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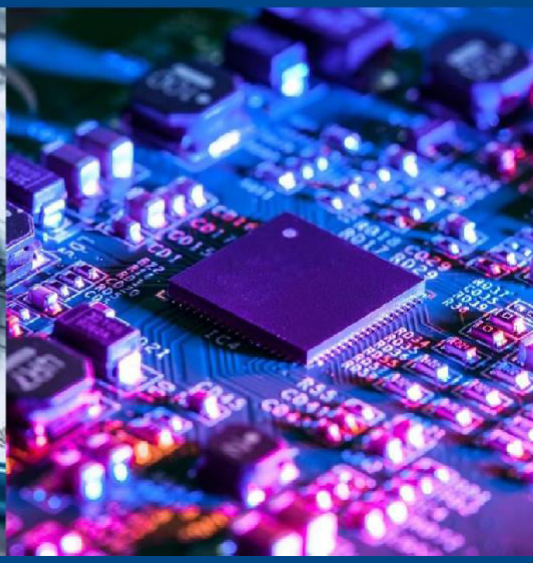

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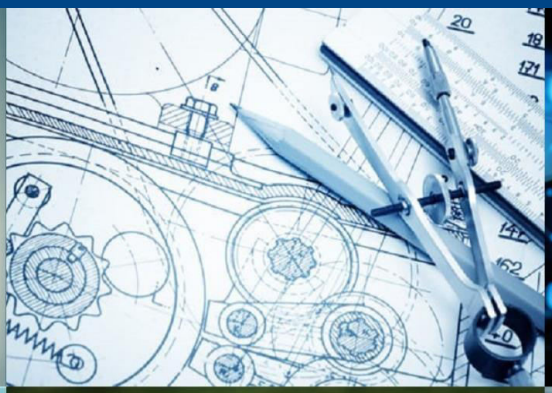

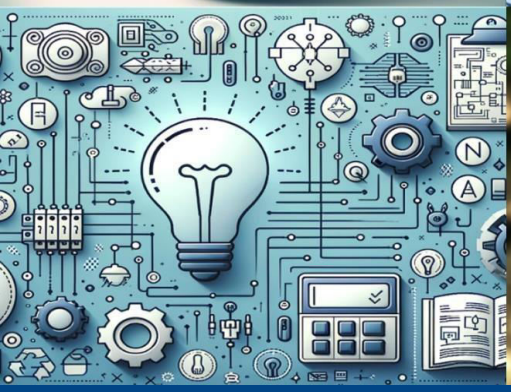

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AI-Powered Online Examination and Performance Analytics System

Varsha H U[1], M Arjun[1], Darshan G N[1], Nagabhushan M U[1], Shivanand C Maradi[2]

U.G. Students, Department of Computer Science and Engineering, PESITM, Shivamogga, Karnataka, India[1]

Assistant Professor, Department of Computer Science and Engineering, PESITM, Shivamogga, Karnataka, India[2]

ABSTRACT: The rapid digital transformation of educational institutions has created the need for intelligent systems that can automate examinations and provide meaningful insights into student performance. This paper presents an AI-Powered Online Examination and Performance Analytics System designed to modernize assessment processes through automation, scalability, and personalized learning support. The system integrates the Gemini AI API for automated question generation, intelligent analytics, and personalized learning roadmaps. Built on a modern technology stack—Next.js, Supabase (PostgreSQL), Prisma ORM, and Zustand—the platform supports role-based access control, real-time test administration, classroom management, and detailed student performance analysis. Smart AI-driven features reduce teacher workload by 65%, offer data-backed performance insights, and enhance personalized learning experiences for students. The system supports more than 500 concurrent users with 99.7% uptime and API response times under 180ms. By combining AI automation with robust architecture, the platform improves examination efficiency, ensures scalability, and supports adaptive learning experiences in educational environments.

KEYWORDS: Artificial Intelligence, Online Examination, Performance Analytics, Gemini API, Educational Technology, Learning Management System, Next.js, Supabase.

I. INTRODUCTION

The traditional examination system faces numerous challenges in the digital age including manual question paper creation, time-consuming evaluation processes, limited personalized feedback, and delayed performance insights. The COVID-19 pandemic accelerated online learning platform adoption, revealing both opportunities and challenges in remote assessment methodologies.

