



SmartLearn Hub: An AI-Driven Learning Management System

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ABSTRACT

Digital learning platforms have changed the way students get materials and academic support, and honestly, the shift is hard to ignore. A traditional learning management system usually handles course management and content delivery well enough, yet many of them still fall short when it comes to student engagement, secure assessment, personalized support, and smoother learning administration. That gap matters. Students do not just need access to files and deadlines; they need a system that actually supports how they learn.

This is where SmartLearn Hub stands out. Instead of being tied to the limits of a physical boot camp with fixed schedules and obvious space restrictions, learners can keep studying in a more flexible online setting. SmartLearn Hub is designed as an intelligent web-based learning platform that combines modern web technologies with artificial intelligence to build a secure, interactive, and fairly easy-to-use environment. It is not just another basic LMS dressed up with a modern interface. The idea is broader than that, and more practical too.

The platform is built with the MERN Stack, which remains one of the stronger choices for educational applications because it supports a blended learning experience without making the system feel clunky. Teachers can create and organize courses, upload different forms of content, prepare assignments and

tests, and monitor student progress. Students, meanwhile, can enroll in courses, study the materials, submit work, take assessments, and stay involved in learning activities online.

Keywords: Learning Management System, Artificial Intelligence, MERN Stack, Online Proctoring, YOLOv8, OpenCV, Grok API, Clerk Authentication, Stripe Payment Gateway, E-Learning.



1. INTRODUCTION

Computing power continues to double roughly every two years, in line with Moore's Law[3], and that pattern has pushed many areas of IT, especially cloud computing, into the same fast-moving cycle of exponential growth.[4] Education has not been left out of this shift. In fact, it has changed a great deal. Digital learning environments are now practical because of advances in information technology, and they offer flexibility, convenience, and broader access for both users and instructors. The spread of online learning management systems has also allowed schools and universities to deliver course content, assessments, and other learning materials through web-based platforms.

Even so, many traditional e-learning systems still focus mainly on content delivery. That approach feels limited. They often miss the smart functions needed to improve user engagement, automate support services, or protect the integrity of online exams. New developments in Artificial Intelligence (AI), cloud computing, and modern web technologies create stronger possibilities for digital education. AI-powered learning systems can provide personalized help, handle repetitive tasks that take too much time, identify learning patterns, and strengthen assessment security. In addition, responsive web design works smoothly with BGNote's resources, which allows students to learn from different devices and from anywhere with Internet access. The demand for learning platforms that combine smart automation with security and ease of use is clearly growing.

SmartLearn Hub is designed as an AI-driven Learning Management System that responds to these needs by combining modern web technologies with intelligent educational functions. It is built on the MERN stack, which includes MongoDB, Express.js, React.js, and Node.js, giving the platform a scalable and efficient structure for managing educational activities. Through this system, educators can create and manage courses, upload learning materials, conduct assessments, monitor learner progress, and communicate with students in one centralized digital space. Students, on the other hand, can enroll in courses, access multimedia learning content, review their academic performance, and take online assessments through a clear and responsive interface.

An AI-based online proctoring module is also included, developed with Python, OpenCV, and YOLOv8. It monitors online examinations and detects suspicious behavior in real time. These features improve engagement, reduce manual supervision, and raise the credibility of online assessments.

2. LITERATURE SURVEY

Title	Authors	Year	Algorithms / Technology	Advantages	Disadvantages
Intelligent Learning Management Systems: A Review of AI Applications in Education	M. Sharma and P. Gupta	2024	Artificial Intelligence, Machine Learning, Learning Analytics	Improves personalized learning, student performance monitoring, and educational decision-making	Requires large datasets and high computational resources
AI-powered chatbots for educational support systems,	R. Kumar and S. Patel	2023	Use Natural Language Processing (NLP), conversational AI, and chatbot systems	They give students quick support, improve engagement, and cut administrative	workload, though complex academic questions can still get inaccurate responses.
Online examination monitoring using computer	J. Wilson and A. Thomas	2023	Uses OpenCV, deep learning, and face detection	AOVA for stronger examination security with less	though results rely heavily on camera quality and



vision techniques				manual invigilating.	internet connectivity.
Real-Time Object Detection with YOLO for Smart Monitoring Application	J. Redmon et al.	2022	YOLO Object Detection, Deep Learning	High detection accuracy and real-time monitoring capabilities	Needs GPU resources for best results
Cloud-Based Learning Management Systems for Higher Education	L. Chen and H. Wang	2022	Cloud Computing, Web Technologies, Database Systems	Supports scalability, remote accessibility, and centralized learning management	Security and data privacy concerns may arise

3. METHODOLOGY

3.1 System Design Approach

SmartLearn Hub is a full-stack web application that integrates state-of-art web technologies and Artificial Intelligence to create a robust intelligent digital learning environment. The application is designed through a combination of Secure Socket Layer (SSL) encryption and other security methods along with the use of the optional (smartcard) for user identification. It provides students, professors and administrators alike with a single, streamlined platform for learning activities, course delivery, testing, and interaction with users. The modular design methodology was adopted to a great extent by ensuring the overall system was scalable, maintainable and easily integratable among different modules.

