



A Cost-Effective Smart Attendance Management Framework Using QR Code Staff IDs for Staff in Federal Polytechnic Wannune.

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Abstract

Staff attendance is important for accountability and quality assurance in tertiary institutions. Yet, some institutions still rely on the manual approach to attendance records management which is prone to proxy attendance, falsification, and poor record management. This study presents a cost-effective smart staff attendance management system using QR code-enabled staff identity cards. The system automates staff identification, attendance capture, academic contact-hour tracking, Quality Assurance (QA) classroom verification, analytics, and reporting. It distinguishes between academic and non-academic staff and accommodates legitimate activities such as rescheduled lectures, venue changes, makeup classes, and lecturer class swaps. A functional prototype is being developed based on the identified requirements and tested for its core functions. The system is being designed to use existing smartphones, computers, tablets, and webcams, reducing dependence on specialized attendance hardware. The proposed system provides an integrated approach to staff attendance, academic activity monitoring, and institutional quality assurance.

Keywords: Staff attendance, QR code, Academic Contact Hours, Quality Assurance, Attendance Management, Tertiary Institutions

1. Introduction

Staff attendance is an important component of accountability, productivity, and quality assurance in tertiary institutions. Accurate attendance records help institutions monitor staff commitment to assigned duties, support administrative decisions, and ensure that academic activities are delivered as scheduled. However, many institutions still depend on manual attendance registers, which are vulnerable to proxy attendance, falsified entries, inaccurate time records, and inefficient record management. The limitations of manual systems have encouraged the adoption of automated attendance technologies, including biometric systems, Radio Frequency Identification (RFID), Global Positioning System (GPS), geofencing, and Quick Response (QR) codes. All the automated attendance technologies available have their own advantages but also have their limitations that may make them unsuitable in certain environments.

Even though Biometric systems provide stronger identity verification, they often require dedicated hardware, thereby increasing the cost of implementation and maintenance (Jamil, 2011; Trabelsi & Shuaib, 2011). As evident in research, GPS and geofencing approaches can provide location information but may be affected by device limitations and positioning accuracy (Enikuomihin & Dosumu, 2021). QR-based systems, on the other hand, can provide a relatively simple means of identifying users through smartphones, tablets, computers, or other camera-enabled devices. And although QR-based attendance systems have been widely explored, much of the existing work focuses on student attendance and conventional attendance recording. Staff attendance in tertiary institutions presents additional requirements because academic and non-academic staff do not necessarily follow the same attendance pattern. While non-academic staff may be assessed mainly through office-hour attendance, academic

staff may be required to fulfil teaching, examination, supervision, and other approved academic duties. Academic staff may also change teaching venues, participate in rescheduled or makeup classes, or exchange teaching responsibilities. Consequently, a staff attendance management system should account for these legitimate variations rather than treating all staff as having identical attendance requirements.

Beyond ordinary attendance recording, institutions also need mechanisms for monitoring academic contact hours and verifying that scheduled teaching activities take place. Quality Assurance (QA) personnel may need to verify a lecturer's presence during a scheduled class, while administrators and heads of departments require timely information about attendance, contact-hour completion, and unusual attendance patterns. This study therefore presents a cost-effective smart staff attendance and academic contact-hour management system based on QR code-enabled staff identity cards. The system integrates staff attendance capture, differentiated attendance rules, academic contact-hour monitoring, QA classroom verification, attendance analytics, anomaly flagging, and automated reporting within a unified framework. A functional prototype was developed from the identified requirements, with emphasis on practical deployment using existing smartphones, computers, tablets, and camera-equipped devices. The proposed system is intended to provide tertiary institutions with a flexible and scalable approach to improving staff accountability and academic quality assurance.

2. Literature Review

2.1 Manual Attendance Management

Manual attendance systems remain common in many educational institutions because they are simple to establish and require little technical infrastructure. Typically, staff sign attendance registers when they arrive and sometimes when they leave. However, such systems provide limited protection against proxy attendance, falsified entries, incomplete records, and inaccurate time reporting. They also make it difficult to generate timely attendance statistics and monitor long-term patterns. Ali et al. (2022), in a systematic review of automated attendance management systems, noted that the limitations of conventional attendance methods have encouraged institutions to adopt automated technologies capable of improving accuracy, efficiency, and record management. The shift toward automated systems is therefore driven not only by convenience but also by the need for reliable institutional information.

