Corbett and Anderson [2] introduced knowledge tracing, modeling student knowledge as a latent variable that evolves through practice. Their Bayesian Knowledge Tracing (BKT) model estimates the probability that a student has mastered a skill based on sequences of correct and incorrect responses. Their approach underpins intelligent tutoring systems that adapt difficulty based on estimated mastery and remains foundational to adaptive educational systems today. Item Response Theory (IRT), developed by Lord [3], provides a psychometric framework for calibrating question difficulty and estimating latent ability, and informs the adaptive weightage logic in the proposed system.

Deterding et al. [4] formally defined gamification as the application of game design elements in non-game contexts. Hamari, Koivisto, and Sarsa [5] conducted a systematic review of 24 empirical studies on gamification and found consistent positive motivational outcomes, particularly when leaderboards and achievement systems are combined. Their meta-analysis showed statistically significant improvements in engagement and task completion rates, directly motivating the gamification module integrated in this work.

Taghipour and Ng [6] demonstrated that LSTM-based neural networks can achieve near-human performance on automated essay scoring, establishing the viability of AI evaluation for open-ended responses. Subsequent work with transformer architectures has further improved scoring accuracy. The proposed platform extends this

authenticates with their org-admin credentials and accesses their scoped dashboard. (2) A new exam record is created with metadata including name, description, category, subject, and difficulty level. (3) Questions are populated from the private question bank or created inline as MCQ, passage-based, or descriptive items. (4) Exam parameters are configured: time limit, total marks ceiling, maximum allowed attempts per participant, and the exam access window (open/close timestamps). (5) The exam is published, making it visible and accessible to all enrolled participants. (6) Participants attempt the exam; each submission is scored adaptively and descriptive responses are forwarded asynchronously to the AI evaluation service. (7) The admin reviews aggregate results, individual score breakdowns, question-level difficulty analytics, and the exam-specific leaderboard. (8) The admin approves or rejects certificates for participants who meet the qualifying score threshold.

C. Organization Admin Dashboard

The Organization Admin Dashboard consolidates all exam lifecycle operations into a single interface. It provides exam management controls (create, edit, publish, archive), a private question bank with full CRUD and categorization, participant enrollment management with bulk import support, individual and aggregate results views with AI feedback inspection and score override, exam-specific leaderboards scoped to the organization, and performance analytics charts including score distribution histograms and per-question difficulty ratings.

Feature	Description
Exam Management	Create, edit, publish, archive exams
Question Bank	Private org-scoped question repository
Exam Config	Time limit, marks, attempt limits
Participant Mgmt	Enroll and manage exam participants
Results Dashboard	Individual scores, AI feedback review
Exam Leaderboard	Org-scoped ranking by exam score
Analytics	Score distribution, difficulty analysis

Table II. Organization Admin Dashboard Features

IX. CERTIFICATE GENERATION SYSTEM

The certificate generation system completes the exam lifecycle by enabling formal credential issuance directly from the platform. Upon exam completion, the Organization Admin reviews participant performance and manually approves certificates for those who achieve the qualifying score threshold. Certificate approval is a

capability via LLM API integration for descriptive quiz answers, providing not just a score but also structured written feedback to the learner.

Bezemer and Zaidman [7] identified data isolation, customization, and access control as the three primary design challenges in multi-tenant SaaS architectures. All three challenges are explicitly addressed in the Organization Admin design of this platform. Comparatively, commercial platforms such as Kahoot!, Quizlet, and Google Forms lack dynamic difficulty adaptation, multi-tenant support, or AI evaluation [8], motivating the development of the proposed system as a research and engineering contribution.

III. PROBLEM STATEMENT

Existing online quiz and assessment platforms exhibit the following critical deficiencies that reduce their educational effectiveness and organizational applicability:

- Uniform question delivery irrespective of individual user ability or performance history, resulting in under-challenge for advanced learners and overwhelm for beginners.
- Fixed difficulty levels with no mechanism to adapt to demonstrated user competency over time, producing scores that reflect familiarity with the platform rather than true mastery.
- Absence of engagement mechanisms such as leaderboards, achievement badges, or daily challenges, leading to high dropout rates and low long-term retention.
- Centralized single-administrator architecture that prevents independent organizations from creating and managing their own isolated examination environments on a shared infrastructure.
- Restriction to objective question types only, with no support for AI-evaluated descriptive responses that test higher-order thinking skills.
- No built-in certificate issuance mechanism to formally recognize learner achievement, creating a gap between exam completion and credential delivery.
- Lack of per-organization analytics, making it impossible for institutional administrators to derive actionable insights about their own cohort's performance independently.

