International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 13 Issue: 04 | Apr 2026 www.irjet.net p-ISSN: 2395-0072

LibAccess : A Smart Barcode-Based Library Entry Monitoring System

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Abstract - *Manual library entry in colleges is time-consuming, prone to errors, and difficult to monitor accurately. LibAccess is a smart, barcode-based library entry system that automates student and teacher entries using barcode ID cards. The system consists of a PC or laptop application with a ReactJS frontend and FastAPI backend, a barcode scanner, and an SQL database to validate and store all data. When a user scans their card, the system checks the timetable and academic calendar, logs the entry, and displays real-time results such as access granted or class-skip alerts. If a student enters the library during scheduled class hours, an automatic email notification is sent to the teacher concerned. Administrators can access a dashboard for managing users, timetables, and academic events, as well as view logs and generate reports in CSV, Excel, or PDF formats. LibAccess ensures accurate, real-time monitoring of library visits, reduces manual work, prevents class skipping, and improves administrative efficiency in educational institutions.*

Key Words: Library Management, Barcode ID, Real-Time Monitoring, Automated Attendance, FastAPI, ReactJS, SQL Database, Class-Skip Alert, Student Tracking, Admin Dashboard.

1.INTRODUCTION

In many educational institutions, library entry and attendance tracking are still managed using manual or partially automated methods, which are time-consuming, prone to errors, and difficult to monitor accurately. Maintaining physical registers makes it challenging for administrators to generate timely reports and analyze library usage effectively.

To address these limitations, there is a growing need for automated and digitally monitored library entry systems that can provide real-time validation and accurate record keeping. Barcode-based identification offers a cost-effective and reliable approach for automating entry logging without requiring specialized hardware.

This paper presents LibAccess, a smart barcode-based library entry monitoring system designed to automate student and faculty entries while validating access against academic timetables and calendars. The system supports real-time monitoring, automated logging, and administrative oversight, making it suitable for deployment in educational institutions. Its low-cost architecture and ease of deployment enable colleges and universities to improve library management and discipline efficiently.

2. LITERATURE REVIEW

Library entry and attendance monitoring systems have been studied extensively in academic research, with solutions ranging from simple automation to intelligent identification techniques. Historically, earlier systems used manual registers for entry tracking, which were simple but prone to human errors and lacked automation. Later, barcode-based systems were introduced to automate attendance tracking and reduce manual effort. These systems improved efficiency but were often limited in features such as real-time alerts and administrative analytics.

Other research has explored the use of radio-frequency identification (RFID) technology to manage entries in educational settings. RFID systems can automate user identification and record keeping efficiently; however, they require specialized hardware, making them costly and difficult to maintain. Biometric approaches, including fingerprint and face recognition, have also been applied to attendance and access control. These methods provide higher security by uniquely identifying individuals, but they introduce challenges such as higher equipment costs, hygiene concerns, and limited scalability in high-traffic areas like libraries. More recent work in this domain has focused on web-based systems integrated with centralized databases, allowing administrators to monitor attendance records online and generate reports. While these systems improve accessibility and convenience, they typically rely on manual schedule checks and lack context-aware validation based on academic timetables. Some hybrid systems combine identification technologies with analytical dashboards to provide usage insights. However, these systems generally emphasize historical analysis rather than real-time decision-making, making them less effective at detecting policy violations such as class skipping at the time of entry.

Overall, existing solutions often address specific problems such as automation or access control but lack a comprehensive approach that integrates identification, real-time validation against academic schedules, alert notifications, and efficient analytics. The proposed **LibAccess system** is designed to fill this gap by offering a lightweight, barcode-based monitoring solution that performs real-time entry validation, detects deviations from expected attendance behavior, and supports administrative oversight through logs and dashboards.

3. PROBLEM STATEMENT

Many educational institutions rely on manual or partially automated methods for library entry and attendance monitoring, which are time-consuming, error-prone, and lack real-time visibility. Existing digital systems do not validate library access against academic timetables or detect class-skipping behavior at the time of entry, while advanced solutions such as RFID and biometric systems increase cost and complexity. Therefore, there is a need for a low-cost, real-time library entry monitoring system that ensures accurate validation, automated alerts, and efficient administrative oversight.