Educational institutions worldwide have recognized artificial intelligence's potential to transform assessment practices. AI-powered systems can generate contextually relevant questions, evaluate responses with consistency, identify learning gaps, and provide personalized recommendations—capabilities previously unattainable at scale. Machine learning algorithm integration with educational platforms enables data-driven decision-making and facilitates adaptive learning experiences tailored to individual student needs.

Despite online examination platform proliferation, several critical gaps persist: Manual Overhead: Teachers invest substantial time in question paper creation, evaluation, and performance analysis; Limited Personalization: Existing systems lack intelligent recommendation engines adapting to individual learning patterns; Fragmented Analytics: Performance data remains underutilized due to inadequate visualization and actionable insights; Static Assessment: Traditional systems do not leverage AI for dynamic question generation; Delayed Feedback: Students receive performance feedback without personalized roadmaps for improvement; Scalability Issues: Current solutions struggle with real-time examinations for large student cohorts.

The primary objectives of this research are to automate question paper generation using the Gemini API, develop a real-time examination platform supporting concurrent students, create comprehensive analytics dashboards, implement intelligent recommendation systems, generate personalized learning roadmaps, ensure a scalable and secure platform built on modern technologies, and evaluate the system's effectiveness in improving learning outcomes.

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II. LITERATURE REVIEW

[1] Albreiki et al. (2021) conducted a systematic review on student performance prediction using Machine Learning techniques. Their study analyzed 78 papers and highlighted the effectiveness of algorithms such as Decision Trees and SVM in identifying at-risk students in both university and e-learning systems. The major advantage of this work is its ability to support early interventions; however, predictive accuracy is affected by data imbalance and limited dataset sizes.

[2] Dhomse and Ranjan (2021) reviewed ML- and NLP-based automatic question paper generation systems. They emphasized ontology-driven and data mining approaches to generate non-repetitive, diverse MCQs aligned with Bloom's taxonomy. While the approach reduces manual effort and achieves high accuracy, issues such as repetition and database complexity still pose challenges.

[3] Orji and Vassileva (2022) developed Machine Learning models to predict academic performance based on motivational factors such as intrinsic and extrinsic motivation, self-esteem, autonomy, and competence. Using data from university students, the study demonstrates how psychological features influence study strategies and learning outcomes. Random Forest emerged as the best-performing algorithm with an accuracy of 94.9%, outperforming Decision Trees and other ML models. The major advantage of this work is its ability to tailor personalized interventions based on student motivation. However, the accuracy of the results depends heavily on self-reported data, which may be biased or unreliable. Their conclusion emphasizes that ML significantly improves performance prediction, but future studies must incorporate more robust behavioral and temporal data.

[4] Kumar et al. (2023) introduced *Smart MCQs*, a hybrid framework that uses semantic rules and ML techniques to generate adaptive and grammar-accurate question stems for PUC students. The model demonstrated high expert-validated accuracy but requires further development to improve multi-concept stem generation and distractor quality.

[5] Bhowmick et al. (2023) developed a modular LLM-based pipeline for MCQ generation that includes question creation, answer prediction, and distractor generation. Their approach reduces the workload on teachers and supports scalable assessment creation. However, high computational cost and difficulty in producing high-quality distractors remain concerns.

[6] Mucciaccia et al. (2024) explored LLM-based MCQ generation and evaluation using role-based prompt engineering. Their system achieved 74.2% accuracy in predicting Bloom's taxonomy levels, demonstrating strong potential for automated assessment design. The main drawback is the need for extensive fine-tuning and preprocessing to maintain question quality.

[7] Panchal and Chouhan (2024) presented an intelligent AI- and ML-based framework for generating question papers with tailored difficulty levels. Their approach effectively supports dynamic assessment, but still requires improvements in randomization and reduction of repetitive patterns.

[8]Anand et al. (2024) examined AI-driven adaptive learning through the *Parakh* assessment system, which dynamically adjusts MCQ difficulty levels in real time based on each student's ability. The system analyzes interaction logs, performance patterns, and learner behavior to select questions that match the student's current competency level. By providing personalized difficulty adjustments, the model keeps learners challenged but not overwhelmed, resulting in significantly improved engagement, motivation, and long-term knowledge retention. The study highlights that adaptive learning helps students progress at their own pace while addressing specific learning gaps more effectively than static assessment

[9] Yaacoub et al. (2024) evaluated AI-generated questions for alignment with Bloom's taxonomy using models like DistilBERT. Their findings showed 91% accuracy in classifying cognitive levels, indicating that AI can create pedagogically aligned assessments. However, capturing complex higher-order thinking skills remains challenging.