These limitations reduce the educational effectiveness, organizational utility, and commercial viability of existing platforms. The Adaptive General Quiz Platform addresses all of the above deficiencies in a single, cohesive system built for both individual learners and institutional deployments.

IV. OBJECTIVES

The primary objectives of the Adaptive General Quiz Platform are:

deliberate human-in-the-loop step, ensuring institutional control over credential issuance rather than fully automated generation.

Approved certificates are generated server-side using a Node.js PDF library (pdfkit or puppeteer) from pre-designed HTML/CSS templates. Each certificate includes: Student Full Name, Exam Name and Description, Score and Percentage Achieved, Organization Name and Logo, Date of Completion, a system-generated globally unique Certificate ID (UUID v4), and the Organization Admin's digital signature block. Template customization options include logo upload, custom title text (e.g., 'Certificate of Excellence'), a descriptive body message, and theme color selection from a provided palette.

Generated PDFs are stored on the server and linked to the student's profile. Students are notified via an in-app alert and can download their certificate from the personal dashboard at any time. The unique Certificate ID enables future verification by a third party through a planned verification portal. This full-stack certificate pipeline significantly increases the organizational value of the platform, particularly for coaching institutes and corporate HR departments that require formal, verifiable credentials.

X. DATABASE DESIGN

The MongoDB database comprises ten primary collections organized to support adaptive scoring, multi-tenancy, gamification, and certificate management. The organizationId field embedded on all organization-scoped resources is the foundational anchor of the multi-tenant isolation strategy. Compound indexes on (userId, categoryId) and (organizationId, examId) ensure performant queries for both adaptive scoring lookups and exam result aggregations. The schema design favors denormalization for read-heavy paths (leaderboard, results) while maintaining referential integrity through Mongoose populate for audit and analytics paths.

Collection	Key Fields
Users	userId, name, email, role, organizationId, attemptHistory
Organizations	orgId, name, adminUserId, status
Categories	categoryId, name, scope, organizationId
Questions	questionId, type, content, levelId, organizationId
Exams	examId, organizationId, timeLimit, totalMarks, status
QuizAttempts	attemptId, userId, examId, answers[], scores[]
Leaderboard	userId, scopeType, scopeId, totalScore, rank

1) To design and implement a full-stack adaptive quiz system that personalizes question difficulty and scoring based on individual user performance history using a tier-based weightage algorithm.
2) To support multiple question formats including MCQ, passage-based MCQ, and AI-evaluated descriptive questions within a single unified question delivery pipeline.
3) To integrate gamification elements—leaderboards, achievement badges, and daily quizzes—to sustain learner motivation and encourage habitual platform engagement.
4) To implement a three-tier RBAC model (Super Admin, Organization Admin, User) enabling multi-tenant exam conduction by independent organizations with strict data isolation.
5) To develop an Organization Admin module with full exam lifecycle management including creation, configuration, publication, participant management, AI evaluation review, and analytics.
6) To build a certificate generation system allowing Organization Admins to issue approved, uniquely identified PDF certificates to qualifying participants with customizable templates.
7) To construct the platform on a scalable MERN architecture deployed as a single instance capable of serving simultaneous multi-organizational usage without performance degradation.

V. SYSTEM ARCHITECTURE

The Adaptive General Quiz Platform adopts a three-tier client-server architecture providing clear separation of concerns, modularity, and horizontal scalability. The architecture is designed to support high concurrency across multiple organizational tenants without data interference.

A. Presentation Layer

The frontend is implemented in React.js using a component-based single-page application (SPA) architecture. Tailwind CSS provides utility-first responsive styling ensuring consistent rendering across desktop and mobile viewports. The frontend renders role-aware views dynamically based on the authenticated user's JWT role claim: a personalized learning dashboard for Users, an exam management panel for Organization Admins, and a full control panel for the Super Admin. React Router v6 handles client-side navigation with route guards that prevent unauthorized page access. Axios handles all API communication with the backend, with interceptors managing token refresh and error normalization.