2.2 Biometric Attendance Systems

Biometric attendance systems identify individuals through physical or behavioural characteristics such as fingerprints or facial features (Trabelsi & Shuaib, 2011). Fingerprint-based systems are particularly common because fingerprints provide relatively distinctive characteristics for personal identification. Oyebola et al. (2018), developed a fingerprint-based attendance information management system and demonstrated the potential of biometric identification for reducing identity-related problems in attendance recording. Despite their advantages, biometric systems often require dedicated scanners, additional installation, maintenance, and reliable power or network infrastructure to function optimally. They may also introduce concerns related to biometric data protection and system maintenance (Trabelsi & Shuaib, 2011). These considerations can make biometric solutions less attractive especially for resource constrained institutions that require a low-cost solution that can be deployed using existing devices.

2.3 GPS, RFID, and Geofencing Approaches

Location-based attendance systems attempt to verify that an individual is physically present at an approved location. In their work, Uddin et al. (2014) proposed a location-based time and attendance system that uses location information to improve attendance verification. Similarly, Shinde et al. (2018) examined a GPS-based attendance management system integrated with RFID technology. Geofencing extends this concept by defining a virtual geographical boundary and determining whether a user's device is within the permitted area. Enikuomelin and Dosumu (2021) examined geofencing for attendance monitoring and recognized that such systems can reduce attendance from outside an approved location, but they depend on location services and may be affected by GPS accuracy, device settings, connectivity, and environmental conditions.

These technologies are useful where location verification is a primary requirement. However, for a cost-conscious institutional system, requiring continuous GPS services or additional RFID infrastructure may introduce operational and implementation considerations that can be avoided through simpler identification approaches.

2.4 QR Code-Based Attendance Systems

QR codes have increasingly been applied to automated attendance because they can store or represent unique identifiers that can be read quickly using camera-equipped devices. Rahmawati et al. (2019) developed a QR-based student attendance system in which QR codes were used during lectures. Liew and Tan (2021) similarly developed a QR code-based student attendance system that incorporated class-hour and location-related checks. More recent studies have further demonstrated the application of QR codes to automated attendance management. Asogwa et al. (2025) developed a QR code-based university student attendance system that incorporated real-time database storage, attendance reporting, time-sensitive QR functionality, and campus-radius restrictions. Bhure et al. (2023) investigated the use of QR codes as a mechanism for automating attendance recording, demonstrating their suitability for replacing conventional manual attendance procedures with faster digital identification and record capture. Similarly, Tan et al. (2024) examined the feasibility and acceptability of QR code-based attendance-taking in a higher-education setting, providing evidence of the practicality of QR technology for routine attendance management. Although these studies demonstrate the usefulness of QR codes for automated attendance, they are primarily focused on student attendance or general attendance capture. They do not fully address the distinctive requirements of staff attendance in tertiary institutions, particularly the need to differentiate academic and non-academic attendance rules, monitor academic contact hours, support legitimate timetable and teaching-session changes, and provide independent QA classroom verification.

3. Methodology

3.1 Research Design

The system extends QR technology beyond basic attendance recording by integrating staff attendance management, academic contact-hour monitoring, QA verification, flexible session management, anomaly detection, analytics, and automated reporting within a unified framework. It uses a modular, service-oriented architecture built with HTML5, CSS3, JavaScript, Python, and Django, with MySQL for secure data storage.

3.2 QR Staff Identity Management

Each staff member is assigned a unique QR code associated with their institutional staff record. The QR code functions primarily as a digital identifier or protected token through which the system retrieves the corresponding staff profile. During scanning, the system validates the submitted QR information against the staff database before processing the attendance transaction. Server-side validation and timestamps are used to prevent users from manipulating attendance records by changing device time settings.

Because a QR card by itself does not provide biometric proof of identity, the system treats QR identification as the primary mechanism in the prototype while recognizing biometric verification as a future enhancement.

3.3 Overall System Architecture

A functional prototype was developed based on the requirements identified during the study. The prototype provides interfaces for authentication, staff registration, QR generation, attendance scanning, academic-session management, QA verification, analytics, and reporting.

The prototype was designed around commonly available computing devices, including smartphones, tablets, laptops, desktop computers, and camera-equipped devices. This approach supports the cost-effective deployment of the system without requiring a dedicated scanning terminal at every scanning point. The system is designed such that each staff member is assigned a unique QR code associated with their institutional staff record and printed on their staff ID cards. The QR code functions primarily as a digital identifier or protected token through which the system retrieves the corresponding staff profile. Figure 1: Overall System Architecture of the Proposed Framework illustrates the complete structure of the proposed system, showing the interaction between input data, processing components, analytical modules, and output mechanisms that collectively enable the framework's operation and functionality.

