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Smart College Equipment Tracking System: A QR Code-Based Web Platform for Laboratory Asset Management

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ABSTRACT

Colleges manage hundreds of laboratory components, project kits, and devices across several departments, yet most still record issue and return in paper logbooks. This leads to misplaced equipment, entry errors, overdue items, and no real-time view of where an item is.

This paper proposes the Smart College Equipment Tracking System, a web-based platform that digitises the full equipment life cycle. Each asset carries a unique QR code. A lab assistant scans the code to issue or receive the item, and the database is updated at once with the borrower, the due date, and the condition of the item. The design uses a React front end, a Node.js or Python (Django/Flask) back end with a REST API, and a MySQL or PostgreSQL database that can be hosted on a cloud platform such as AWS. Role-based access separates Admin, Staff, and Student users, and the system also provides due-date notifications, ratings and feedback, audit logs, and reports.

The system is organised into five modules: homepage, admin panel, lab assistant panel, student panel, and database. The paper presents the architecture, methodology, database design, and planned evaluation of the system.

Index Terms - QR Code, Asset Tracking, Laboratory Equipment Management, Web Application, Role-Based Access, Inventory Database, RFID

I. INTRODUCTION

Laboratory equipment, project kits, computers, and measuring devices are among the most valuable resources of an engineering college. In many institutions their issue and return is still written by hand in logbooks. This is slow and error-prone, and staff have no quick way to know which item is with which student or when it is due. Missing and damaged items are often found only during the annual stock verification.

Web technologies, relational databases, and low-cost identification methods such as QR codes make it possible to automate this work. A QR code printed on a label can be read with any smartphone or scanner, so no special hardware is needed. Research on laboratory management has mostly explored IoT and RFID based solutions [1], [2], [3], which are accurate but costly for a typical college laboratory.

1.1 Background and Motivation

This paper proposes the Smart College Equipment Tracking System, a central web platform where students, lab assistants, and administrators can see the live status of any asset. When a student borrows a component, the lab assistant scans its QR code, and the database records the borrower and the return deadline. The platform replaces paper registers with a digital record that every authorised user can check.

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1.2 Contributions

The main contributions of this work are as follows:

- A low-cost, QR code-based workflow for issuing and returning laboratory equipment.
- A role-based, modular web architecture for Admin, Staff, and Student users.
- A normalised database design that links requests, returns, and ratings so that every item can be traced.

If implemented as designed, the system can save administrative time, reduce equipment loss, and give departments reliable usage data.

1.3 Organisation of the Paper

Section II reviews the literature and Section III analyses the problems of manual equipment management. Section IV describes the methodology as five modules together with the database design and the issue and return workflow. Section V discusses the expected benefits and the evaluation plan, Section VI concludes the paper, and Section VII lists future work.

II. LITERATURE REVIEW

A. IoT-Based Instrument Management: Liu et al. described a laboratory instruments management system based on the Internet of Things. Connecting instruments to a central network gives real-time updates and replaces ledgers that depend on manual entry. However, every instrument needs network-enabled hardware, which raises the cost [1].

B. RFID-Based Equipment Logistics: Zhang and Reha studied RFID-based logistics for laboratory equipment in a university. Automatic entry and exit logs improve data integrity and keep records in step during issue and return. The study also notes problems with read stability and with scaling the tracking database across departments [2].

C. RFID Asset Localisation: Aminah et al. built a laboratory asset localisation system that uses RFID readings with a Kalman filter to estimate the room in which an item is kept. It helps to detect unauthorised movement of assets, but it focuses on location and has no borrower workflow, ratings, or reports [3].

D. User and Customer Experience: Sellier et al. reviewed how the terms user experience, customer experience, and consumer experience are used in the literature and showed that different groups of people judge a system by different criteria [4]. For an equipment platform this supports separate, role-based screens for staff and for borrowers.

E. Website Design and Engagement: Garett et al. reviewed the website design elements linked to user engagement, such as clear navigation, graphical representation, readability, and simple organisation [5]. These guidelines are useful for designing dashboards that students and staff will keep using.

A comparison of the reviewed studies is given in Table 1, arranged from the most recent study to the oldest.

Table 1. Comparative analysis of reviewed studies

Ref.	Year	Technique	Key Finding	Limitation
[3]	2022	RFID + Kalman filter localisation	Locates assets room by room	No borrower workflow
[4]	2021	Review of UX, CX, and consumer experience	User groups judge systems differently	Review only, no system
[5]	2016	Review of website design	Navigation and readability drive engagement	General web guidance
[1]	2015	IoT-based instrument network	Real-time instrument status	Hardware on every item
[2]	2014	RFID-based equipment logistics	Automatic entry and exit logs	Reader cost and stability

2.1 Research Gap

The reviewed works deal with IoT or RFID hardware, localisation, or interface design separately. None of them offers a low-cost, QR code-based solution that combines role-based web access, issue and return logging, due-date alerts, feedback, and reports for a college laboratory. The proposed system is designed to fill this gap.

III. PROBLEM ANALYSIS

The main problems of manual equipment management, and how the proposed system responds to each, are discussed below.