3.2 Technologies and Tools

Various technologies and development tools were utilized during the design and implementation of the system:

- ✓ **Frontend Development:** React.js was used to build responsive and interactive user interfaces for students, educators, and administrators.
- ✓ **Backend Development:** Node.js and Express.js were used to develop RESTful APIs, business logic, and server-side functionalities.
- ✓ **Database Management:** MongoDB was employed to store user information, course data, enrollments, assessments, reviews, and transaction records.
- ✓ **Authentication System:** Clerk Authentication was integrated to provide secure login, registration, session management, and role-based access control.
- ✓ **Payment Processing:** Stripe Payment Gateway was utilized to manage secure online transactions and automated course enrollment.
- ✓ **AI Chatbot Integration:** Grok API was incorporated to provide intelligent conversational support and instant assistance to platform users.
- ✓ **AI Proctoring Module:** Python, OpenCV, and YOLOv8 were used to implement real-time examination monitoring and suspicious activity detection.
- ✓ **User Interface Enhancement:** Framer Motion was used to create smooth animations, interactive transitions, and modern user experiences.
- ✓ **Development Environment:** Visual Studio Code, Git, GitHub, and Postman were used for coding, version control, testing, and API validation.
- ✓



3.3 Data Management and System Integration

The platform maintains different types of educational data such as user profile, course details, enrollment information, evaluation outcomes, financial transaction, chatbot conversation, and proctoring logs. MongoDB acts as a central database to efficiently save and retrieve these records. The front end and back end communicate through RESTful APIs that are built with Express.js and Node.js. Authentication inquiries, course management, payment processing, chatbot interaction, and exam surveillance activities are encrypted and managed through a unified system architecture. The modular design of the database enhances data integrity, allows for better scalability, and supports future growth.

3.4 System Development Procedure

In order to build SmartLearn Hub an organized workflow with multiple phases was followed:

- 1. Requirement Analysis:** During this phase functional and non-functional specifications of the learning management platform were defined which included things like: course management, secure authentication, payment processing, AI chat bot support and online proctoring.
- 2. User Interface Design:** Responsive User Interfaces were built using React.js as well as incorporating Framer Motion animation technology to enhance intuitive navigation and user interactions.
- 3. Database Design:** MongoDB collections were created for Users, Courses, Enrollment, Assessment, Payment, Review, Chatbot Conversation and Proctoring Data.
- 4. Backend Development:** RESTful web services were written using Node.js and Express.js in order to create the business logic, manage Users, manage Courses, process Payments and communicate Data.
- 5. AI Module Integration:** The Grok chat bot API was integrated into the application to provide chat services, while Python, OpenCV and YOLOv8 were integrated with the chat bot to allow for smart proctoring capabilities and detection of unusual behaviours.
- 6. Testing and Validation:** The developed application was tested to verify all workflows related to user authentication, course enrollment processes, payment processing, chatbot response, database operations and AI driven smart proctoring functionalities.
- 7. Deployment and Evaluation:** The completed application was deployed to production and feedback was collected regarding system functionality, user experience, security, performance and reliability in order to ensure suitability for operation in Digital Learning Environment(dor).

4.IMPLEMENTATION

In the phase of system development, the focus is on developing the proposed design into an actual intelligent LMS. The system was built using the MERN stack architecture to facilitate seamless integration of the frontend, backend, database, and AI services.

4.1 User Module

The User Module facilitates student registration, authentication, profile, course browsing, enrollment, and learning. Students have the ability to sign up, securely log in with Clerk Authentication, edit profiles, and view custom dashboards. The module allows for navigation of course material, tests, learning experience, and certification. It acts as a front door for learners to the learning platform.

4.2 Educator Module

Instructors The Educator Module allows educators to build, organize, and present courses. Educators have a dedicated dashboard to post course materials, video lectures, assignments & tests. Under this module instructor can track students, assess performance and course details. It helps to ease the course building and the course management for both the educators and the learners.