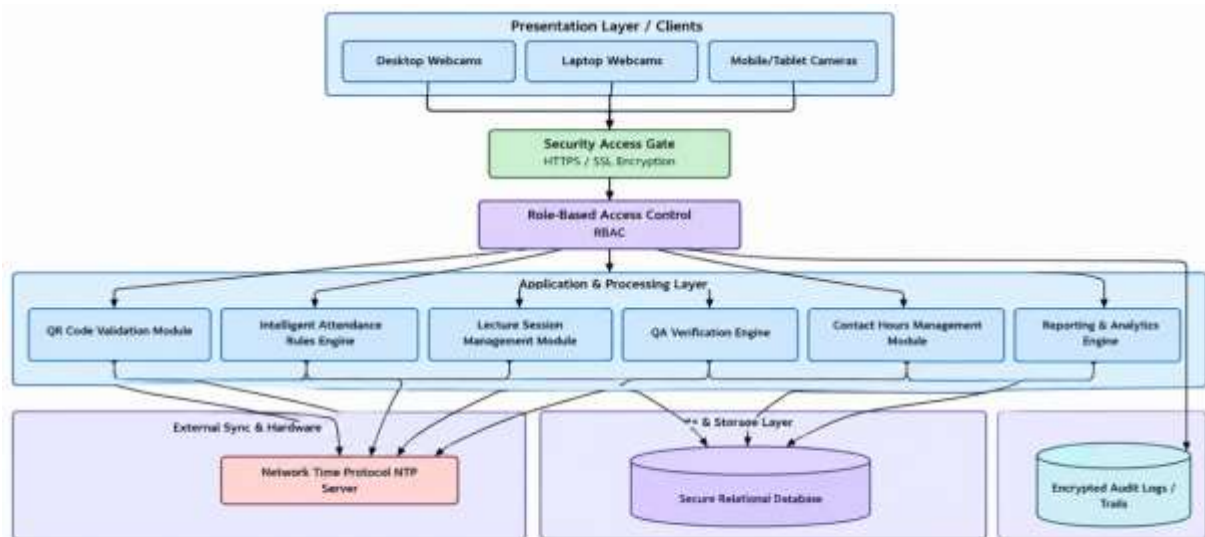


Figure 1: Overall System Architecture of the Proposed Framework

4. System Process

4.1 Overall System Process

The overall system process begins with staff registration and QR code assignment. When a staff member presents the QR-enabled identity card, the scanning device reads the QR code and sends the identifier to the application server. The server validates the identity, determines the appropriate attendance rule, checks relevant academic information where necessary, and records the transaction. The resulting information is stored in the database and becomes available to authorized users through the analytics and reporting interfaces. Figure 2: Overall System Process Flowchart presents the sequential workflow of the proposed system, highlighting the step-by-step processes from data input and processing stages to decision-making operations and the generation of final outputs.

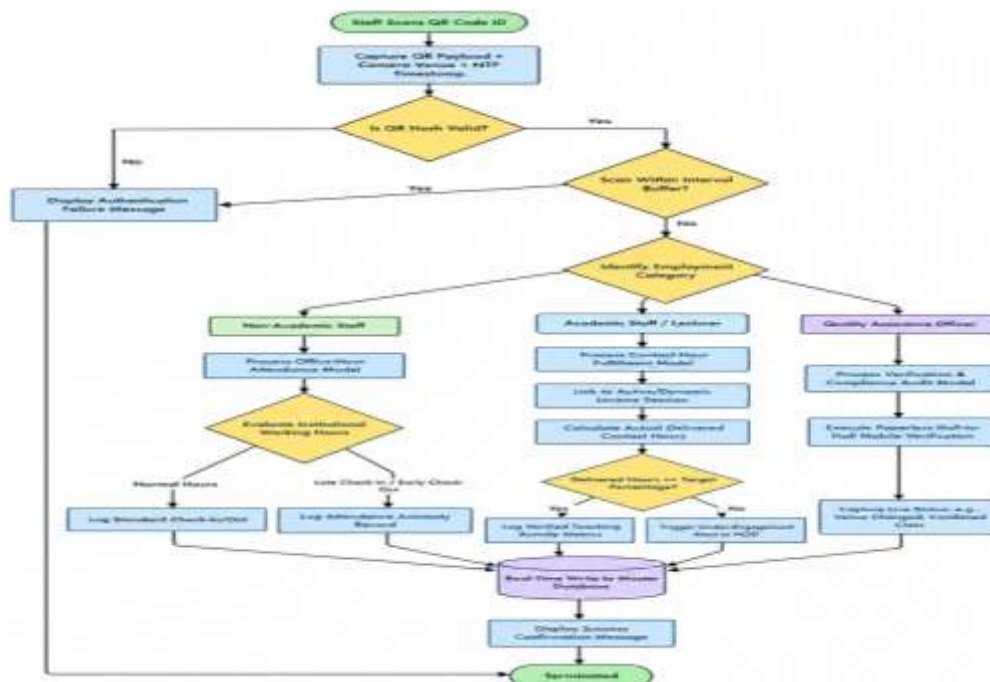


Figure 2: Overall System Process Flowchart

Fig. 3: Sequence Diagram of the Proposed System illustrates the chronological interaction and communication flow among the system components, showing how users, processes, and modules exchange information and execute operations to achieve the intended system functionality.