4. PROPOSED SYSTEM

The proposed LibAccess system is a smart, barcode-based library entry monitoring solution designed to automate and digitize library access in educational institutions. The system replaces manual entry registers by validating user access in real time using barcode ID cards issued to students and teachers.

LibAccess performs timetable-aware validation by checking scanned entries against academic schedules and calendar data to determine access permissions. All entry events are logged automatically, and class-skipping behavior is detected instantly. In such cases, automated email notifications are sent to the faculty concerned members. An administrative dashboard enables centralized management of users, timetables, and reports, ensuring efficient monitoring and improved accountability with minimal hardware requirements.

5. SYSTEM ARCHITECTURE

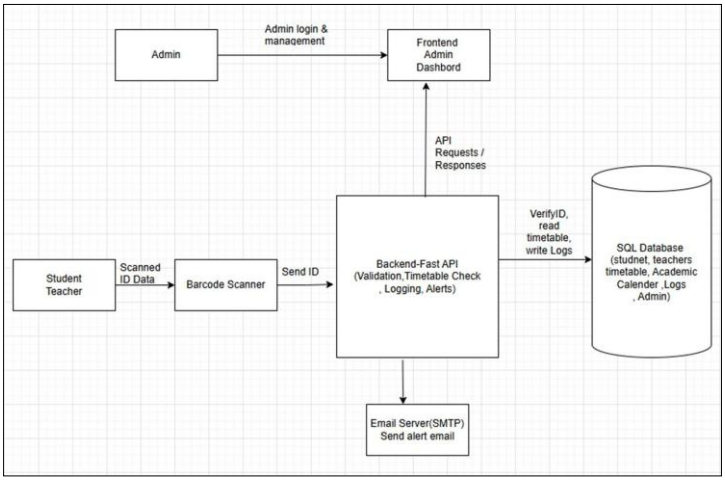

Fig -1 : System Architecture of the Proposed LibAccess System

Figure 1 illustrates the overall system architecture of the proposed LibAccess library entry monitoring system. The architecture follows a modular design that separates user interaction, backend processing, data storage, and notification services to ensure scalability and efficient operation.

Students and teachers interact with the system by scanning their barcode ID cards using a barcode scanner. The scanned ID data is sent to the backend application developed using FastAPI, which acts as the central decision-making component. The backend validates the user ID by verifying student or teacher records stored in the SQL database and checks the academic timetable and calendar to determine access permissions.

All scan events are logged in the database for monitoring and reporting purposes. If a student accesses the library during scheduled class hours, the backend triggers an automated alert through the SMTP email server to notify the concerned faculty member. Administrative users interact with the system through a web-based frontend dashboard, which communicates with the backend via API requests to manage users, timetables, and view logs and analytical reports. This architecture enables realtime monitoring, automated validation, and centralized administrative control while maintaining a low-cost deployment suitable for educational institutions.

6. METHODOLOGY

This section describes the methodology adopted for implementing the LibAccess system, focusing on real-time barcode-based validation, timetable-aware decision making, and automated monitoring. The system is

developed using a combination of barcode scanning hardware and a software-based architecture consisting of a ReactJS frontend, FastAPI backend, and an SQL database. The methodology focuses on processing real-time user inputs instead of relying on historical attendance records. User identification is performed through barcode ID cards, and system decisions are made by validating scanned data against stored academic schedules and calendar information. The complete workflow ensures accurate monitoring, automated alerts, and secure data management with minimal manual intervention.

6.1 Hardware and Input Collection

The primary input to the LibAccess system is obtained through barcode ID cards issued to students and teachers. A wired or wireless barcode scanner connected to a PC or laptop is used to capture the barcode data. The scanner works as a keyboard input device and transfers the scanned ID directly to the application. This method ensures fast, contactless, and error-free data collection. The collected ID serves as the basis for further validation and decision making within the system.

6.2 Data Processing and Validation

Once the barcode ID is received, the frontend application forwards the data to the backend server. The backend processes the scanned ID by verifying its existence in the Students or Teachers database tables. It then checks the timetable and academic calendar to determine whether the scan occurs during a lecture, free time, holiday, or examination period. This validation ensures that system decisions are rule-based and context-aware. Invalid or unregistered IDs are immediately rejected by the system.