B. Application Logic Layer

The backend is built on Node.js with Express.js, exposing a comprehensive RESTful API covering authentication, user management, quiz delivery, adaptive scoring, leaderboard updates, organization management, exam

Achievements	achievementId, userId, badgeName, awardedAt
Certificates	certId, userId, examId, orgId, pdfUrl, status

Table III. Database Collections

XI. ADAPTIVE SCORING LOGIC

A. Accuracy Computation

Upon each quiz attempt, the system retrieves the user's complete historical performance record for the relevant question category from the Users collection's embedded attemptHistory array. Accuracy is computed as a rolling percentage across all recorded attempts within that category:

$$Accuracy\ (\%) = (Correct\ Answers / Total\ Attempts) \times 100 \quad (1)$$

This rolling accuracy metric is recalculated on each submission and stored back to the user's profile, ensuring the adaptive algorithm always reflects the most current performance profile. Separate accuracy values are maintained per category, allowing granular differentiation between a user who excels in Mathematics but struggles in Verbal Reasoning, for example.

B. Weightage Adjustment Tiers

Three discrete tiers govern the per-question marks multiplier applied at scoring time. The multipliers are applied to the base marks defined on each question by the quiz or exam creator:

Accuracy	Multiplier	Interpretation
≥70%	×0.75	Mastery – reduced reward
40–69%	×1.00	Learning Zone – baseline
<40%	×1.25	Challenging – bonus reward

Table IV. Adaptive Weightage Tiers

C. Cold-Start Mitigation

For users with fewer than five historical attempts in a given category, the system defaults to base marks (multiplier ×1.00) to avoid biased or volatile weightage adjustments during early usage. The five-attempt cold-start threshold was selected empirically to balance responsiveness with statistical reliability of the accuracy estimate. Once the threshold is crossed, the adaptive tier activates automatically on the next quiz attempt. This mitigation ensures equitable assessment for new users while preserving the adaptive benefit for established users with sufficient history.

D. Adaptive Score Calculation

The effective score for a question is calculated as the product of its base marks and the applicable tier multiplier, floored to two decimal places. For a quiz containing questions from multiple categories, each

lifecycle operations, AI evaluation proxying, and certificate generation. JWT-based stateless authentication secures all endpoints with access and refresh token pair management. An RBAC middleware layer enforces permission boundaries at every route, rejecting cross-role access with HTTP 403 responses. The adaptive scoring engine, AI evaluation proxy, and certificate generation service are implemented as modular service classes injected into route handlers.

C. Data Layer

MongoDB serves as the primary database, chosen for its flexible document model which naturally accommodates the varied and nested structures of quiz questions, user performance histories, exam configurations, and organization data. Mongoose ODM defines schemas with strict validation, pre/post hooks, and inter-collection references via ObjectId population. Multi-tenancy is enforced at the data layer by embedding an organizationId field on all organization-scoped resources, ensuring every query from an Organization Admin is automatically scoped to their tenant. Indexes on userId, organizationId, and examId fields ensure sub-millisecond query performance even at scale.

Table I. System Architecture Summary

Layer	Technology	Responsibility
Frontend	React, Tailwind	UI, SPA routing
Backend	Node, Express	APIs, RBAC, logic
Database	MongoDB	Persistence, isolation
AI Service	LLM API	Descriptive eval.

VI. ROLE-BASED ACCESS CONTROL MODEL

The platform implements a three-tier RBAC model that governs all access to resources and operations system-wide. Role assignments are stored in the JWT payload and enforced server-side on every request; client-side route guards provide an additional UX-layer enforcement. Each role has a distinct permission scope, a dedicated frontend interface, and strictly bounded backend API access.

A. Super Admin

The Super Admin has unrestricted platform-wide access and is responsible for global platform governance. Responsibilities include managing all user accounts across organizations, creating and provisioning Organization Admin accounts with associated organizational tenants, maintaining the global quiz library (categories, subjects, levels, and questions), configuring platform-wide adaptive weightage thresholds, monitoring system-wide usage analytics, and managing platform health and user reports. The Super Admin is the only role permitted to create new organizational tenants.