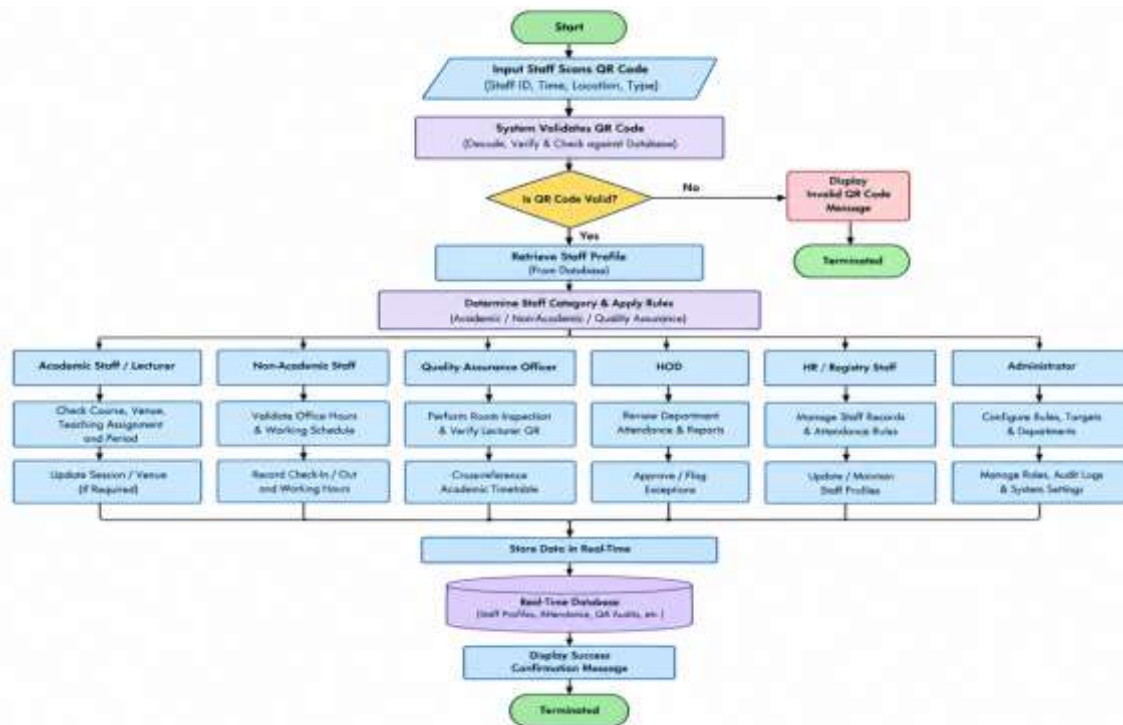


Fig. 3 Sequence Diagram of the Proposed System.

4.2 Staff Check-In and Check-Out

The attendance process involves the following general steps:

1. A Staff presents the QR-enabled identity card.
2. Authorized scanning device reads the QR code.
3. System retrieves the staff profile.
4. Server validates the QR identifier.
5. System determines whether the transaction is a check-in or check-out.
6. Server records the date and server-generated time.
7. Duplicate or invalid transactions are rejected or flagged.
8. Attendance confirmation is displayed to the user.

A duplicate-prevention mechanism is configured to prevent repeated scans within a defined period of five minutes.

4.3 Academic and Non-Academic Attendance Rules

The system distinguishes between academic and non-academic staff because their work patterns and institutional responsibilities differ.

Non-Academic Staff

For non-academic staff, attendance monitoring follows a conventional office-hour model. The system records: check-in time, check-out time, lateness, early departure, absence, and attendance frequency. These records are then compared against the institution's approved working hours.

Academic Staff

Academic staff are monitored according to approved academic duties rather than assuming that they must remain in one location for the entire conventional working day. Their attendance may include scheduled lectures, examinations supervision, approved makeup classes, rescheduled lectures, and other recognized institutional duties.

This approach provides a more appropriate representation of academic staff activity while still allowing institutional policies to define the specific compliance requirements.

4.4 Academic Contact-Hour Management

The contact-hour component compares the academic hours assigned to a staff member with the hours verified through recognized academic activities. The dashboard displays required hours, completed hours, outstanding hours, and a percentage of total verified sessions.