6.3 Backend Validation and Timetable-Based Decision Making

The backend system plays a crucial role in validating scanned barcode data and making logical decisions. When a barcode is scanned, the backend first checks whether the ID exists in the database. If the ID is not found, the system immediately marks the entry as invalid and prevents further processing. Once the user is verified, the backend compares the scan time with the academic timetable stored in the system. This comparison helps determine whether the student is scanning during a free period or during scheduled lecture hours. The decision is made using predefined rules to ensure consistency. This timetable-based logic helps in identifying class-skipping behavior automatically. If a student enters the library during class time, the system records the event as a violation. This significantly reduces the need for manual monitoring by staff members.

The backend ensures that teachers are not restricted by timetable rules. Faculty members are allowed to enter the library at any time. This role-based decision making makes the system fair, accurate, and suitable for real-world academic environments.

6.4 Logging and Notification Mechanism

Every entry scan in the LibAccess system is automatically recorded in the database as a log entry. The log contains important details such as the user ID, role (student or teacher), scan time, entry status, and any relevant remarks. This ensures that there is a permanent record of all library access events, which can be retrieved at any time for monitoring, auditing, or analysis. Logging is an essential part of the system because it creates accountability and provides a clear timeline of user activity.

In addition to recording scans, the system uses the log data to detect unusual or rule-breaking behavior. For example, if a student scans their ID during a scheduled lecture or practical session, the backend identifies this as a potential class-skipping event. This event is flagged in the logs with a specific status, which differentiates it from normal library visits. By structuring logs in this way, administrators can quickly review incidents and track patterns of behavior over time. The notification mechanism works alongside the logging system to ensure that relevant parties are informed immediately. When a student enters the library during a scheduled class, the system automatically sends an email to the subject teacher concerned. The email contains the student's name, ID, department, subject, and the exact time of entry. This allows teachers to be aware of potential class-skipping without needing to manually check records or supervise the library physically.

Furthermore, the logging and notification system supports reporting and analytics. Logs can be used to generate reports filtered by department, date, time, or type of event. These reports help administrators understand library usage trends, peak hours, and student behavior. By

combining real-time notifications with historical log analysis, LibAccess provides a comprehensive monitoring and management tool that enhances discipline, accountability, and operational efficiency.

6.5 System Evaluation

The LibAccess system is evaluated based on functional accuracy, response time, and reliability of alerts. Since the system operates on real-time rule-based validation rather than prediction models, traditional machine learning evaluation metrics are not applied. Instead, system performance is assessed by verifying correct entry detection, accurate alert generation, and consistency of log records. The evaluation confirms that the system efficiently automates library entry management while reducing manual effort and improving discipline monitoring.

7. ALGORITHM

LibAccess: A Smart Barcode-Based Library Entry Monitoring System

1. Start
2. Initialize the LibAccess system on the PC/Laptop.
3. Wait for a user (Student/Teacher) to scan the barcode ID card.
4. Capture the scanned ID from the barcode scanner.
5. Validate the scanned ID with the database.
    - If the ID is invalid, display "Access Denied" and log the attempt.
    - If the ID is valid, proceed to the next step.
6. Identify the role of the user (Student or Teacher).
7. If the user is a Teacher:
    - Grant access.
    - Record entry details (ID, role, date, time) in the log table.
    - Display "Access Granted".
8. If the user is a Student:
    - Check the academic calendar.
        i. If it is a holiday or examination day, grant access and log the entry.
        ii. Otherwise, proceed to timetable validation.
9. Verify the student's timetable for the current time slot.
    - If no lecture is scheduled, grant access and log the entry.
    - If a lecture is scheduled, proceed to class-skipping detection.
10. Detect class-skipping conditions:
    - Grant access.
    - Send an automatic email notification to the concerned subject teacher.
    - Log the entry with the remark "Class Skipping Detected".
11. Store all entry details in the database for reporting and analytics.
12. Display appropriate status messages ("Access Granted" / "Alert Sent") on the screen.
13. Return to waiting state for the next scan.