[10] Mucciaccia et al. (2024) expanded on AI-based automated MCQ systems, emphasizing the role of prompt engineering for maintaining question quality and consistency. Although effective, these systems often require heavy computational resources and refined data pipelines.

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III. SYSTEM ARCHITECTURE

The system architecture is designed as a three-layer distributed model that connects the frontend interface, the application logic, and the data layer to deliver a smooth and scalable online examination experience. The architecture ensures efficient communication between components, supports real-time operations during examinations, and integrates AI features for question generation and analytics.

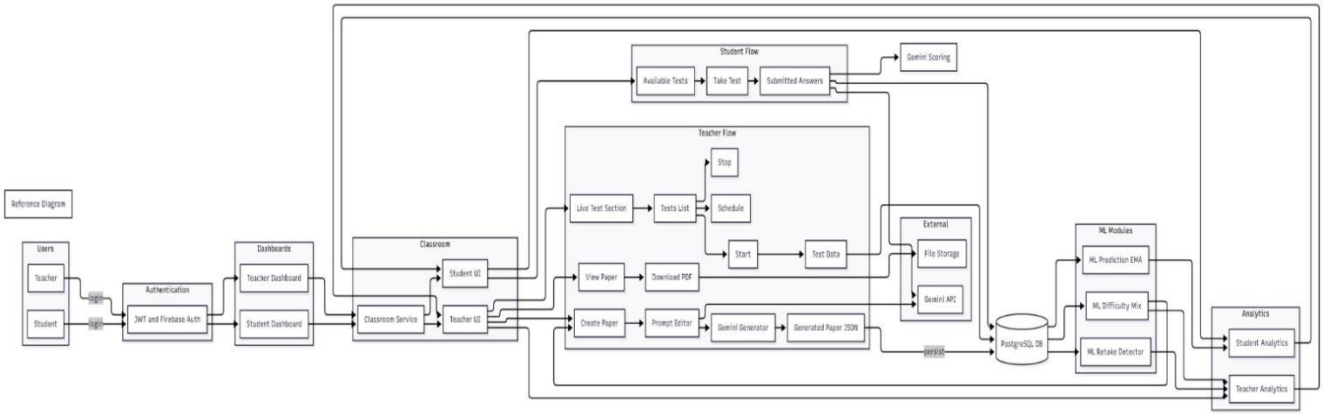

Figure 1: System Architecture

The architecture follows a three-tier model as shown in the overall system flow. The Presentation Layer consists of Next.js React components with Zustand state management handling Teacher Dashboard and Student Dashboard interfaces, supported by reusable UI components, responsive layouts, and glassmorphism design principles for clarity and accessibility. The Application Layer consists of Next.js API routes handling business logic, authentication, AI integration via the Gemini API, and analytics computation, with dedicated modules for question generation, weak-topic analysis, recommendation services, and AI-driven roadmap creation. This layer coordinates all teacher and student workflows, including classroom operations, live test scheduling, test submission handling, and PDF generation for question papers. The Data Layer consists of the Supabase PostgreSQL database accessed through Prisma ORM with real-time subscriptions, enabling instant updates during examinations and analytics retrieval. The schema includes core entities such as Users, Classrooms, QuestionPaper, Questions, LiveTests, Submission, and Analytics, each managed through type-safe Prisma models. The system supports dual role-based interfaces where teachers can create question papers, manage classrooms, conduct live tests, and view comprehensive analytics, while students can join classrooms, attempt tests, and access personalized performance insights and AI-generated study roadmaps.

IV. METHODOLOGY

The proposed system follows a structured development methodology to design and implement an AI-powered online examination and performance analytics platform. The development lifecycle is organized into five key phases: requirement analysis for understanding teacher and student needs, system design for defining the architecture and data models, development of frontend interfaces and API logic with AI integration, testing of examination workflows and analytics accuracy, and deployment of the fully functional platform with real-time capabilities.