For example, if a lecturer is assigned 40 contact hours during a monitoring period and 38 hours are verified, the system calculates:

$$\text{Contact-Hour Compliance} = (\text{Verified Hours} / \text{Required Hours}) \times 100$$

Therefore: $(38 / 40) \times 100 = 95\%$

4.5 QA Classroom Verification

The QA classroom verification process provides an additional mechanism for confirming academic activity.

A typical QA classroom verification process is as follows:

1. The QA officer signs into the system.
2. The officer selects the classroom verification function.
3. The lecturer's physical QR staff ID is scanned.
4. The system identifies the lecturer.
5. The system checks the relevant academic session and timetable information.
6. The QA officer confirms the classroom activity.
7. The system records the lecturer, course, venue, date, time, QA officer, and verification status.
8. The record is stored in the QA audit database.

4.8 Attendance Analytics and Reporting

The system provides analytical information to authorized institutional users. These reports include individual staff attendance, departmental attendance, punctuality, absence, academic contact-hour achievement, QA verification and attendance anomalies.

Anomalies may include repeated scans, incomplete attendance records, check-out without check-in, unusual attendance patterns, or contact-hour deficits. These are treated as flags for review rather than automatic proof of misconduct.

5. Results and Discussion

5.1 Prototype Functionality

The developed prototype demonstrates the core functionality required for QR-based staff attendance and academic activity monitoring. The major implemented functions include user authentication, staff registration, QR code generation, QR scanning, attendance recording, academic session management, QA verification, analytics, and report generation.

Figure 4: Staff Registration Interface presents the user interface for registering staff details into the proposed system, showing the input fields and controls used to capture, validate, and store essential employee information for subsequent system operations.

The screenshot shows a 'Register Staff' modal form. It is divided into three main sections: Personal Information, Employment Information, and Contact Information. The Personal Information section includes fields for Staff ID, Title (a dropdown), Gender, First Name, Middle Name, and Last Name. The Employment Information section includes fields for Department, Rank/Position, Staff Category, Staff Type, Date Joined (with a date picker), and Status (a dropdown). The Contact Information section includes fields for Phone Number and Official Email. There is also a 'Staff Photograph' section with a 'Photograph / Passport Photo' label and a 'Browse...' button. At the bottom right, there are 'Cancel' and 'Save Staff Profile' buttons.

Figure 4: Staff Registration Interface.

Figure 5: QR Code/ID Card Generation Dashboard displays the dashboard interface used for creating and managing unique QR codes or identification cards, enabling the system to generate secure staff identification credentials for authentication and attendance tracking purposes.

The screenshot shows a 'QR CODE GENERATION' dashboard. The main feature is a generated 'Staff ID Card' for 'MR. APOLLOS SAMUEL GANDE'. The card includes a photo of the staff member, their name, staff ID (FPW/CA/1/PER/372), department (Accountancy), position/rank (Lecturer II), category (Academic), phone number (09036431028), and status (ACTIVE). A QR code is also displayed on the card. Below the card, there are buttons for 'Close', 'Download PDF', and 'Print / Save PDF'. The background shows a sidebar with navigation options like 'Dashboard Overview', 'STAFF MANAGEMENT', 'ATTENDANCE', and 'REPORTS'.

Figure 5: QR Code/ ID Card Generation Dashboard

Figure 6: Attendance Rules Creation Interface presents the configuration module where administrators define and manage attendance policies, including work schedules, check-in requirements, and operational rules that guide the system's attendance monitoring process.

The screenshot shows the 'ATTENDANCE CONFIGURATION' section with the title 'Attendance Rules'. Below the title is a description: 'Configure work hours, grace periods, checkout requirements, and duplicate scan cooldowns.' There is a '+ New Rule' button in the top right corner. Below this is a search bar labeled 'Search rule or category'. The main part of the interface is a table with the following columns: RULE, APPLIES TO, HOURS / CONTACT HOURS, GRACE, STATUS, and ACTIONS.

RULE	APPLIES TO	HOURS / CONTACT HOURS	GRACE	STATUS	ACTIONS
Non Teaching Staff Cooldown: 3 min	Non-Academic	08:30 – 04:00 Working Hours	Late: 30 min Early: 30 min	Active	 
Teaching Staff Cooldown: 3 min	Academic	Contact Hours Based on Lecture Timetable	Late: 30 min Early: 30 min	Active	 

Figure 6: Attendance Rules Creation Interface.

Figure 7: Staff ID Validation illustrates the verification interface used to authenticate staff identity by validating submitted identification details, ensuring that only authorized employees can access the attendance system.

