AI-Driven System for Enhanced Learning Environments

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***Abstract*—In modern education, efficient classroom management is crucial, yet traditional methods are often manual, time-consuming, and error-prone. "EduZen" is a comprehensive web application designed to address these challenges by simplifying smart classroom management for administrators, teachers, and students. The platform allows administrators to seamlessly manage curriculums, empowers teachers to track attendance, grades, and resources, and enables students to monitor their performance using AI-powered tools like personalized tracking, quiz generation, and chatbots for learning gap analysis. Additionally, EduZen integrates a video lecture module, enabling teachers to upload and manage topic-wise video lessons using Cloudinary, thereby enhancing accessibility and supporting self-paced learning for students. This research examines the design and implementation of EduZen, evaluating its potential to streamline classroom operations and foster a data-driven learning environment. The study provides a scalable model for integrating smart technology in education, presenting a solution that improves both administrative efficiency and academic performance.**

***Index Terms*—Student Progress Tracking, AI in Education, Educational Analytics, Academic Monitoring, Data-Driven Learning, Video Lecture Management**

I. INTRODUCTION

In modern education, efficiently managing classrooms to ensure a conducive learning environment is crucial. Traditional methods are often manual, time-consuming, and prone to error, disrupting the core learning process. The academic ecosystem involves two primary stakeholders-teachers and students each with distinct needs for interaction and performance tracking. A comprehensive, integrated platform is therefore essential to streamline academic workflows, enhance pedagogical strategies, and empower learners on their educational journey.

This paper introduces 'EduZen,' a web application designed to simplify classroom management and enhance student tracking. The platform offers tailored functionalities for both educators and learners. Teachers are provided tools to efficiently manage attendance, grades, and class resources, enabling a more organized approach to instruction. An integrated video lecture module, implemented using Cloudinary, allows teachers to seamlessly upload and manage topic-wise video lessons, ensuring flexible access to course content for students and promoting self-paced learning. Simultaneously, students can actively monitor their performance. By integrating AI-powered tools like personalized progress tracking, adaptive quiz generation, and analytical chatbots, EduZen fosters a data-driven environment that empowers both users to improve academic outcomes.

A. Challenges in existing systems

1) Disconnected Teacher Workflows: Teachers often have to juggle separate applications for attendance, grading, and course materials, creating a fragmented workflow that takes valuable time away from actual teaching.

2) Time-Consuming Manual Tasks: Critical classroom routines, especially taking attendance, remain a tedious manual process. This is not only prone to errors but also offers no immediate insight into who is present and engaged in the lesson.

3) Data Overload Without Clear Insights: Many platforms can overwhelm educators with raw data but often fail to provide simple, actionable insights that help identify which students might be falling behind or disengaging.

4) Inadequate Personalization: Most models focus on aggregate performance rather than enabling adaptive quiz generation, automated self-assessments, and targeted recommendations tailored to individual learner profiles.

5) Communication Barriers: Lack of integrated communication channels between teachers and students limits collaborative engagement and sharing of timely academic insights.

6) Scalability and Usability Issues: Several platforms struggle with scalability across diverse educational contexts and suffer from complex interfaces not optimized for multi-device accessibility.

B. Solutions

The EduZen system is designed to streamline academic management by defining clear roles and responsibilities for teachers and students.

1) Teacher Functions

a) unique classroom code generates and share: Add students to classrooms by sharing classroom code generated after creating the classroom.
b) Assignment Allocation: Assign projects and tasks with deadlines and necessary resources.
c) Feedback and Interaction: Engage with students through comments, providing feedback on submissions and addressing queries.
d) Announcements: Share important information and updates via a centralized announcement feature.
e) Progress Analysis: Assess student performance by assigning grades and using analytics tools to monitor progress.

2) Student Functions

a) Task Submission: Submit assigned tasks and projects through the platform.
b) Self-Analysis via AI Reports: Access AI-driven reports offering insights into academic performance.
c) AI-Powered Quiz Generation: Generate quizzes tailored to individual learning needs for self-practice.
d) Report Submission to Teachers: Compile and send performance reports to respective teachers.