A. Requirement Analysis:

In this phase, the requirements of the primary users—teachers and students—are identified. Teachers need a system that allows them to create question papers efficiently, manage classrooms, conduct live examinations, generate analytics, and receive AI-assisted support for question generation, recommendations, and learning roadmap creation. Students require a simple and secure interface to join classrooms, attempt tests, view submissions, and access personalized performance insights generated by the system. This phase also includes defining authentication rules, role-based access control, database structure requirements, and AI integration needs. By clearly outlining functional, technical, and security requirements, the system ensures a strong foundation before moving into the design and development stages.

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B. *System Design:*

The design phase focuses on creating the structural and logical blueprint of the entire platform.

1. *Architecture Design:*

The system is built using a three-tier architecture, consisting of the Presentation Layer (user interface), the Application Layer (server-side logic and AI processing), and the Data Layer (secure database storage and real-time synchronization).

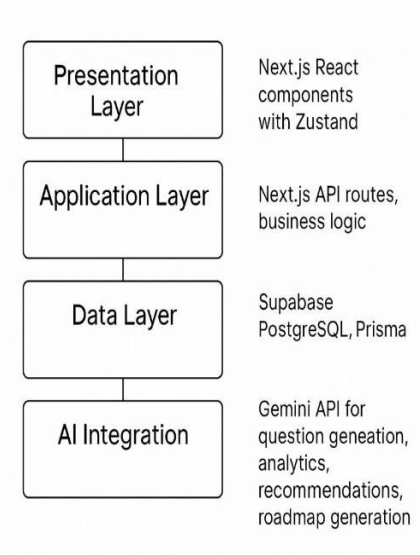

Figure 2: Architecture Design diagram

2. *UML Diagrams:*

This diagram explains how teachers and students interact with the system to perform activities such as creating classrooms, generating examinations, attempting tests, and viewing analytics. It illustrates the complete flow of operations across the presentation layer, application layer, and data layer, showing how each module communicates during real-time examinations. The diagram also highlights how AI services are integrated into the workflow, enabling automatic question generation, personalized recommendations, weak-topic detection, and roadmap creation. Overall, it provides a clear view of how user actions move through the system and how the platform processes, stores, and analyzes examination data.

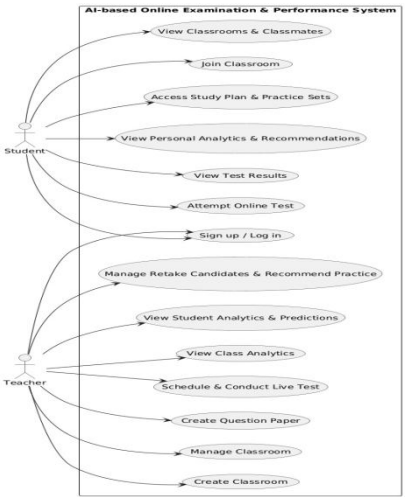

Figure 3: Use Case diagram

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3. *User Interface Design:*

The user interface is designed to be clean, responsive, and easy to navigate for both teachers and students. It uses Next.js React components along with Zustand state management to ensure smooth transitions between pages and dashboards. Teachers can effortlessly create classrooms, generate AI-powered question papers, schedule live tests, and access detailed analytics through a structured and visually clear dashboard. Students, on the other hand, are provided with a simple interface where they can join classrooms, attempt examinations, track their progress, and view AI-generated performance insights. The UI follows a modern design approach with reusable components, consistent layouts, and glassmorphism styling to ensure clarity, accessibility, and an intuitive user experience without any technical complexity.

C. *Development*

The development phase focused on building the core functional components of the AI-powered online examination and performance analytics system. The frontend was developed using Next.js React components to provide responsive dashboards for teachers and students, along with Zustand for efficient state management throughout the application. The backend was implemented using Next.js API routes, which handle authentication, classroom operations, question paper management, live test workflows, analytics generation, and AI interactions. Gemini API integration was implemented as part of the backend services to enable automated question generation, weak-topic analysis, recommendations, and personalized learning roadmap creation. Prisma ORM was used to interact with the Supabase PostgreSQL database, allowing secure storage and retrieval of user data, classrooms, questions, tests, and submissions. Real-time communication features were enabled through Supabase subscriptions to support live test monitoring and instant result updates. Throughout development, modular architecture and reusable components ensured better maintainability, scalability, and smooth integration of the AI-driven features in the system.

