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Student QR System Using HTML, CSS & JavaScript: An Automated Attendance Management Solution

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Abstract

The old way of taking attendance is really slow. Often has mistakes. It is also easy for someone to pretend to be another student. This is a problem for schools. That is why we made the Student QR System. It is a website that uses QR codes to identify students and keep track of attendance. We built this system using HTML, CSS and JavaScript. This means it is easy to use and can be accessed from any computer or phone with a web browser. We do not need any equipment.

Each student gets a QR code with their name and information on it. We can scan this code with a phone or camera to mark them present quickly and correctly. The Student QR System solves a lot of problems with the way of taking attendance. It gets rid of paperwork reduces mistakes stops people from pretending to be someone and saves time for both students and teachers.

The system has five parts: making QR codes scanning QR codes, managing student information, managing attendance and the user interface. It uses JavaScript to process information and PHP and MySQL to store data. When we tested the system we found that it is much better than the way. It stops people from pretending to be someone marks attendance much faster. Under 30 seconds per class gets rid of all paperwork and makes attendance records more accurate.

The Student QR System is a solution, for schools because it is affordable and can be used by schools of all sizes. All we need is a web browser and a camera. In the future we want to add features like using fingerprints or faces to identify students making a mobile app sending notifications making reports automatically and connecting it to existing student information systems. The Student QR System is a tool for schools to manage attendance in a simple and efficient way.

***KEYWORDS**: the system that uses QR codes to take attendance. This system should be. Manage attendance on its own. It should be something that can be accessed on the web. The main goal is to identify students and keep track of their attendance. I want this system to be built using JavaScript. It should also be able to prevent people from taking attendance on behalf of others. The system should track attendance digitally. Keep a record of it. I want to use a QR code attendance system to make things easier. This system will help with automated attendance management. It will be a web-based attendance system that can identify students and prevent proxy attendance. The digital attendance tracking will be very helpful.*

1. Introduction

1.1. Motivation

The old way of taking attendance is really slow. It often has mistakes. Someone can easily pretend to be another student. This is a problem for schools like ours. That is why we created the Student QR System. The Student QR System is a website that uses QR codes to identify students and keep track of attendance. We made the Student QR System using HTML, CSS and JavaScript. This means the Student QR System is easy to use and can be accessed from any computer or phone with a web browser. We do not need any equipment for the Student QR System.

Each student gets a QR code with their name and information on it. We can scan this code with a phone or camera to mark them present quickly and correctly. The Student QR System solves a lot of problems with the way of taking attendance. The Student QR System gets rid of paperwork reduces mistakes stops people from pretending to be someone and saves time for both students and teachers at our school.

The Student QR System has five parts: making QR codes scanning QR codes, managing student information, managing attendance and the user interface. The Student QR System uses JavaScript to process information and PHP and MySQL to store data. When we tested the Student QR System we found that it is much better than the way. The Student QR System stops people from pretending to be someone marks attendance much faster. Under 30 seconds per class gets rid of all paperwork and makes attendance records more accurate for our school.

The Student QR System is a solution for schools because it is affordable and can be used by schools of all sizes. All we need is a web browser and a camera to use the Student QR System. In the future we want to add features to the Student QR System like using fingerprints or faces to identify students making a mobile app, for the Student QR System sending notifications making reports automatically and connecting the Student QR System to existing student information systems. The Student QR System is a tool for schools to manage attendance in a simple and efficient way.

1.2. Contribution

The making of research in several significant contributions to the field of automated attendance management:

1. **Development of a fully browser-based QR attendance system** that requires no native mobile applications or specialized hardware, reducing implementation barriers and costs for educational institutions [18].
2. **Implementation of real-time attendance marking** using JavaScript camera APIs (getUserMedia) combined

with QR code scanning libraries, enabling instantaneous attendance recording without server roundtrips for each scan operation [19].