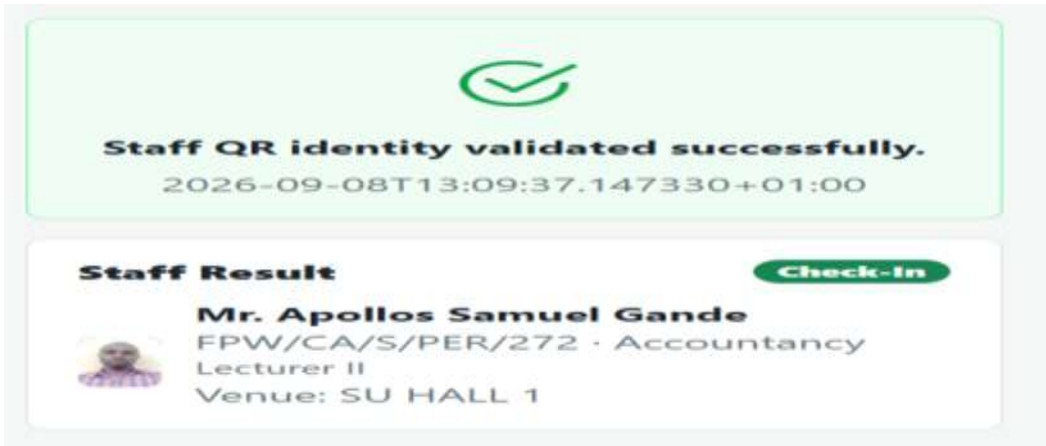


Figure 7: Staff ID Validation

Figure 8: QA Mobile Classroom Verification Interface presents the mobile-based quality assurance module designed for real-time classroom monitoring and verification, enabling authorized personnel to capture, validate, and document classroom activities efficiently through the proposed system.

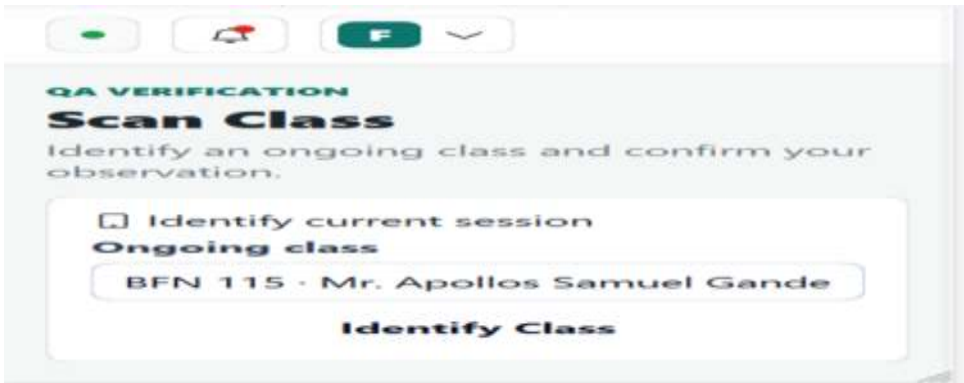


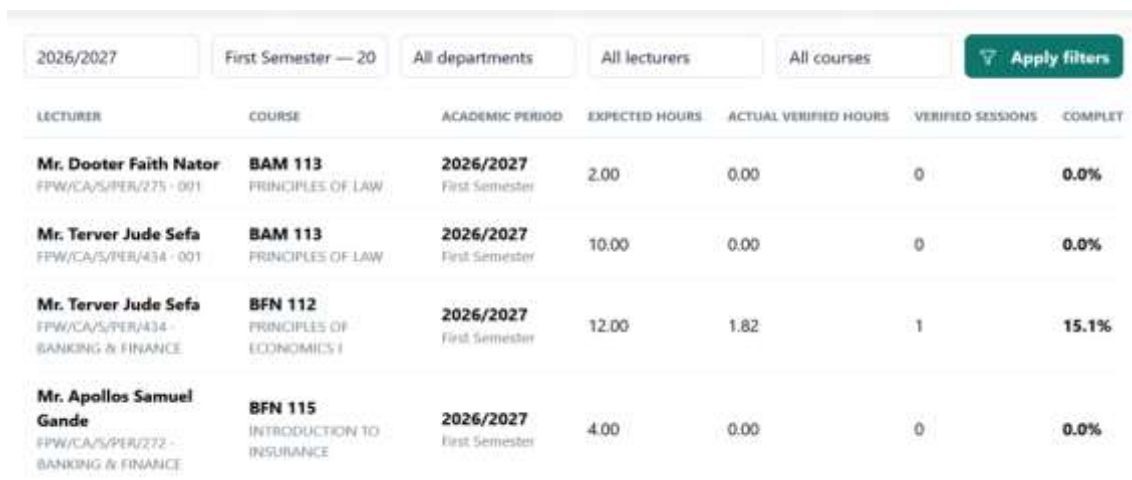
Figure 8: QA Mobile Classroom Verification Interface

Figure 9: Audit Trail of Sessions illustrates the session monitoring interface that records and displays system activities, user interactions, and transaction histories, providing transparency, accountability, and traceability of operations within the proposed system.