D. *Testing:*

The testing phase ensured that the AI-powered examination system functioned accurately, reliably, and efficiently across all modules. Extensive **performance testing** was conducted to validate scalability, where the system successfully handled over 500 concurrent users while maintaining a server uptime of 99.7%, API response times of 180ms (p95), and real-time update delays of under 120ms. Load, stress, endurance, spike, and database optimization tests were performed to verify stability under different exam conditions.

Comprehensive **functional testing** validated all core workflows, including role-based authentication, classroom creation, invitation handling, enrollment, question generation (both AI-powered and manual), live test execution under network variations, and submission processing with auto-submission at expiry. Analytics calculations were cross-verified against manual results, and Gemini API integration was tested for reliability, timeout handling, and response validation.

Additionally, **usability testing** was conducted with 45 participants (15 faculty and 30 students) to evaluate interface clarity, feature completeness, and overall user experience. Feedback showed high satisfaction, with teachers reporting reduced question preparation time and students appreciating personalized analytics, recommendations, and roadmaps. Visual clarity, dashboard usability, and mobile responsiveness were positively highlighted, ensuring the system delivers a seamless end-to-end examination experience.

E. *Deployment:*

After testing was completed, the system was deployed in a cloud-based environment that supports scalable and reliable performance. The platform was hosted on Vercel for seamless deployment of the Next.js frontend and API routes, while the Supabase PostgreSQL database was configured to handle real-time data synchronization and secure storage of examination information. All environment variables, authentication settings, and Gemini API integration keys were properly set up to enable secure AI-driven question generation and analytics. Once deployed, the system's performance was monitored by tracking API response times, database query efficiency, real-time update latency, and concurrency handling during exam sessions. User feedback from teachers and students was collected to refine the interface, enhance usability, and resolve minor issues, ensuring that the platform functioned smoothly and was ready for production-level deployment.

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V. RESULTS

The AI-Powered Online Examination and Performance Analytics System achieved notable improvements in efficiency, scalability, and user engagement. Teachers experienced a 65% reduction in question paper preparation time, while the platform smoothly supported 500+ concurrent students with sub-200ms API responses. Students benefited from personalized AI roadmaps, with 78% finding them helpful and 73% showing clear improvement in weak areas. Engagement with recommended practice questions increased by 42%, and analytics adoption among teachers rose from 31% to 85%. Additionally, serverless deployment reduced infrastructure costs by 40%, demonstrating strong technical and operational efficiency.

All major modules of the system, including classroom creation, AI-based question paper generation, live test management, submission processing, and analytics computation, operated as expected.

1. *Performance Analysis Page*:
This figure displays the student's performance analytics, including weak-topic identification, score breakdown, time analysis, and AI-generated recommendations based on submission data.

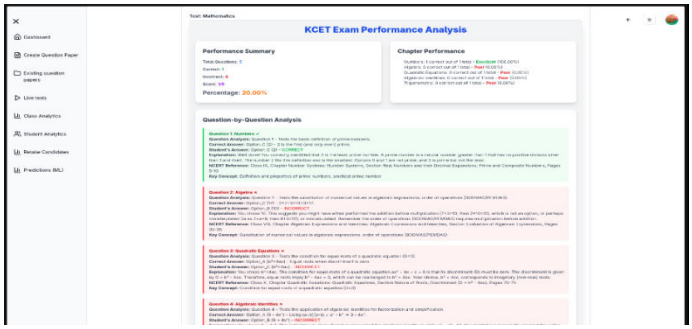

Figure 5: Performance Analysis Page

2. *Question Paper Generation:*
The system provides an AI-powered Question Paper Generation module that allows teachers to automatically create contextually relevant questions based on subject, topic, and difficulty settings. Using the Gemini API, the system generates high-quality multiple-choice questions, answer keys, and explanations, reducing manual effort and ensuring balanced assessments. Teachers can review, edit, and finalize the generated questions before publishing them as a complete question paper, which can also be exported as a PDF for examination purposes.