Feature	Traditional Systems	GradePulse	Survey Insight
Progress Tracking	Manual, time-consuming	Auto-grading with analytics	72% want faster insights
Student Feedback	Scattered & untracked	Centralized comments & feedback	64% miss regular feedback
Task Submission	Email/Forms	In-app classroom-wise submissions	58% face confusion
Self Analysis / Quiz	Not available	AI reports + AI quiz generator	81% want AI support

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Table 1: Comparison of Traditional Systems vs EduZen

II. RELATED WORK

A study involving 126 students in a blended economics and informatics course examined their perceptions of using learning analytics dashboards within the Moodle Learning Management System. The research aimed to uncover connections between progress tracking, motivation, satisfaction, and final grades [1]. Existing Knowledge Tracing methods prioritize prediction accuracy but often neglect aligning students' evolving knowledge states with their learning processes [2]. A study of 54 higher education students found that high performers used Learning Analytics Dashboards more during preview and review phases, employing monitoring and reflection strategies to enhance learning [3]. A web-based school management system can streamline student records, attendance, admissions, and accounting by replacing manual processes with centralized software. It enhances student and guardian communication through email, SMS, and push notifications [4]. In a high school English class, implementing the Stanford Mobile Inquiry-based Learning Environment (SMILE) allowed students to generate and discuss their own questions, enhancing engagement and critical thinking [5]. Integrating Google's Gemini models into school management systems can enhance functionalities such as personalized communication through natural language processing and improving interactions with students or guardians [6]. The report examines Google Gemini, a multimodal generative AI tool capable of processing text, images, audio, and video, highlighting its transformative potential in educational technology. It also addresses empirical studies, practical applications, and ethical considerations for integrating Gemini into future

educational endeavors [8]. The Artificial Intelligence-Enabled Intelligent Assistant (AIIA) is an AI and NLP-based framework that personalizes higher education by tailoring learning support to individual styles and needs. Its features include responding to student inquiries, generating quizzes and flashcards, and creating personalized learning pathways [9]. A study comparing AI-driven personalized learning on the Korbit platform with traditional MOOC platforms found significantly higher learning gains (2–2.5x) and course completion rates. These results highlight AI's potential to revolutionize online education and democratize learning worldwide [10].

III. METHODOLOGY

"EduZen" is a web-based application developed with React.js, Node.js, Express.js, and MongoDB, integrating the Gemini API for AI-driven analytics to enhance communication and collaboration among teachers and students. Additionally, the system incorporates Cloudinary for efficient cloud-based video lecture storage and management, enabling teachers to upload topic-wise video content that supports flexible and self-paced learning.

A. Database Management

The application employs MongoDB as its database, interfaced through Mongoose, an Object Data Modeling (ODM) library for Node.js. Mongoose provides a schema-based solution to model application data, ensuring consistency and facilitating complex queries. The database stores comprehensive information, including institution details, curricula, branches, teacher and student profiles, classroom assignments, and user-generated data such as assignments, grades, feedback, and video lecture metadata (titles, topics, URLs, and upload timestamps). This centralized data management ensures data integrity and supports real-time updates across the system, including seamless integration with Cloudinary for managing and retrieving video content.

B. User Interface and Experience

The application features an intuitive, user-friendly interface tailored to the distinct needs of teachers and students:

1. Teachers: Utilize tools for enrolling students via classroom codes, assigning projects and assignments, uploading video lectures directly through Cloudinary integration, making announcements, interacting with students through feedback mechanisms, and analyzing student progress through grading systems.
2. Students: Engage with features for submitting assignments, accessing uploaded video lectures for concept reinforcement, utilizing AI-generated reports for self-analysis, generating quizzes for self-practice, and communicating performance reports to teachers.

The interface employs responsive design principles, ensuring accessibility across various devices and promoting an engaging and dynamic user experience.

C. AI-Driven Analytics and Reporting

An integral component of the system is its AI-driven analytics engine, which processes data to provide actionable insights:

1) For Teachers: Analyze student performance trends, identify areas requiring intervention, and tailor instructional strategies accordingly.
2) For Students: Receive personalized reports highlighting strengths, areas for improvement, and suggested resources or activities to enhance learning outcomes.