8. HARDWARE REQUIREMENTS

The proposed LibAccess: A Smart Barcode-Based Library Entry Monitoring System is designed to operate using minimal and cost-effective hardware, making it suitable for deployment in educational institutions without requiring specialized infrastructure. The system relies on commonly available computing devices and standard barcode scanning equipment to ensure ease of adoption and low maintenance cost.

The hardware requirements for implementing the system are as follows:

- Processor: Intel Core i3 or higher.
- RAM: Minimum 4 GB.
- Barcode Scanner: Wired or wireless (USB/Bluetooth) 1D/2D barcode scanner.
- PC/Laptop: Used to run the LibAccess application and receive barcode scanner input.
- Internet Connection: Required for database synchronization and automated email notifications.

The barcode scanner functions as a keyboard input device, allowing seamless integration with the system without requiring additional drivers or specialized hardware. This hardware setup ensures reliable real-time operation while maintaining affordability and simplicity.

8.1 Hardware Prototype for Automated Door Control

To improve the LibAccess system, a small hardware prototype has been created. This prototype shows how the

system can control a real library door, not just track data digitally. It connects the barcode scanning process with a physical door mechanism.

In this setup, when a user scans their ID card, the system checks the barcode. If the ID is valid, the door opens automatically using a motor. This helps demonstrate how the system can be used in real-world situations for secure entry.

The prototype uses a barcode scanner connected to a microcontroller, which controls a servo motor. The servo motor acts like a door by opening and closing based on the scan result.

Components used in this prototype:

- Barcode Scanner (1D/2D): Used to scan ID cards of students or teachers
- ESP32 Microcontroller: Works as the main controller that processes the data and controls the system
- Servo Motor: Used to simulate the opening and closing of the door
- Breadboard: Helps in connecting all components without soldering
- Jumper Wires: Used to make connections between components
- USB/Data Cable: Provides power and is used to program the ESP32

8.1.1 Working of Prototype System

The hardware prototype works by connecting the barcode scanner, main system, and ESP32 microcontroller in real time. When a user scans their ID card, the system checks whether the ID is valid or not. If the access is approved, a signal is sent to the ESP32 through Wi-Fi or serial communication. The ESP32 then controls the servo motor, which opens the door. After a few seconds, the motor moves back and closes the door. If the ID is not valid, no signal is sent, and the door stays closed. This setup shows how an automatic door system can be built using simple and low-cost hardware.

9. SOFTWARE USED

The LibAccess system is implemented using modern, open-source software technologies to ensure scalability, reliability, and ease of maintenance. The software components are selected to support real-time processing, secure data handling, and smooth user interaction.

The software tools and technologies used in the system are listed below:

- Operating System: Windows 10 / Windows 11 / Linux
- Frontend Technology: ReactJS (HTML, CSS, JavaScript)
- Backend Framework: FastAPI (Python)
- Database: MySQL
- Development Tools: Visual Studio Code, Postman
- Email Service: SMTP-based email service for alert notifications
- Application Type: Web-based application

The use of FastAPI enables efficient request handling and fast backend processing, while ReactJS provides a responsive and user-friendly interface. The integration of these technologies supports real-time validation, automated alerts, and reliable system performance.

10. SYSTEM IMPLEMENTATION

This section describes the practical implementation of the proposed LibAccess system. The system is implemented as a webbased application integrated with barcode scanning hardware to automate library entry monitoring. The frontend interface is developed using ReactJS, while the backend services are implemented using FastAPI. A relational SQL database is used to store user information, timetables, academic calendar data, and entry logs.

The barcode scanner functions as an input device that captures user ID data and forwards it to the application for validation. The backend processes each scan in real time by verifying user credentials and evaluating access permissions based on academic schedules. All access events are recorded automatically, and alert notifications are generated when class-skipping behavior is detected.

Administrative users interact with the system through a dashboard that enables management of users, timetables, and academic events, as well as monitoring of access logs and report generation. The following figures illustrate key interfaces and outputs of the implemented system.