B. Organization Admin

question's multiplier is looked up independently from the user's category-specific accuracy record. The aggregate quiz score is the sum of all per-question effective scores, normalized to a percentage of the total maximum possible marks for display and leaderboard purposes.

XII. SYSTEM FLOW

A. User Flow

A standard user session proceeds through the following sequence: (1) User registers or logs in; JWT access and refresh tokens are issued and stored in memory. (2) Dashboard loads with a personalized performance summary including accuracy trends per category, recent quiz history, earned badges, and leaderboard rank. (3) User selects a quiz by level, category, and subject from the available library. (4) The backend retrieves the question set and pre-calculates adaptive weightage multipliers from the user's historical accuracy per category. (5) The quiz is rendered with MCQ, passage-based, and/or descriptive questions as appropriate. (6) On submission, MCQ and passage-based answers are evaluated synchronously; descriptive answers are forwarded to the LLM evaluation service. (7) Results are displayed immediately with per-question scores, AI feedback for descriptive items, the updated leaderboard position, and any newly awarded achievement badges.

B. Organization Admin Flow

The Organization Admin session follows a structured exam lifecycle: (1) Admin authenticates with org-admin credentials; all subsequent API calls are scoped to their organizationId. (2) Admin creates an exam with category, subject, and difficulty level metadata. (3) Questions are sourced from the private question bank or created inline with type selection (MCQ, passage-based, or descriptive). (4) Exam is configured with time limit, total marks ceiling, maximum attempt count, and access window timestamps. (5) Exam is published; enrolled participants receive in-app notification. (6) Participants attempt the exam; all result data is tagged with organizationId for isolation. (7) Admin reviews the results dashboard: individual scores, AI feedback logs, score distribution histogram, and per-question difficulty statistics. (8) Admin approves certificates for qualifying participants, triggering server-side PDF generation and student notification.

XIII. RESULTS AND DISCUSSION

The Adaptive General Quiz Platform was evaluated across all core functional modules during development through unit testing, integration testing, and end-to-end scenario validation. The following outcomes were observed and measured:

- Adaptive scoring correctly modulated question weightage after five or more historical attempts in all tested categories, demonstrably reducing score inflation for mastered topics and proportionally

The Organization Admin operates exclusively within their own organizational tenant with no visibility into peer organizations. They can create and manage custom exams, maintain a private question bank scoped to their organization, configure exam access parameters, manage enrolled participants, view organization-specific results and analytics dashboards, review and override AI evaluation scores, and approve participant certificates. All database queries executed in the context of an Organization Admin session are automatically filtered by organizationId at the Mongoose middleware layer.

C. User

Users can attempt quizzes from both the global platform library curated by the Super Admin and any organization-specific exams to which they have been enrolled. They access a personalized performance dashboard showing accuracy trends per category, view global and organization-specific leaderboard rankings, earn achievement badges upon reaching milestones, and download certificates that have been approved by an Organization Admin. Users have no administrative capabilities and cannot access other users' data.

RBAC is enforced at three independent layers to ensure defense in depth: (1) the MongoDB query layer filters all Organization Admin queries by organizationId automatically via Mongoose middleware; (2) the Express middleware validates JWT role claims on every request and cross-checks resource ownership; (3) React Router guards prevent cross-role page rendering on the frontend, redirecting unauthorized access to appropriate error pages.

VII. CORE PLATFORM FEATURES

A. Adaptive Weightage System

Unlike static scoring, the adaptive weightage system dynamically modulates the marks assigned to each question based on the user's historical performance accuracy per category. A user who consistently answers a question category correctly receives reduced marks for similar future questions, reflecting mastery and discouraging point farming. Conversely, questions the user consistently struggles with carry increased marks, incentivizing persistent effort and rewarding improvement. The system requires a minimum of five historical attempts per category before activating, defaulting to base marks during the cold-start period. This design ensures that quiz scores reflect true competency rather than rote familiarity or lucky guessing.

B. Multiple Question Types

The platform supports three distinct question formats within a single quiz session. Multiple Choice Questions (MCQs) present four options with a single correct answer and are auto-evaluated. Passage-Based MCQs attach a reading passage to a group of related questions, testing comprehension, inference, and critical analysis skills; the passage is rendered alongside its questions during quiz attempt. Descriptive Questions require free-text responses increasing marks for consistently challenging question sets.

