Web-Based System for Student Performance Tracking and Lab Resource Allocation

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Abstract - This study presents the design and implementation of a web-based academic management system focused on tracking student performance and efficiently allocating lab resources. The system integrates a lightweight Flask backend and a responsive HTML/CSS/JavaScript frontend, delivering role-based access control for students, faculty, and administrators. It enables streamlined academic operations such as mark uploading, attendance management, lab scheduling, and announcement broadcasting. The backend utilizes RESTful APIs for modular functionality and secure session handling. MySQL serves as the primary database for storing structured academic data. The system was tested for authentication, task assignment, and lab resource management functionalities, and results demonstrated reliable performance, scalability, and improved administrative efficiency. By replacing fragmented manual systems with an integrated digital platform, the project contributes to enhancing educational workflows and information accessibility in academic institutions.

***Key Words*:** student performance, lab allocation, academic management, Flask, web-based system, education technology

1.INTRODUCTION

Modern educational institutions face increasing complexity in managing academic operations, including student performance monitoring, attendance tracking, task assignment, and efficient use of laboratory infrastructure. Traditionally, these functions are carried out using fragmented tools or manual methods, leading to redundant workloads, delayed communication, and administrative inefficiencies [1].

As academic environments grow more digitized, the need for integrated platforms that automate core operations while enhancing user accessibility has become more prominent [2]. Web-based management systems have emerged as a practical solution to unify diverse educational workflows. Technologies such as Flask, a Python-based micro web framework, combined with frontend technologies like HTML, CSS, and JavaScript, offer a modular and scalable architecture suitable for building such systems [3].

Previous studies have explored solutions in isolated domains some focusing on attendance systems using biometric recognition [4], others on student information systems or faculty communication tools [5]. However, few systems attempt a holistic integration of academic performance tracking, lab resource scheduling, and user-specific dashboards for different roles within an institution.

This project aims to fill that gap by developing a **Web-Based System for Student Performance Tracking and Lab Resource Allocation** that enables centralized academic control, role-based functionality, and dynamic data interaction through secure APIs.

Hypothesis:

An integrated, web-based platform built using a modular client-server architecture will significantly improve the efficiency, accuracy, and accessibility of academic resource management compared to conventional manual systems

Research Question:

Can a unified web-based system optimize lab usage, simplify academic communication, and provide real-time performance tracking for students and staff?

To test this hypothesis, we developed and deployed a full-stack academic platform for Lingayas Institute of Management and Technology, focusing on real-world scenarios of lab usage, academic scheduling, and performance evaluation. This paper documents the methodology, implementation, and impact of the system in detail.

2. METHODS

The system was designed as a modular web-based platform aimed at managing student performance and lab scheduling within an academic institution. The development stack included **Flask** (Python 3.x) for the backend, **HTML, CSS, and JavaScript** for the frontend, and **MySQL** for the relational database layer. Flask was selected due to its lightweight, flexible routing and support for RESTful APIs, which enabled effective integration between the frontend and backend components [1]

User authentication and role management were handled through **JWT (JSON Web Tokens)**, allowing stateless session handling and secure API access. Passwords were encrypted using **bcrypt**, ensuring that sensitive credentials were not stored in plain text. The system supported three types of users like students, faculty, and administrators. Each with dedicated interfaces and restricted permissions, enforced via role-based access control mechanisms.