3. The system has a QR code maker that puts student information like student ID, name, program and semester into a single code that people can scan. This code helps with identifying and verifying students.
4. The system stops people from pretending to be someone by using QR codes that work on any device and cannot be easily copied or shared. Each code is one of a kind. Checks the time when it is scanned.
5. The system is made up of parts that do different things like making QR codes scanning them managing students, recording attendance and making reports. This makes it easy to keep the system working and add things to it later.
6. The system is a way to do things because it gets rid of paper and reduces the work that faculty members have to do by about 80 percent. It also does not need any equipment beyond what schools already have.
7. The system is designed to work with classes of all sizes from groups with 10 students to big lecture halls with 300 or more students. The system is made to be flexible so schools can try it out with a few classes first and then use it for the school.
8. The rest of this paper is organized like this: The next part looks at work that has been done on systems that automatically take attendance. It checks out the technologies that have been used and how they are better or worse than each other. The part after that talks about how we did our research, including what problems we were trying to solve how we designed the system. How we made it work. The following part describes how we set up our tests how we did them and what we found out. The part after that talks about what our results mean what the system is not good at and what we should look into in the future. The last part sums up what we did. Makes some suggestions, for people who might use the system.

2. Related Work

Attendance management systems have been studied for a time over ten years. People have been trying to find ways to do this using technology because the old ways are not good enough. This part of the work looks at what other people have done and groups the work, by the type of technology used. It also talks about the bad points of each type of attendance management system like the advantages and limitations of these attendance management systems.

RFID-Based Attendance Systems

Radio Frequency Identification technology is used for tracking attendance.

Patel and others proposed a system where students carry ID cards with RFID tags.

These tags are scanned by readers at classroom entrances.

The RFID technology helps track attendance.

It is used in schools and colleges.

The RFID tags are on the ID cards.

The readers are at the classroom doors.

This system is helpful, for attendance tracking.

RFID technology is useful.

It makes tracking easy.

The system achieved 98% accuracy in attendance marking and significantly reduced time compared to manual roll calls. However, the primary limitation is the substantial infrastructure cost—RFID readers cost $200-500 per unit, and institutions must install readers in every classroom. Additionally, RFID tags can be transferred between students, failing to prevent proxy attendance effectively.

Khan and Khiyal[25] enhanced RFID systems by integrating them with biometric verification, requiring both RFID card scanning and fingerprint authentication. While this approach effectively prevents proxy attendance, it doubles the infrastructure cost and creates bottlenecks when large numbers of students attempt to authenticate simultaneously before class begins. The dual-verification process can take 3-5 minutes for a class of 50 students, partially negating the efficiency gains.

Biometric Attendance Systems

Biometric technologies, like fingerprint scanning and facial recognition have been looked at a lot for attendance applications. For example Shoewu and Idowu made a system that uses fingerprints to take attendance. It is very accurate with 99.2% accuracy. This system is good because it stops people from taking attendance for someone since fingerprints are unique and cannot be easily copied or shared.

However fingerprint scanners have some problems. Students have to touch the device, which can be a hygiene issue especially when there is a pandemic. Also some students may have fingerprints that are worn out or have skin conditions that make it hard for the scanner to read their fingerprints.

Some other researchers, proposed a system that uses recognition to take attendance. They used computer models that were trained on pictures of students. The system was pretty accurate with 94% accuracy, when the lighting was good.. When the lighting was not so good like, in a real classroom the accuracy went down to 78%.

Facial recognition also has some issues. Some people may think it is an invasion of privacy since cameras have to be watching all the time.. To make it work in real time you need very powerful computers, which can be expensive.

Mobile Application-Based Systems

Some people who do research have made programs for phones to help with taking attendance. People made a program for Android phones that uses a way to check where someone is to make sure students are really in the classroom when they say they are there. This program made codes that showed up on a big screen and students used their phones to scan these codes. This way of doing things works well but it needs students to put a new program on their phone, which can be a problem if they have different kinds of phones like iPhones or Android phones. Also when you are inside a building it can be hard to know where someone is because the special way to check where someone is is not very good at that. It can say someone is somewhere. It might be wrong by a lot, like 10 to 50 meters, which is not good enough to know if someone is, in one classroom or another.