D. System Architecture

1. Core Technology Stack: The system is built using the Next.js framework, Recharts, React Hook Form, and MongoDB.
2. AI Integration: Utilizes the Gemini API for advanced AI-driven analytics, reporting, and adaptive quiz generation.
3. Cloud Integration: Incorporates Cloudinary for secure video storage, streaming, and retrieval, allowing scalable and efficient handling of multimedia content.
4. Application Type: Architected as a multi-role web application.
5. User Roles: Caters to two distinct user roles Teachers and Students, each with specific interfaces and functionalities.
6. Central Interaction Point: Users interact with a central Web Application that hosts the primary modules and services.
7. Key Functional Modules: a) User Management: Handles authentication, authorization, and role-based access control. b) Curriculum Management: Manages curriculum details and assignments. c)

Classroom Management: Oversees student enrollment, progress tracking, and project assignments. d) Video Lecture Management: Enables teachers to upload, store, and stream topic-wise video lectures using Cloudinary's cloud infrastructure. e) AI Services: Provides AI-powered features such as performance reports and adaptive quiz generation.

8. Database Backend: Employs MongoDB as its database, with Mongoose as the Object Data Modeling (ODM) library.

Data Repository: The database acts as a centralized repository for all institutional information, user profiles, academic materials, assignments, grades, feedback, and video content metadata, ensuring data integrity and real-time synchronization across all system modules.

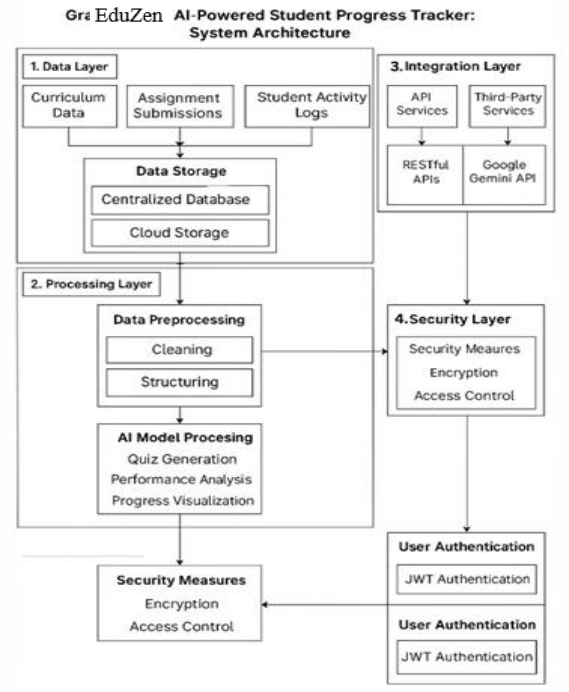

Fig. 1. System Architecture

IV. EXPERIMENTAL SETUP

A. Driver Technology

"EduZen" is built using the Next.js framework, offering server-side rendering and efficient routing for optimal performance and scalability. The frontend is enhanced with Shadcn UI components for design consistency and React Hook Form for reliable form handling across student and teacher interfaces. NextAuth is implemented for secure authentication and role-based access, using JWT tokens and session-based validation. MongoDB serves as the backend database, providing flexibility and scalability for storing institutional, academic, and performance data. For AI-driven quiz generation and performance feedback, the system integrates with the Google Gemini API. Data visualizations, including student performance trends and analytics, are rendered using Recharts, enabling intuitive and dynamic graphical representation.

V. RESULTS

A. Visual Description

"EduZen" features an intuitive, responsive interface designed specifically for two user roles teachers and students. Each role has a tailored dashboard to streamline academic interactions and promote personalized learning.

The teacher dashboard enables student enrollment through Classroom Code Sharing, assignment distribution, feedback sharing, and performance tracking. Teachers can analyze student progress through dynamic, AI-powered insights and communicate announcements via a central platform.

The student dashboard facilitates assignment submission, access to AI-generated self-assessment reports, and personalized quiz generation based on subject and difficulty preferences. Students also receive visual performance breakdowns and improvement suggestions.

Visualizations across the platform are rendered using Recharts, presenting data such as quiz scores, assignment trends, and growth analytics through line graphs, bar charts, and pie charts. This enhances understanding of learning patterns and supports data-driven decision-making for both users.