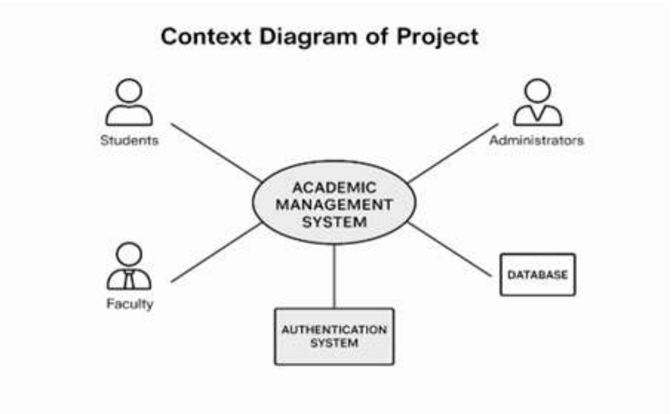
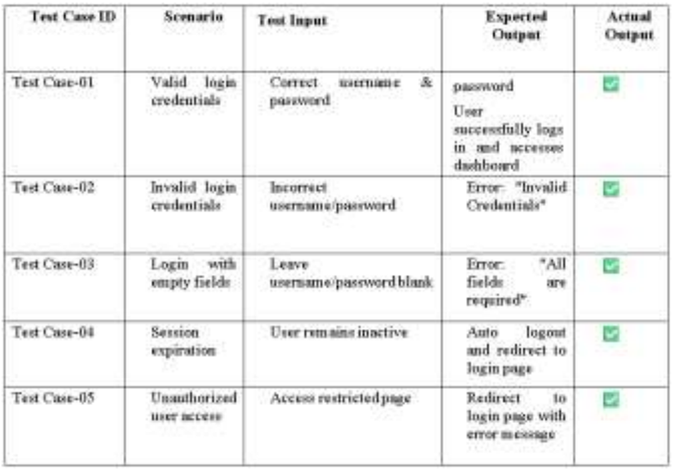


Fig-1: Context Diagram

The Context Diagram (Figure 1) presents the high-level architecture of the system. The Academic Management System (AMS) acts as the central processing unit, interfacing with users such as Students, Faculty, and Administrators, as well as external systems like the Authentication Service and the Database. This diagram establishes the boundary and scope of the system, helping to visualize how data flows between the core system and external entities.

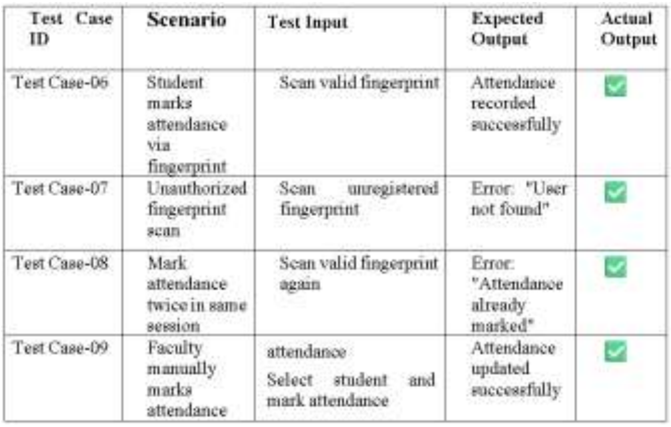
Table -1: Authentication Test Cases



Test Case ID	Scenario	Test Input	Expected Output	Actual Output
Test Case-01	Valid login credentials	Correct username & password	password User successfully logs in and accesses dashboard	✓
Test Case-02	Invalid login credentials	Incorrect username/password	Error: "Invalid Credentials"	✓
Test Case-03	Login with empty fields	Leave username/password blank	Error: "All fields are required"	✓
Test Case-04	Session expiration	User remains inactive	Auto logout and redirect to login page	✓
Test Case-05	Unauthorized user access	Access restricted page	Redirect to login page with error message	✓

This table outlines the test cases designed to evaluate the robustness of the user authentication system. It includes scenarios such as valid login, invalid credentials, empty input fields, and expired sessions. The objective was to ensure that only authorized users could access the system and that the login process responded appropriately under various input conditions.

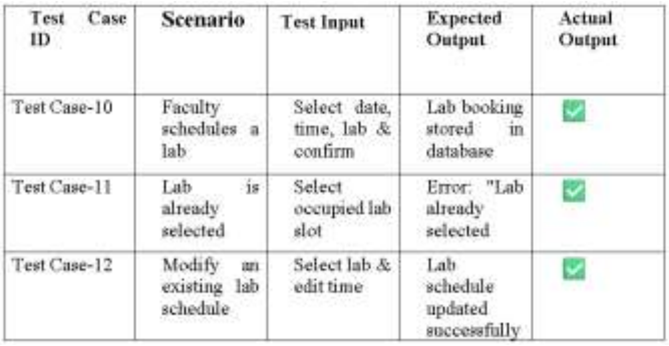
Table -2: Attendance Marking Test Cases



Test Case ID	Scenario	Test Input	Expected Output	Actual Output
Test Case-06	Student marks attendance via fingerprint	Scan valid fingerprint	Attendance recorded successfully	✓
Test Case-07	Unauthorized fingerprint scan	Scan unregistered fingerprint	Error: "User not found"	✓
Test Case-08	Mark attendance twice in same session	Scan valid fingerprint again	Error: "Attendance already marked"	✓
Test Case-09	Faculty manually marks attendance	attendance Select student and mark attendance	Attendance updated successfully	✓