Kadry and Smaili [29] developed a Bluetooth-based mobile attendance system that automatically detected student presence when their smartphones came within range of Bluetooth beacons installed in classrooms. This approach eliminates the active scanning step, providing seamless attendance marking. However, Bluetooth beacons cost $30-50 per classroom, require periodic battery replacement, and can be spoofed by students using Bluetooth amplification techniques to mark attendance from outside the classroom.

Web-Based QR Code Systems

Web-based QR code attendance systems represent a more recent approach that balances effectiveness with accessibility. Masalha and Hirzallah[30] developed a web-based system where instructors generate session-specific QR codes displayed during class, which students scan using their smartphone cameras through a web interface. The system achieved 97% accuracy and reduced attendance marking time by 75% compared to manual methods. However, their implementation required students to log into a web portal before scanning, adding friction to the attendance process.

Raveendran and Patnaik [31] proposed an enhanced QR system incorporating geo-fencing to verify students are within the classroom physical boundary when scanning QR codes. Their system successfully prevented remote attendance marking but required students to enable location services, which some declined due to privacy concerns, resulting in only 68% adoption rate in pilot testing.

Comparative Analysis

Existing research demonstrates that no single approach optimally balances all desirable characteristics: accuracy, cost-effectiveness, ease of implementation, proxy prevention, and user acceptance. RFID and biometric systems offer high accuracy and effective proxy prevention but require substantial infrastructure investment [32]. Mobile application-based systems provide good functionality but face adoption barriers across diverse device ecosystems [33]. Pure web-based approaches offer the best accessibility but traditionally sacrifice some security features.

The Student QR System presented in this paper synthesizes insights from previous work while addressing key limitations. Like web-based QR systems [30][31], it operates entirely through web browsers, eliminating application installation requirements. Unlike previous web-based implementations requiring authentication before scanning, this system streamlines the process by embedding student identification directly within unique QR codes. While sacrificing geo-verification features present in some systems [31], it maintains security through unique, non-transferable QR codes that can be validated server-side during scanning. The system's architecture draws from modular design principles demonstrated in RFID systems [24] while adapting them for web technologies to minimize infrastructure costs.

Research gaps identified in existing literature include: (1) limited exploration of purely browser-based QR scanning without native applications, (2) insufficient attention to minimizing user friction in attendance workflows, and (3) lack of cost-benefit analyses comparing implementation costs across different technological approaches. This research addresses these gaps by presenting a streamlined, cost-effective implementation validated through practical deployment.

3. Research Methodology

This section presents the system architecture, design decisions, implementation details, and algorithmic approach employed in developing the Student QR System.

3.1. Problem Statement

Building an effective automated attendance system presents several interconnected challenges. First, the system must accurately identify individual students from potentially large populations (hundreds or thousands) without errors or ambiguities. Traditional identification methods such as student ID numbers rely on manual data entry, which introduces error potential [34].

Second, the system must prevent proxy attendance—the practice of one student marking attendance on behalf of absent peers. This requirement necessitates some form of verification that the person marking attendance is indeed the enrolled student. However, verification mechanisms must not create bottlenecks or significantly slow the attendance process, as this would undermine the efficiency objective [35].

Third, the system must operate reliably across diverse device types and capabilities. Educational institutions serve student populations with varying technological access—some students have current-generation smartphones, while others use older devices with limited camera capabilities or smaller screens. The system must provide acceptable functionality across this spectrum without requiring expensive devices [36].

Fourth, attendance data must be securely stored and easily retrievable for reporting purposes. Faculty need to access attendance records to monitor student participation and determine examination eligibility. Administrators require aggregated attendance data for assessment and accreditation purposes. The system must provide these reporting capabilities while protecting student privacy and preventing unauthorized data access [37].

Fifth, implementation and maintenance costs must remain reasonable for educational institutions operating under budget constraints. Solutions requiring extensive hardware purchases, specialized equipment, or ongoing license fees face adoption barriers. The ideal system leverages existing infrastructure and open-source technologies to minimize costs [38].

3.2. System Architecture

The Student QR System employs a three-tier architecture consisting of presentation layer, application layer, and data layer, as illustrated in Figure 1.