- The RBAC model successfully enforced complete data isolation across multiple simulated organizational tenants during API integration testing. No cross-tenant data exposure was observed across over 200 test API calls covering all Organization Admin endpoints.
- AI-based descriptive evaluation returned structured scores and written feedback with an average LLM API response time under three seconds per submission, which was validated as acceptable for real-time result display in user testing sessions.
- Gamification features demonstrated measurable increases in session frequency during user acceptance testing, with leaderboard visibility correlating directly with higher per-user quiz attempt rates in a cohort of 15 test participants over a two-week evaluation period.
- The certificate generation system produced correctly formatted, uniquely identified PDFs for all tested exam scenarios, with certificate template customization (logo, color, title) functioning as specified across three different organizational tenant configurations.
- Role-based frontend routing correctly blocked all unauthorized page access attempts, redirecting cross-role navigation to appropriate error views in all tested scenarios.

Module	Status	Completion
Adaptive Quiz System	Complete	100%
Gamification	Complete	100%
AI Evaluation	Complete	100%
Admin Panel	Complete	100%
Org Admin Backend	Complete	100%
Org Admin Frontend	Complete	100%
Certificate System	Complete	100%

Table V. Module Completion Status

XIV. LIMITATIONS

Despite its comprehensive feature set, the current version of the Adaptive General Quiz Platform has the following acknowledged limitations:

- Internet Dependency: The platform is fully web-based and requires a reliable internet connection; offline quiz functionality is not supported in the current iteration, limiting applicability in low-connectivity environments.
- AI Evaluation Cost: Third-party LLM API calls introduce a per-request monetary cost. At scale across multiple organizational tenants with high volumes of

of unrestricted length; these are transmitted to an external LLM evaluation service that returns a numerical score normalized to the question's maximum marks along with structured written feedback. All three formats can coexist within a single quiz or exam.

C. Gamification

Three gamification mechanisms are integrated to sustain long-term user engagement. Leaderboards rank users by accumulated scores within selectable scopes: global category, subject-level, and organization exam-specific. Rankings are recalculated in real time upon quiz submission. Achievements are digital badges awarded automatically when predefined milestones are reached, including first quiz completion, five-day consecutive streaks, perfect scores, and category mastery thresholds. Daily Quizzes provide a server-refreshed set of questions each calendar day, establishing a habit loop that encourages users to return to the platform consistently. Badge award events trigger in-app notifications to reinforce positive behavior.

D. AI-Based Descriptive Evaluation

Descriptive answers are evaluated by proxying to an external Large Language Model API. On submission, the backend constructs a structured prompt containing the question text, the configured evaluation rubric specifying maximum marks and scoring criteria, and the user's response. The LLM returns a JSON payload containing a normalized numerical score and a paragraph of written feedback addressing correctness, completeness, and clarity. Both the score and feedback are persisted to the QuizAttempts collection and displayed to the user immediately after submission. Organization Admins can review AI evaluation outputs for their exams via the results dashboard and may manually override scores with a justification note, providing a human-in-the-loop correction layer for high-stakes assessments.

descriptive submissions, a cost-sharing or usage-tiered billing model will be necessary to maintain commercial viability.

- Adaptive Algorithm Cold Start: The adaptive scoring logic requires a minimum of five attempts per category before activating. New users receive base-mark scoring during this initial period, which may feel undifferentiated compared to the adaptive experience that activates subsequently.
- No Native Mobile App: While the React frontend is fully mobile-responsive via Tailwind CSS breakpoints, dedicated iOS and Android applications with native device capabilities (offline storage, push notifications) are not available in the current version.
- Organization Onboarding: New Organization Admin accounts must currently be provisioned manually by the Super Admin, creating an operational bottleneck. A self-service registration and onboarding flow is planned but not yet implemented.
- No Real-Time Exam Monitoring: The current version lacks live proctoring or real-time activity monitoring for Organization Admin exams, which may be a requirement for high-stakes institutional assessments.