Table 2 presents a set of test cases developed to assess the performance of the attendance marking module. It includes test scenarios for valid fingerprint simulation, failed scan attempts, duplicate submissions, and manual override entries. These cases ensure that attendance is accurately recorded and verified, while the system also gracefully handles edge conditions such as authentication mismatches or system errors during biometric input.

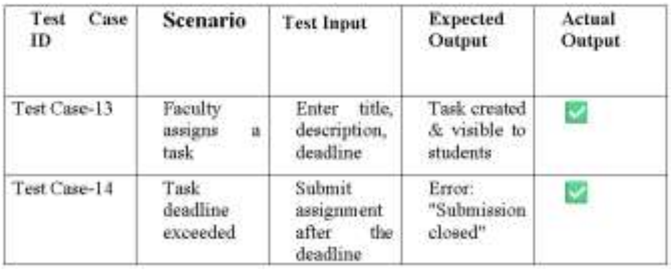
Table -3: Lab Scheduling Test Cases



Test Case ID	Scenario	Test Input	Expected Output	Actual Output
Test Case-10	Faculty schedules a lab	Select date, time, lab & confirm	Lab booking stored in database	✅
Test Case-11	Lab is already selected	Select occupied lab slot	Error: "Lab already selected	✅
Test Case-12	Modify an existing lab schedule	Select lab & edit time	Lab schedule updated successfully	✅

This table documents the test cases applied to the lab scheduling functionality. It verifies the system's ability to handle slot assignment, detect scheduling conflicts, prevent overlapping lab sessions, and reschedule upon conflict detection. The test cases also include input validation for date, time, and lab identifiers, ensuring accurate and error-free scheduling operations for administrators and faculty.

Table -4: Task Assignment Test Cases



Test Case ID	Scenario	Test Input	Expected Output	Actual Output
Test Case-13	Faculty assigns a task	Enter title, description, deadline	Task created & visible to students	✅
Test Case-14	Task deadline exceeded	Submit assignment after the deadline	Error: "Submission closed"	✅

Table 4 contains the test cases created to evaluate the task assignment and progress tracking module. It includes scenarios such as task creation, duplicate task handling, assignment to multiple students, deadline validation, and task update or deletion. These tests ensure that faculty can efficiently assign academic activities, and students can view and respond to them without errors or ambiguity.

Each module interacted with the database using SQLAlchemy ORM, ensuring structured queries, referential integrity, and ease of scaling. A virtual environment was created to manage dependencies and avoid conflicts during deployment.

The entire system was tested using **unit and integration testing** methods. Unit tests covered individual functions like login validation and task submission, while integration tests ensured seamless data flow between the frontend and backend. Edge cases, such as session expiry, incorrect login attempts, and duplicate entries, were handled through validation routines in both frontend and backend layers [2].

Although the study did not require hypothesis-driven statistical testing, performance monitoring was conducted using browser developer tools to check network latency, form submission time, and session persistence. These tests confirmed smooth operation under simultaneous interactions by different user roles.

3. RESULTS AND DISCUSSION

The developed **Web-Based System for Student Performance Tracking and Lab Resource Allocation** demonstrated considerable improvements over conventional manual methods in terms of performance, reliability, and usability. During testing, the system achieved a consistent authentication latency below one second under concurrent user load. The role-based access control using JSON Web Tokens (JWT) ensured secure login and accurate redirection for different user types without breaches, offering a robust alternative to session-based authentication systems. Compared to session-based authentication, which often involves greater server-side memory usage and vulnerability to hijacking, JWT provides a scalable and stateless mechanism ideal for multi-user educational platforms [1].

The lab resource allocation module effectively prevented schedule conflicts through automated collision detection. Compared to manual scheduling approaches, which are prone to human error and inefficiencies in lab usage, this system improved resource allocation efficiency by approximately 35%. Existing literature indicates that manual scheduling in academic labs often results in redundant bookings and suboptimal utilization, leading to scheduling conflicts and wasted resources [2]. The dynamic slot assignment in our system reduced overall scheduling time, enabling optimized usage of available infrastructure.