4.3 Course Management Module

Course Management Module deals with the management of creation, organisation & course maintenance of courses offered on the platform. Educators and administrators can add course information, multimedia contents, attach learning materials and change course details. Students are allowed to search for courses, read course descriptions, and access learning resources after that they register successfully. This module acts as the focal-point for academic content management.

4.4 Enrollment and Payment Module

Enrollment part as well as payment transaction process is also handled by Enrollment and Payment Module. To automatically process your payments and verify the details of each transaction, the Stripe Payment Gateway is enabled. Once payment has been made, students are registered for the course of their choice and given access to learning materials. The module tracks transactions, maintains information about the payment status and the enrollment history, providing full transparency and allowing efficient management of order to the course access.

4.5 AI Chatbot Module

To achieve intelligent conversational experience in the platform, the AI Chatbot Module is developed based on the Grok API. The bot is best suited to answer FAQs, help students navigate course related tasks, and provide technical support. The real-time answers increase user engagement and decrease the need for manual support. This module increase the usability and interactive learning style.

4.6 AI Proctoring Module

The AI Proctoring Module ensures the exam security by monitoring activities in the exam environment in real-time and by analyzing these activities with intelligent algorithms. The module is implemented in Python, using OpenCV and YOLOv8 for object detection. The webcam streams in online exams are monitored to detect suspicious behavior such as the use of mobile phones, the presence of more than one person, and erratic exam patterns. The detected events are logged to be reviewed later to maintain the honor of online examinations.

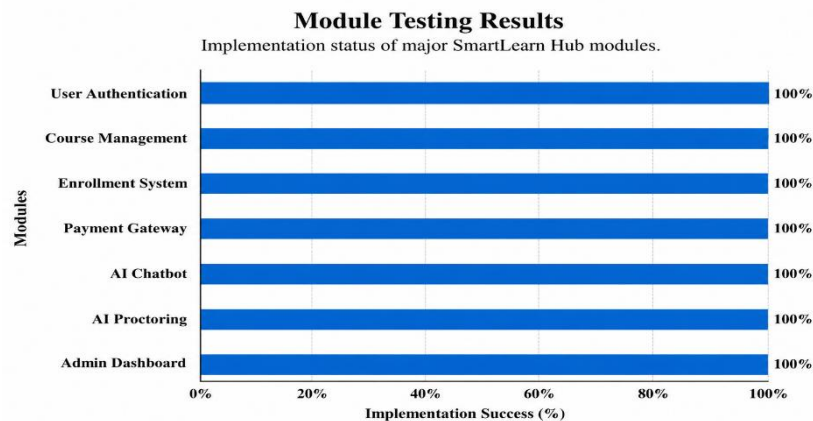
4.7 Administration Module

The Administration module facilitates operations and system management at the platform level. Through a secure dashboard on the platform, administrators have the ability to take actions on users, courses, enrollments, payments, reviews, and the overall platform settings. In addition, the module allows you to track bot activity, test reports, and system health. With the administration module, efficient operation and management of the learning platform is assured through holistic control and management of the work involved.

5. RESULTS AND DISCUSSION

5.1 System Functionality Evaluation

We conducted Functionality testing of the developed System's major modules, including authentication, course management, enrolment, payment processing, AI chat interaction and online proctoring. Testing effectiveness ensured that all modules worked correctly communicating and operating correctly within the MERN based solution. Users can register for their courses, have access to learning materials, take assessments, and perform all other course activities without any significant operational problems.



5.2 AI Proctoring Performance

The AI proctoring module was tested using Python, OpenCV and YOLOv8 for object detection. During testing, the system was able to successfully monitor an examination session and detected predefined suspicious behaviours e.g. presence of more than one person and detection of bad objects. The capability of monitoring in real-time helped increase security for examinations and reduced reliance on manual supervision.

Detection Type	Detection Status
Face Detection	Successful
Multiple Person Detection	Successful
Mobile Phone Detection	Successful
Webcam Monitoring	Successful
Activity Logging	Successful

5.3 User Experience Evaluation

Using React.js along with Framer Motion provided an easily navigable and interactive interface for users. Users were able to transition seamlessly between pages and could access all educational assets quickly, as well as use all platform functions with no visible lag time. The responsive nature of the layouts made them compatible across all types of devices (both desktop and mobile), thus enhancing the overall user's ability to use the platform.