The system architecture visually depicts seamless communication among key components:

- Frontend: Built with Next.js, Shadcn UI, and React Hook Form for interactive, structured interfaces.
- Backend: Node.js with NextAuth for secure authentication and role-based session control.
- Database: MongoDB for storing curriculum, performance data, and feedback.
- AI Engine: Google Gemini API powers quiz generation and performance evaluation.

- Cloud Integration: Incorporates Cloudinary for efficient video management, enabling teachers to upload, store, and stream high-quality lecture videos directly through the platform. This integration ensures optimized video delivery, scalable storage, and easy retrieval for students, supporting flexible and self-paced learning experiences.

Together, these components create a unified, scalable, and user-friendly platform for managing and improving student academic progress

B. Comparison with Existing Systems

"EduZen" addresses several limitations identified in traditional student information systems and LMS platforms. While platforms like OpenSIS, Alma, ThinkWave, Teachmint, and OpenEduCat provide basic academic management features, they fall short in delivering AI-driven personalization and real-time analytical insights.

Unlike OpenSIS and ThinkWave, which lack advanced self-assessment tools, EduZen integrates the Gemini API to enable adaptive quiz generation and real-time performance evaluation. Alma and OpenEduCat offer curriculum organization tools but do not provide AI-powered feedback mechanisms or personalized growth tracking, both of which are core features in EduZen.

Furthermore, EduZen supports dynamic data visualization through Recharts, empowering teachers and students with clear academic insights something most existing systems offer only at a basic level, if at all. Platforms like Teachmint provide online class management and communication tools but do not focus on AI-based self-analysis or automated quiz generation.

Feature	GradePulse	OpenSIS	Alma	ThinkWave	Teachmint	OpenEduCat
AI-Generated Quizzes	EduZen – API to create quizzes by topic/difficulty	Not available	Not supported	Not supported	Not supported	Not available
AI-Driven Performance Analytics	Real-time insights using Gemini AI + Recharts	Basic reports, no AI	Limited to grade tracking	No AI or adaptive analytics	No performance analytics	Static analytics, no AI
Real-Time Feedback Mechanism	Instant AI + teacher feedback to students	Manual grading	Non-AI-based feedback available	Delayed manual feedback	Live class feedback only	Admin-managed reporting
Visual Progress Representation	Recharts used for live performance charts	Minimal visuals	Basic dashboard views	No visual representation	No performance charts	Text-based progress reports
Excel-Based Student Enrollment	Teacher uploads student data via Excel	Admin can add, but not teachers	Not clearly supported	Manual entry	Bulk upload supported	Excel upload available
Adaptive Learning Engine	Quiz difficulty adjusts based on student performance	Not supported	Not supported	Not supported	No AI adaptation	Not supported
Role-Specific Dashboards	Teacher and student-specific dashboards	Admin-focused view	Separate role-based dashboards	Generic interface	User role support	Customizable role views

Table 2. Feature Comparison with Existing Systems.

VI. CONCLUSION

The "EduZen" project offers an innovative and user-friendly solution to the challenges of academic performance monitoring and classroom management. By utilizing the MERN stack and integrating advanced analytics through the Google Gemini API, the application provides educators and students with an efficient way to track and enhance academic progress, thereby promoting personalized learning experiences.

A key enhancement of the system is the integration of Cloudinary-based video lecture management, which enables teachers to upload, store, and deliver topic-wise video lessons securely and efficiently. This feature supports flexible, self-paced learning, allowing students to revisit lectures anytime and strengthen conceptual understanding beyond the classroom.

The platform not only improves accessibility but also raises awareness about effective educational practices, significantly contributing to better student outcomes. User feedback has been overwhelmingly positive, with many highlighting the convenience, interactivity, and scalability of the application.

Future enhancements could include real-time performance alerts, integration with additional educational tools, and community-driven collaborative features to broaden EduZen's functionality. Overall, this project underscores the potential of web-based educational platforms in transforming the learning experience and highlights the vital role of AI and cloud technologies in fostering a smarter, more connected, and engaging academic environment.

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