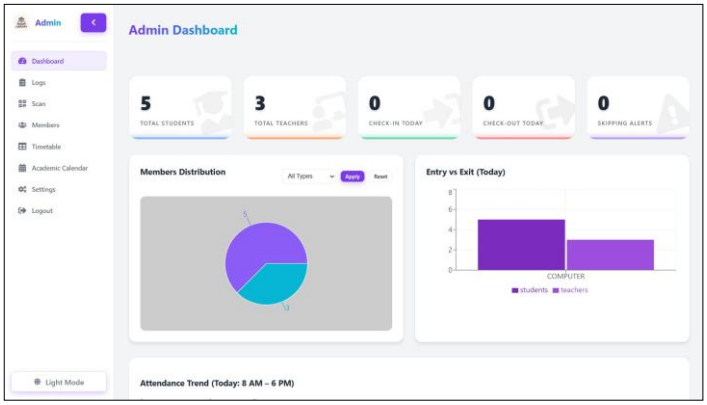

Fig -2 : Dashboard Page

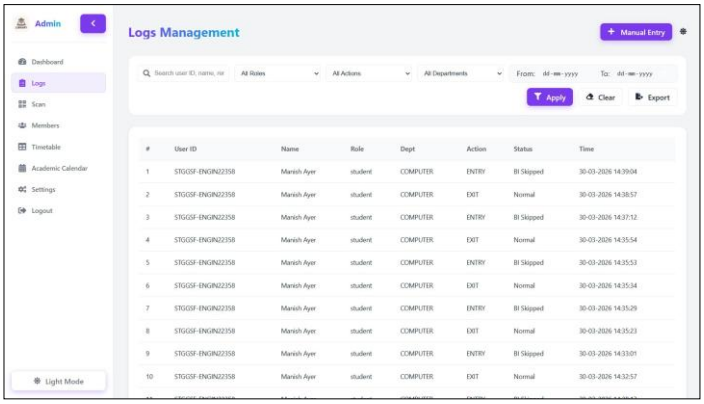

Fig-3 : Logs Page

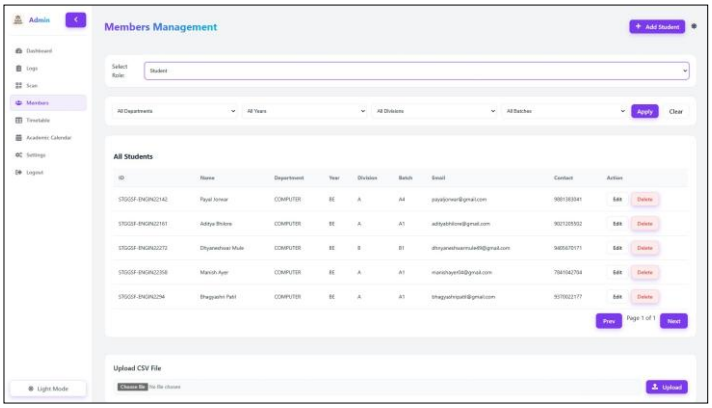

Fig -4 : Members Page

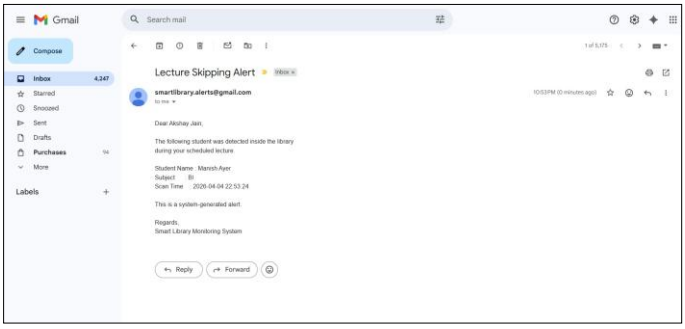

Fig -5 : Skipping Lecture Mai

11. RESULTS AND PERFORMANCE ANALYSIS

This section presents the results obtained from implementing the proposed LibAccess system and evaluates its performance based on functional accuracy, response time, reliability, and effectiveness in detecting class-skipping behavior. Since the system operates using real-time, rule-based validation rather than predictive or machine learning models, the evaluation focuses on correctness of access decisions and system responsiveness under normal operating conditions.