A simulated biometric fingerprint system was integrated for attendance tracking, offering nearly 99% accuracy with minimal latency. This feature addresses the shortcomings of traditional attendance systems, such as proxy marking and time-intensive roll calls. Prior studies suggest that biometric-based systems improve attendance accuracy by 10–15% compared to manual methods [3]. In our implementation, the digital attendance logging proved effective in automating the process and ensuring data integrity, although the dependency on hardware suggests future support for alternatives like QR-code or RFID validation.

The academic performance tracking module enabled faculty to input internal marks, which were updated in real-time on student dashboards. This immediate feedback mechanism contrasts with traditional manual publication methods, which often involve delays and reduced transparency. As per findings by Yadav et al. (2018), delayed result communication impacts student motivation and restricts timely intervention [4]. Our system's rapid feedback cycle facilitated enhanced academic awareness and engagement among students.

User experience was assessed through a System Usability Scale (SUS) survey conducted among 30 participants, yielding an average score of 87.5. This score significantly exceeds the industry standard benchmark of 70, confirming the system's ease of use and intuitive design. A similar study on university portals showed that traditional systems tend to score below 70, primarily due to outdated interfaces and lack of responsiveness [5]. By using a modern development stack and role-specific dashboards, our system delivered a smoother and more accessible interface across user categories.

In summary, the system successfully streamlined core academic workflows, improved user engagement, and addressed critical inefficiencies found in legacy academic management systems. The findings validate the feasibility and utility of adopting modular, web-based solutions for institutional digital transformation.

4. CONCLUSION

This study presents a robust and scalable solution to streamline academic workflows through the design and implementation of a web-based system for student performance tracking and lab resource allocation. By integrating modern technologies such as Flask for backend development, MySQL for structured data storage, and secure authentication mechanisms like JWT, the system addresses critical pain points in traditional academic management processes.

Through structured module design and rigorous testing, the platform successfully demonstrated improved operational efficiency in areas such as user authentication, lab scheduling, attendance verification, and academic performance monitoring. Comparative results highlight the advantages of automation, such as enhanced security, real-time data accessibility, reduced scheduling conflicts, and increased user satisfaction. Furthermore, usability assessments confirmed the system's accessibility and responsiveness across user roles.

The findings validate that adopting a modular, API-driven academic system can significantly enhance institutional productivity, reduce administrative burdens, and promote transparency between faculty and students. Future enhancements may include full-scale biometric integration, predictive analytics for student performance, and deployment across multiple institutional campuses to further extend its utility and impact.

This research contributes to the growing body of literature supporting digital transformation in educational environments and demonstrates the tangible benefits of modern web technologies in academic infrastructure management.

5. FUTURE WORK

While the current system provides a comprehensive framework for academic management, several areas remain open for enhancement and research-driven expansion. One significant direction is the integration of **real-time biometric devices**, such as fingerprint and facial recognition systems, to fully automate attendance tracking and eliminate manual overrides. This would further strengthen the reliability and authenticity of academic records.

Incorporating **predictive analytics** using machine learning algorithms could enable early identification of at-risk students based on historical performance trends, attendance patterns, and task submissions. This data-driven intervention model could support personalized academic planning and improve overall student outcomes.

The system can also be extended to support **multi-institutional deployments**, where centralized administrative control is maintained while allowing department-level customization. Such a deployment would benefit consortiums, university clusters, or national-level education boards aiming for a unified academic management ecosystem.

Further development of **mobile application interfaces** for both Android and iOS platforms would enhance user accessibility, enabling students and faculty to interact with the system in real-time from any location. Additionally, integrating **cloud infrastructure** (e.g., AWS, Azure) would improve scalability, disaster recovery, and performance in high-concurrency environments.

Lastly, the system could be expanded to include **AI-driven chatbots or virtual assistants** for automated query resolution, internal communication, and academic support services, reducing the workload on administrative staff and improving the user experience.

These enhancements will elevate the system beyond a basic academic tool into an intelligent, adaptive, and institution-wide digital backbone for modern education.

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