3.1 User Experience

A complicated interface makes users give up on a system quickly. The platform uses a simple, responsive design that works on computers and smartphones.

3.2 Trust in Records

If the actual status of an asset cannot be checked, administrators do not trust the records. Live logs, status audits, and QR verification at every issue and return address this.

3.3 Tracking and Logistics

Late or missing allocation entries frustrate staff and students. Scanning at the counter creates the record at the moment the item changes hands.

3.4 Quality Control

Without condition checks, a student may receive a faulty component. Return verification and condition ratings keep track of damaged items.

3.5 Scalability, Security, and Privacy

As more departments join, the amount of data grows, so the system is designed to run on a cloud server. Profiles and allocation details are protected with hashed passwords, encrypted connections, and role-based access.

IV. METHODOLOGY

The system has three types of users and follows the layered design shown in Figure 1. Students create accounts, search for equipment, submit requests, and track due dates. Lab assistants manage the inventory of their lab, approve requests, scan items, and record returns. Administrators, such as the HOD or Dean, supervise activity, resolve disputes, and view reports. The modules are summarised in Table 2.

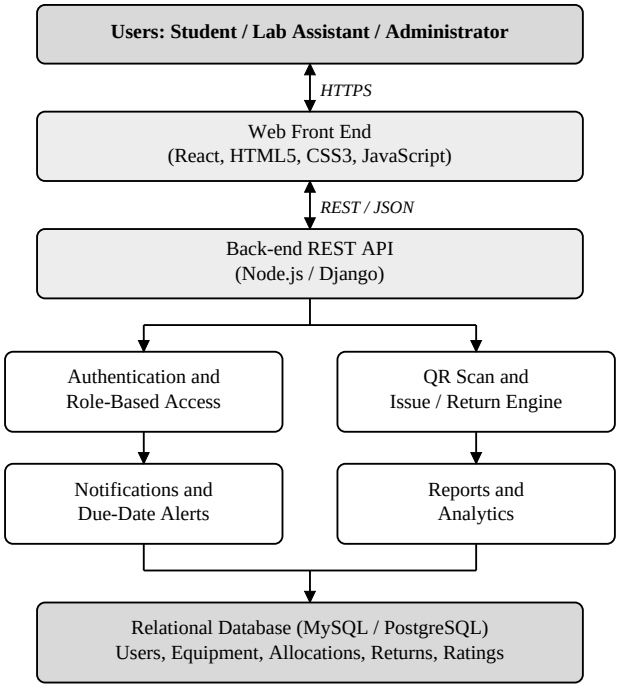


Figure 1. Block diagram of the proposed Smart College Equipment Tracking System.

Table 2. Summary of the modules of the system

Module	Function	Key Tools
1. Homepage	Home, About, Services, FAQs, Contact, Login	HTML5, CSS3, React
2. Admin	Dashboard, users, equipment, reports, audit logs	Node.js / Django
3. Lab assistant	Inventory, issue and return, scanning, notifications	QR scanner library
4. Student	Search, request, track due dates, rate items	React, REST API
5. Database	Users, equipment, requests, returns, ratings	MySQL / PostgreSQL

4.1 Module 1: Homepage

The public homepage introduces the system and contains the Home, About Us, Services, FAQs, Newsletter, and Contact sections. A single login portal takes students, lab assistants, and administrators to their own panels.

4.2 Module 2: Admin Panel

The admin panel is used for supervision. It provides a dashboard of key figures, profile and password management, user management, equipment and allocation management, review of feedback and ratings, reports, settings, a support centre, and audit logs of all administrative actions. Admins can also edit or remove ratings, resolve rating disputes, and reply to feedback.

4.3 Module 3: Lab Assistant Panel

Lab assistants manage their profile and availability, browse the inventory by category and lab location, check allocation status, and view ratings. They scan the QR code on an item to issue or receive it, follow return schedules, and get notified about new requests.

4.4 Module 4: Student Panel

Students keep their profile up to date, search for equipment by category, location, and availability, and submit allocation requests with the date they need the item. They track the request status and the return due date, rate the condition of the item after return, and receive reminders before the due date.

4.5 Module 5: Database Design

A relational database stores all records. The proposed tables are listed in Table 3. A student can submit many allocation requests, and each request refers to one equipment item. A staff member reviews each request before checkout, and every completed allocation creates a return log that records the condition of the item and whether it came back on time.