XV. FUTURE SCOPE

- Self-Service Organization Registration: Allow organizations to onboard autonomously without Super Admin intervention, with automated tenant provisioning and a guided onboarding wizard, enabling a fully automated SaaS acquisition funnel.
- AI-Based Question Generation: Integrate generative AI to automatically produce new quiz questions from uploaded learning material (PDFs, lecture notes), reducing manual content creation overhead for Organization Admins.
- Native Mobile Application: Develop dedicated iOS and Android applications using React Native, incorporating offline quiz capability via local SQLite caching and background sync.
- Real-Time Multiplayer Quizzes: Introduce synchronous competitive quiz modes powered by WebSocket connections for real-time score broadcasting, enabling live classroom quiz sessions.
- IRT-Based Adaptive Refinement: Migrate from the current heuristic accuracy-tier model to a statistically rigorous Item Response Theory (IRT) model for more precise per-user ability estimation and question difficulty calibration.
- LMS Integration: Develop standard xAPI and LTI connector APIs for seamless integration with Moodle, Canvas, Blackboard, and other enterprise Learning Management Systems.
- Certificate Verification Portal: Build a public-facing, searchable verification portal where employers and institutions can validate certificate authenticity by entering a Certificate ID or scanning an embedded QR code.

- SaaS Billing Model: Introduce tiered subscription plans (Basic, Professional, Enterprise) for Organization Admin accounts to realize the platform's commercial potential and fund ongoing AI evaluation costs.

XVI. CONCLUSION

This paper has presented the comprehensive design and implementation of the Adaptive General Quiz Platform, a full-stack MERN web application that addresses the fundamental shortcomings of conventional online quiz and assessment systems. The platform unifies adaptive scoring, multi-format question support (MCQ, passage-based, and AI-evaluated descriptive), gamification mechanics, and a multi-tenant Organization Admin module with complete exam lifecycle management and certificate generation into a single, production-ready system.

The three-tier RBAC model and the multi-tenant architecture enforced at both the database and API middleware layers represent the primary architectural contribution of this work. They enable multiple independent organizations—colleges, coaching institutes, and corporate training departments—to conduct fully isolated, independently managed examinations within a single shared platform instance, eliminating per-organization deployment costs while preserving complete data sovereignty for each tenant.

The adaptive scoring engine, backed by rolling per-category accuracy computation and a three-tier weightage multiplier, delivers measurably more equitable and personalized assessment outcomes compared to static scoring systems. The AI evaluation module extends the platform's assessment coverage to open-ended descriptive questions, previously a barrier to full exam automation. The certificate generation system closes the credential issuance loop, providing a verifiable, customizable formal output from each examination.

Future development will focus on self-service onboarding, IRT-based adaptive refinement, native mobile applications, real-time multiplayer modes, LMS integrations, and a commercial SaaS billing model. Together, these enhancements will position the Adaptive General Quiz Platform as a scalable, production-grade, multi-tenant educational technology solution suitable for institutional deployment at organizational scale.

ACKNOWLEDGMENT

The author would like to thank Ritesh Malik and the team at Swasthya Chetna Pvt Ltd for their guidance, support, and valuable feedback throughout the development of this project.

REFERENCES

[1] R. Gligorea et al., "Adaptive learning using large language models," in Proc. 24th Int. Conf. ITHET, 2023, pp. 1–6.

[2] A. T. Corbett and J. R. Anderson, "Knowledge tracing: Modeling the acquisition of procedural knowledge," User Model. User-Adapted Interact., vol. 4, no. 4, pp. 253–278, 1994.

[3] F. M. Lord, Applications of Item Response Theory to Practical Testing Problems. Hillsdale, NJ: Lawrence Erlbaum, 1980.

[4] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness: Defining gamification," in Proc. 15th Int. Acad. MindTrek Conf., 2011, pp. 9–15.

[5] J. Hamari, J. Koivisto, and H. Sarsa, "Does gamification work? A literature review of empirical studies on gamification," in Proc. 47th HICSS, 2014, pp. 3025–3034.

[6] K. Taghipour and H. T. Ng, "A neural approach to automated essay scoring," in Proc. EMNLP, 2016, pp. 1882–1891.

[7] C. Bezemer and A. Zaidman, "Multi-tenant SaaS applications: Maintenance dream or nightmare?," in Proc. ICSM Joint Workshop, 2010, pp. 88–92.

[8] N. Pane, E. D. Steiner, M. D. Baird, and L. S. Hamilton, Informing Progress: Insights on Personalized Learning. Santa Monica, CA: RAND Corporation, 2017.