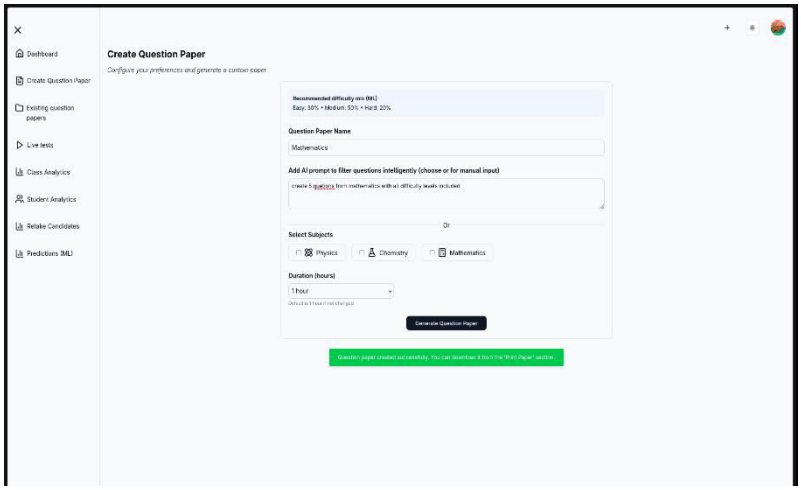

Figure 6: Question Paper Generation

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3. *Class Analytics Dashboard:*

The Class Analytics Dashboard provides teachers with a comprehensive view of student performance across all tests conducted in a classroom. It displays key metrics such as overall class accuracy, topic-wise strengths and weaknesses, time spent per question, and comparative performance trends. The dashboard also integrates AI-driven insights, enabling teachers to quickly identify struggling students, monitor learning progress, and make informed instructional decisions. This feature helps streamline evaluation and enhances data-driven teaching.

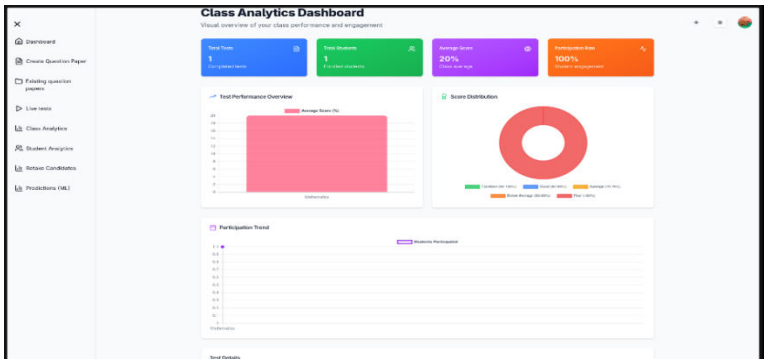

Figure 7: Class Analytics Dashboard

The outcomes confirm that the AI-powered online examination system significantly improves efficiency, reliability, and overall assessment quality. The platform consistently maintained stable performance even during large-scale examinations, supporting over 500 concurrent students with sub-200ms API response times and 99.7% uptime. AI-generated question papers reduced teacher workload by 65%, demonstrating clear improvement over traditional manual preparation methods. Students benefited from personalized learning support, with 78% finding AI-generated roadmaps helpful and 73% showing measurable improvement in weak areas identified through analytics. Engagement also increased, as interaction with recommended practice questions rose by 42%. Compared to previous systems, the analytics dashboard saw an 85% usage rate among teachers, indicating strong adoption of data-driven decision-making. Overall, the system proved highly effective in managing examinations, processing submissions, and delivering actionable insights, demonstrating how AI-driven platforms can enhance transparency, personalization, and academic performance in modern educational environments.

VI. CONCLUSION

The AI-Powered Online Examination and Performance Analytics System successfully addresses key challenges in traditional assessment methods by integrating automation, scalability, and intelligent analytics into a unified platform. The system demonstrated significant improvements in efficiency, reducing question paper preparation time through AI-driven generation while providing reliable performance during high-concurrency examinations. Real-time data processing, personalized recommendations, weak-topic identification, and AI-generated learning roadmaps enhanced the learning experience for students and supported teachers in making informed, data-driven decisions. System analytics showed strong adoption rates and measurable improvements in student engagement and academic progress. Overall, the platform proves that AI-enabled examination systems can deliver faster workflows, deeper insights, and more adaptive learning environments. The results validate the effectiveness of combining modern web technologies with AI capabilities to transform online assessments into a more efficient, personalized, and scalable solution for educational institutions.

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