Lecture Verification Records							
Audit trail of lecture sessions reviewed by QA officers through the Verification Queue, including verification outcomes and inspection details.							
Search lecturer, course or venue				All statuses	dd / mm / yyyy	Filter	
LECTURER	COURSE	VENUE	DATE / TIME	QA OFFICER	VERIFICATION STATUS	REMARKS	ACTION
Mr. Terver Jude Sefa FPW/CA/S/PER/434	BFN 112 PRINCIPLES OF ECONOMICS I	SU HALL 2 (SU HALL 2)	Sep 12, 2026 13:26	Tor Jesse Usende FPW/CA/S/PER/292	Verified	Ongoing session	View
Mr. Apollos Samuel Gande FPW/CA/S/PER/272	BFN 115 INTRODUCTION TO INSURANCE	Multiple Hall (MULTIPLE HALL)	Sep 08, 2026 15:28	Tor Jesse Usende FPW/CA/S/PER/292	Verified	No remarks provided.	View

Figure 9: Audit Trail of Sessions

Figure 10: Academic Contact Hours Monitoring Dashboard presents the dashboard interface for tracking and analyzing academic contact hours, enabling administrators to monitor teaching activities, verify compliance with scheduled hours, and generate accurate reports for effective academic management.



LECTURER	COURSE	ACADEMIC PERIOD	EXPECTED HOURS	ACTUAL VERIFIED HOURS	VERIFIED SESSIONS	COMPLET
Mr. Dooter Faith Nator FPW/CA/S/PER/275 - 001	BAM 113 PRINCIPLES OF LAW	2026/2027 First Semester	2.00	0.00	0	0.0%
Mr. Terver Jude Sefa FPW/CA/S/PER/434 - 001	BAM 113 PRINCIPLES OF LAW	2026/2027 First Semester	10.00	0.00	0	0.0%
Mr. Terver Jude Sefa FPW/CA/S/PER/434 - BANKING & FINANCE	BFN 112 PRINCIPLES OF ECONOMICS I	2026/2027 First Semester	12.00	1.82	1	15.1%
Mr. Apollos Samuel Gande FPW/CA/S/PER/272 - BANKING & FINANCE	BFN 115 INTRODUCTION TO INSURANCE	2026/2027 First Semester	4.00	0.00	0	0.0%

Figure 10: Academic Contact Hours Monitoring Dashboard

Figure 11: Attendance Overview presents the attendance monitoring dashboard that provides a summarized view of staff attendance records, including check-in activities, attendance trends, and performance statistics for effective tracking and management.

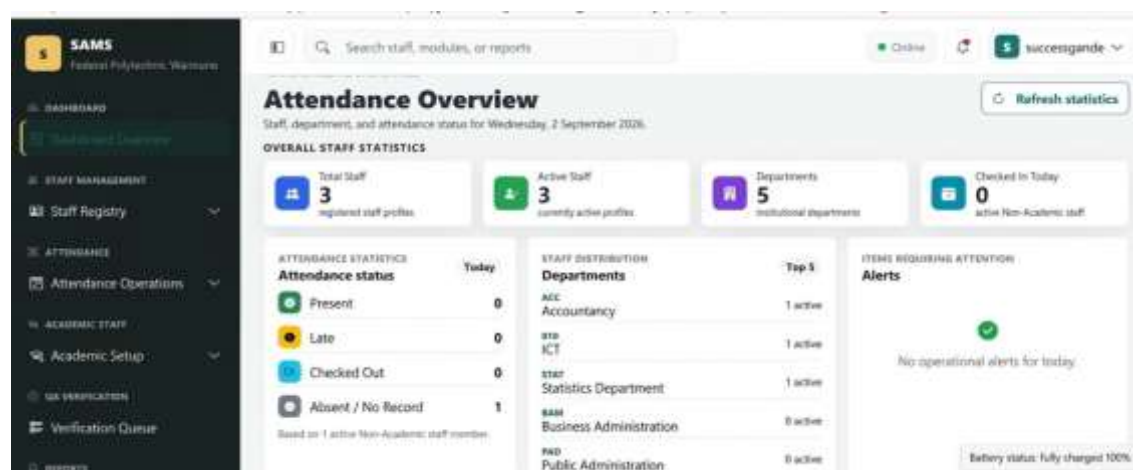


Figure 11: Attendance Overview

5.2 Attendance Capture

The prototype demonstrates the use of QR codes to simplify staff attendance recording. Instead of manually entering staff information, the scanner retrieves the staff profile associated with the QR identifier and records the attendance transaction. This reduces manual data entry and provides electronic records that can be searched, analysed, and reported. The use of existing camera-equipped devices also supports deployment in different locations without requiring a dedicated scanning terminal at each point.