11.1 Functional Accuracy

The LibAccess system was tested using multiple valid and invalid barcode ID cards for both students and teachers. During testing, the system accurately validated registered users and rejected unregistered or invalid IDs. Role identification between students and teachers was correctly performed in all test cases. Access decisions were consistently made based on timetable and academic calendar data, ensuring correct classification of normal entries and class-hour violations. These results confirm the functional accuracy of the proposed system.

11.2 Response Time Analysis

The response time of the system was measured as the duration between scanning a barcode and displaying the access decision on the screen. The use of a lightweight FastAPI backend and optimized database queries resulted in minimal processing delay. The average response time was observed to be less than one second, which is suitable for real-time library entry scenarios and ensures smooth operation during peak usage hours.

11.3 Class-Skipping Detection Performance

Class-skipping detection is a key feature of the LibAccess system. During evaluation, all instances where students attempted to access the library during scheduled lecture or practical sessions were correctly identified. In such cases, automated email notifications were successfully sent to the respective subject teachers in real time. This demonstrates the effectiveness of the timetable-based validation mechanism in detecting and reporting class-skipping behavior without manual intervention.

11.4 Reliability and Logging

All scan events, including valid entries, invalid attempts, and alert-triggered entries, were reliably recorded in the system database. Each log entry contained essential information such as user ID, role, scan time, entry status, and remarks. The availability of complete and structured log data supports report generation, monitoring, and future analytical use. No data loss or inconsistent logging behavior was observed during system operation.

11.5 Comparison with Manual Library Entry System

The performance of the proposed system was compared with the traditional manual library entry method, as shown in Table 1.

Table -1: Comparison of Manual System and LibAccess System

Parameter	Manual System	LibAccess System
Entry Recording	Manual Registers	Automated Digital Logs
Error Probability	High	Negligible
Real-Time Monitoring	Not Available	Available
Class-Skip Detection	Not Possible	Automatic
Report Generation	Time-Consuming	Instant
Administrative Effort	High	Low

The comparison highlights that LibAccess significantly improves efficiency, accuracy, and monitoring capability over manual systems.

11.6 Discussion

The results demonstrate that the proposed LibAccess system successfully automates library entry monitoring while providing real-time validation and alert generation. Its fast response time, accurate detection, and reliable logging make it suitable for deployment in educational institutions. The system achieves these benefits using low-cost hardware and a lightweight software architecture, making it a practical and scalable solution.

12. ADVANTAGES

The proposed LibAccess system offers several advantages over traditional and existing library entry monitoring approaches. By automating entry logging and validation, the system significantly reduces manual effort and minimizes human errors associated with register-based methods. The use of barcode-based identification ensures fast and reliable user authentication without requiring expensive or specialized hardware.

The system provides real-time monitoring and timetable-aware validation, enabling instant detection of class-skipping behavior and automated alert generation. Centralized logging and report generation improve administrative efficiency and support data-driven decision making. Additionally, the lightweight architecture and low hardware requirements make the system cost-effective, scalable, and easy to deploy in educational institutions of varying sizes.

13. APPLICATIONS

The LibAccess system can be effectively deployed in a variety of academic and institutional environments where controlled entry monitoring and attendance tracking are required. Major application areas include:

- College and university libraries for automated entry management
- Academic institutions for monitoring student movement during class hours
- Educational campuses requiring real-time attendance and access validation
- Libraries and study centers with restricted access policies
- Institutional facilities that require rule-based entry monitoring and reporting

These applications demonstrate the practical usefulness of the system in improving discipline, accountability, and operational efficiency.

14. CONCLUSION

This research presented LibAccess, a smart barcode-based library entry monitoring system designed to automate library access, detect class-skipping behavior, and provide real-time administrative oversight. The system integrates barcode-based identification with timetable and academic calendar validation to ensure accurate and rule-based access control.

The implemented system demonstrated high functional accuracy, fast response time, reliable logging, and effective alert generation without requiring expensive hardware or complex infrastructure. By reducing manual effort and improving monitoring capabilities, LibAccess enhances operational efficiency and accountability in educational institutions. The results indicate that the proposed solution is practical, cost-effective, and suitable for real-world deployment in academic environments.

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