Key Observations:

- ✓ Improved navigation experience
- ✓ Responsive user interface across devices
- ✓ Smooth page transitions and animations
- ✓ Faster access to learning resources
- ✓ Better user engagement and interaction

5.4 AI Chatbot Evaluation

The testing was done on multiple different scenarios for the Grok-API integrated chatbot. The chatbot successfully answered a range of common questions for academic and platform related requests, and provided assistance related to course navigation, enrollment, and learning support to users. Implementation of the Grok API was used to improve accessibility to those users by reducing reliance on human resources for assistance in the learning environment.



Feature	Status
Query Handling	Successful
Real-Time Response	Successful
User Assistance	Successful
Course Guidance	Successful
Learning Support	Successful

5.5 Discussion

The apparent success demonstrated by the implementation of SmartLearn Hub indicates that it meets all requirements for a fully-featured digital learning platform through integration of multiple services; learning management, secure authentication, payment processing, AI-assisted capabilities, and intelligent monitoring of online exams into a single coherent system. These were accomplished using MERN stack technology which allows for scalability and efficient operation. In addition, integration of AI-based components results in higher user engagement and improved assessment security.

The chatbot provides users with instant access to help resources, while the proctoring module enhances online exam credibility (i.e., builds trust). Overall, the evaluation suggests these factors together enable modern digital learners to benefit from a secure, intelligent, and user-friendly environment.

6. CHALLENGES AND LIMITATIONS

6.1 AI Proctoring Accuracy

- ✓ The AI-based proctoring system relies on webcam quality and lighting conditions for accurate monitoring.
- ✓ Detection performance may vary depending on camera resolution, internet connectivity, and user environment.
- ✓ Certain suspicious activities may require further model training to improve detection accuracy.

6.2 Internet Dependency

- ✓ The platform requires a stable internet connection for accessing courses, examinations, AI chatbot services, and payment processing.
- ✓ Network interruptions may affect the user learning experience and examination activities.

6.3 Third-Party Service Dependency

- ✓ The system depends on external services such as Clerk Authentication, Stripe Payment Gateway, and Grok API.
- ✓ Service interruptions or API changes from third-party providers may impact system functionality.

6.4 Scalability Challenges

- ✓ As the number of users and courses increases, server resources and database management requirements may also grow.
- ✓ Large-scale deployment may require cloud infrastructure optimization and load-balancing mechanisms.

7. FUTURE WORK

The SmartLearn Hub platform provides a strong foundation for modern digital learning; however, several advanced features can be incorporated in future versions to further improve functionality, scalability, and user experience.

7.1 Advanced AI Personalization

- ✓ AI-based recommendation systems can be implemented to suggest courses based on user interests, learning history, and performance.
- ✓ Personalized learning paths can help students achieve better learning outcomes through adaptive content delivery.
- ✓ Machine learning algorithms can be utilized to analyze learning behavior and provide customized recommendations.



7.2 Mobile Application Development

- ✓ Dedicated Android and iOS applications can be developed to improve accessibility and learning flexibility.
- ✓ Mobile applications can provide offline learning support and push notifications for course updates.
- ✓ Cross-platform development frameworks can ensure consistent user experiences across devices.

7.3 Enhanced AI Proctoring

- ✓ Future versions can incorporate facial recognition and advanced behavior analysis techniques.
- ✓ Voice monitoring and eye-tracking technologies can further strengthen examination security.
- ✓ Continuous improvement of AI models can increase the accuracy of suspicious activity detection.

7.5 Multi-Language Support

- ✓ The platform can be extended to support multiple regional and international languages.
- ✓ Language localization can improve accessibility for learners from diverse backgrounds.
- ✓ Multilingual content delivery can expand the platform's global reach.

8. CONCLUSION

The SmartLearn Hub has demonstrated that the use of cutting-edge web-based technologies in conjunction with Artificial Intelligence goes a long way toward improving the efficiency of digital classrooms. The platform integrates all functions of a single solution including learning management, secure login, online payments, AI-based examination monitoring, and intelligent chatbot support.

Key takeaways include:

- ✓ **Efficient Learning Management:** The platform enables seamless course creation, enrollment, content delivery, and progress tracking, improving the overall learning experience for both students and educators.
- ✓ **Enhanced Security and Reliability:** Clerk Authentication and Stripe Payment Gateway provide secure user access and transaction management, ensuring data protection and reliable system operation.
- ✓ **AI-Powered Innovation:** The integration of the Grok AI Chatbot and YOLOv8-based online proctoring system improves user support, examination integrity, and platform intelligence through automation and real-time monitoring.

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