Table 3. Proposed database tables

Table	Main Fields
Users	user_id (PK), username, hashed password, email, role (Admin, Staff, Student), created_at
Staff	staff_id (PK), user_id (FK), department_skills, availability, rating, lab_location
Students	student_id (PK), user_id (FK), phone_number, department_details
Equipment	equipment_id (PK), name, category, lab_location, qr_code, condition, status
Allocation Requests	allocation_id (PK), student_id (FK), staff_id (FK), equipment_id (FK), status (Pending, Approved, Returned), created_at
Return Logs	return_id (PK), allocation_id (FK), student_id (FK), overdue_days, return_status (Pending, Verified, Damaged), transaction_date
Ratings	rating_id (PK), allocation_id (FK), student_id (FK), staff_id (FK), score, feedback, created_at

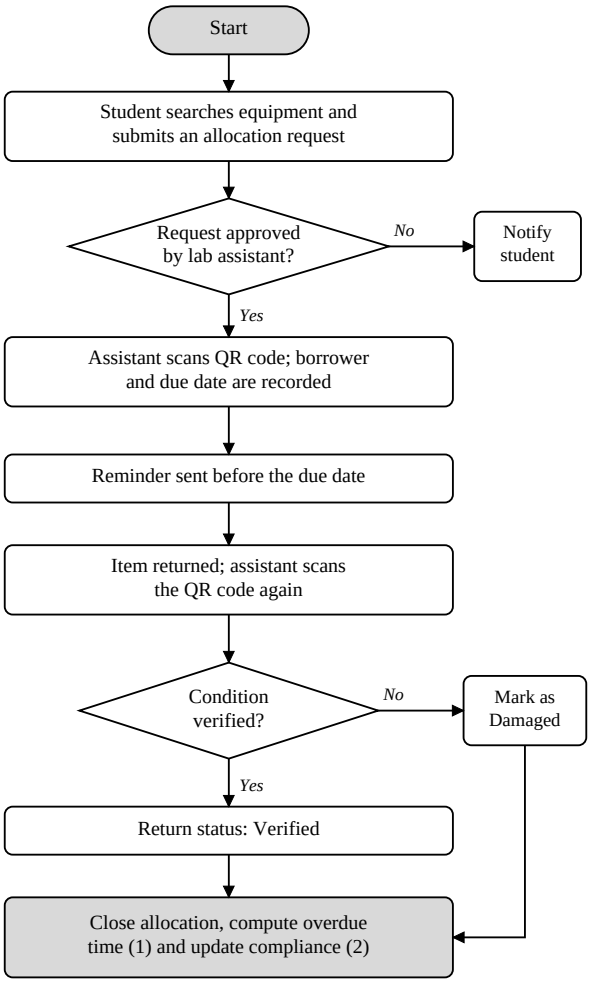


Figure 2. Working flow of equipment issue and return.

4.6 Issue and Return Workflow

The working of an allocation is shown in Figure 2. The student searches for an item and submits a request. The lab assistant approves it, scans the QR code on the item, and the system records the borrower and the due date. A reminder is sent before the due date. On return, the assistant scans the code again and marks the condition as Verified or Damaged, and the allocation is closed.

The overdue time of each allocation is computed as

$$T_{overdue} = \max(0, d_{return} - d_{due}) \quad (1)$$

where d_{return} is the date the item is returned and d_{due} is the agreed due date. The return compliance rate used for evaluation is

$$R = (N_{on\text{-}time} / N_{total}) \times 100\ \% \quad (2)$$

where $N_{on\text{-}time}$ is the number of items returned by the due date and N_{total} is the total number of allocations.

4.7 Technology Stack and Security

The front end uses HTML5, CSS3, JavaScript, and React or Angular for a responsive interface. The back end uses Node.js or Python (Django/Flask) with a REST API. Data is stored in MySQL or PostgreSQL, and the system can be hosted on AWS or Azure. Security measures include hashed passwords, SSL/TLS, role-based access control, audit logs, and regular backups. Development follows Agile practice with GitHub for version control, and testing uses Selenium and Jest.

V. EXPECTED BENEFITS AND EVALUATION PLAN

5.1 Expected Benefits

Based on the design, the system is expected to remove paper registers, show the live status of every asset, reduce loss and misplacement, encourage careful handling through ratings and return history, and give fair access to equipment that is in high demand. It also gives administrators reports for planning purchases. These are design goals and not measured results.

5.2 Planned Evaluation

After implementation, the system will be evaluated on the following points:

- page load time, uptime, and error rate;
- mobile responsiveness and accessibility, checked with WAVE or axe;

- QR scan success rate and the time taken to issue or receive an item;
- return compliance rate R from Eq. (2), before and after deployment;
- daily and monthly active users;
- student and lab assistant satisfaction from user acceptance surveys.

5.3 Feasibility

Technical: React, Node.js, PostgreSQL, and QR code libraries are widely used, open-source, and suited to this application.

Economic: QR labels and a smartphone or scanner are inexpensive, and the system reduces paper logbooks and equipment loss.

Operational: The interface is simple, and a short training session for lab staff and students is enough.

Legal: Student data will be handled under the institution's privacy rules with the required administrative approvals.

VI. CONCLUSION

This paper proposed the Smart College Equipment Tracking System, a QR code-based web platform that replaces manual logbooks with a digital record of laboratory equipment. A React front end, a REST back end, a relational database, and role-based access are combined in a five-module design. The system aims to reduce equipment loss, save administrative time, and make borrowers accountable, and the measures in Section IV give a basis for testing these aims once it is built.

VII. FUTURE ENHANCEMENT AND DIRECTIONS

- Completing the implementation and carrying out the evaluation planned in Section V.
- RFID support for high-value equipment.
- A mobile application for students and lab assistants.
- Automatic maintenance alerts based on condition ratings.
- Integration with the existing college management system.

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