5.3 Academic Contact-Hour Monitoring

A major feature of the prototype is the separation of ordinary attendance monitoring from academic contact-hour monitoring. This distinction is important because academic staff responsibilities cannot always be represented adequately by conventional office-hour attendance.

The contact-hour component provides a more activity-oriented view by linking verified academic sessions to teaching assignments. This allows management to identify outstanding academic hours and monitor teaching compliance based on recognized institutional activities.

5.4 QA Classroom Verification

The QA verification module extends attendance monitoring beyond self-reported attendance. A QA officer can independently verify the presence of a lecturer during a scheduled academic activity. This provides an additional institutional record that can be compared with attendance and timetable information. It can therefore support quality assurance processes and provide evidence for reviewing discrepancies between recorded attendance and observed academic activity.

5.5 Detection of Attendance Anomalies

The prototype supports the identification of potentially unusual attendance records. Examples include repeated scans, missing check-out records, check-out without a corresponding check-in, and discrepancies between expected and verified academic activity. The purpose of anomaly detection is to direct attention toward records requiring review. The system does not automatically classify an anomaly as fraud or misconduct because unusual records may result from legitimate circumstances such as forgotten check-outs, approved timetable changes, network problems, or other operational issues.

5.7 Cost-Effectiveness

The prototype was designed with cost-conscious deployment in mind. Rather than requiring dedicated biometric terminals or specialized attendance equipment at every location, the system can use existing smartphones, tablets, laptops, desktop computers, and webcams with suitable camera capability. This approach may reduce the infrastructure burden associated with deployment, particularly in institutions where staff and QA personnel already have access to camera-equipped devices. However, actual deployment cost will depend on factors such as hosting, networking, identity-card production, maintenance, security requirements, and the number of users.

5.8 Security and Practical Limitations

Several security measures are incorporated into the proposed approach, including role-based access control, server-side QR validation, server-generated timestamps, duplicate-scan prevention, audit logging, authenticated access and secure network communication. Despite these measures, a QR staff card remains a possession-based identifier. A staff member could potentially give the card to another person for scanning. Consequently, QR technology alone cannot provide the same level of identity assurance as biometrics.

Other limitations include dependence on device availability, network connectivity, camera quality, and proper management of timetable changes. These limitations provide opportunities for further development.

5.9 Future Enhancements

Future versions of the system can incorporate additional technologies and institutional integrations like facial recognition, dynamic QR codes, payroll integration, cloud database hosting, advanced staff performance analytics, SMS and push notifications and institution-wide integration with existing academic and administrative systems.

These enhancements can strengthen identity verification and extend the usefulness of the system beyond attendance monitoring.

6. Conclusion

This study presented a cost-effective smart staff attendance and academic contact-hour management system based on QR code-enabled staff identity cards. The proposed approach addresses limitations associated with manual attendance recording by providing automated identification, attendance capture, academic contact-hour monitoring, QA classroom verification, analytics, and reporting. A key feature of the system is its distinction between academic and non-academic staff attendance requirements. Rather than applying a single attendance model to all employees, the system recognizes academic activities such as scheduled lectures, examinations, makeup classes, venue changes, and approved lecturer class swaps. The integration of QA classroom verification further provides an independent mechanism for monitoring academic activities.

The functional prototype demonstrates that QR-based identification can serve as a practical foundation for an integrated staff monitoring system, particularly where institutions wish to use existing smartphones, computers, tablets, and webcams instead of relying entirely on specialized attendance hardware. Nevertheless, QR identification alone does not completely eliminate the possibility of proxy attendance, making biometric and location-based verification important areas for future enhancement when resources become more available and cost is no longer an issue. Overall, the proposed system provides a flexible framework for improving staff accountability, academic contact-hour monitoring, and institutional quality assurance in tertiary institutions. Future implementation and evaluation should examine large-scale deployment, user acceptance, security performance, and integration with biometrics, payroll, and other institutional systems.

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How to Cite this Article: Aderibigbe, T. T., & Dzeremo, M. T. (2026). A Cost-Effective Smart Attendance Management Framework using QR Code Staff IDs for Staff in Federal Polytechnic Wannunne. International Journal of Engineering, Science, and Environmental Research, 2(1), 352–351.