Presentation Layer

The presentation layer encompasses all user-facing interfaces, implemented using HTML5 for semantic structure, CSS3 for styling and responsive layout, and JavaScript for dynamic client-side functionality. The system provides three primary user interfaces:

1. **Faculty Interface**: Allows instructors to generate session-specific QR codes for their courses, initiate attendance sessions, view real-time attendance as students scan codes, and access historical attendance records with filtering and export capabilities.
2. **Student Interface**: Enables students to access their unique personal QR code (generated during registration), view their attendance history by course,

check examination eligibility status based on attendance percentage, and receive notifications about low attendance.

3. **Administrative Interface**: Provides system administrators with tools for managing user accounts, generating comprehensive attendance reports across courses and semesters, configuring system parameters such as minimum attendance requirements, and monitoring system health and usage statistics.

All interfaces are designed using responsive web design principles, ensuring optimal display and functionality across device sizes from large desktop monitors to small smartphone screens. The CSS framework employs flexible grid layouts, relative sizing units, and media queries to adapt the interface dynamically [39].

Application Layer

The application layer implements the core business logic and is divided into five functional modules:

1. **QR Code Generation Module**: Generates unique QR codes for each student by encoding a structured data payload containing student ID, full name, program/course, enrollment year, and a cryptographic hash for validation. The module uses the JavaScript QR Code library (qrcode.js) for client-side generation, producing high-error-correction QR codes that remain scannable even if partially damaged or obscured.
2. **QR Code Scanning Module**: Implements real-time QR code scanning using the JavaScript WebRTC getUserMedia API to access device cameras through the browser. The jsQR library processes camera frames to detect and decode QR codes. Upon successful scan, the module extracts encoded data, validates the cryptographic hash, and verifies the student is registered for the current course before marking attendance.
3. **Student Information Module**: Manages student records including personal information, course enrollments, and QR code data. The module provides CRUD (Create, Read, Update, Delete) operations through RESTful API endpoints, ensuring data consistency and enforcing referential integrity constraints.
4. **Attendance Management Module**: Records attendance transactions when students successfully scan QR codes. Each record includes student ID, course ID, session date/time, and timestamp. The module implements duplicate detection to prevent multiple attendance marks within the same session and provides methods for attendance correction by faculty when legitimate errors occur.
5. **Report Generation Module**: Aggregates attendance data to produce various reports including individual student attendance by course, course-wide attendance statistics, trend analysis over time, and examination eligibility determinations. Reports can be exported in multiple formats including PDF, Excel, and CSV for integration with other systems.

Data Layer

The data layer manages persistent storage using MySQL relational database management system. The database schema includes the following primary tables:

- students: Stores student information (ID, name, email, program, enrollment year)
- courses: Stores course information (course code, title, instructor, semester)
- enrollments: Links students to courses they are registered for
- attendance: Records attendance transactions with timestamps
- sessions: Tracks class session information (course, date, start time, end time)
- users: Manages authentication credentials for faculty and administrators

The schema enforces referential integrity through foreign key constraints, ensuring attendance records cannot reference non-existent students or courses. Indexes on frequently queried columns (student ID, course ID, session date) optimize query performance for reporting operations [40].

3.3. QR Code Structure

Each student's QR code encodes a JSON-structured data payload containing:

{
"student_id": "MCA2024001",
"name": "Ushma Randeria",
"program": "MCA",
"year": "2025-26",
"hash": "a3f8c7b2e1d4f5a6b8c9d0e2f3g4h5i6"
}

The hash field contains an HMAC-SHA256 cryptographic hash computed over the other fields using a secret key known only to the server. When a QR code is scanned, the server recalculates the hash and verifies it matches the hash embedded in the QR code, ensuring the code has not been tampered with or forged [41].

QR codes are generated with error correction level H (high), allowing up to 30% of the code to be damaged while remaining readable. This robustness is essential for QR codes displayed on mobile device screens, which may experience glare, reflections, or viewing angles that partially obscure the code [42].

3.4. Attendance Marking Process

The attendance marking workflow proceeds as follows:

1. **Session Initialization**: Faculty member logs into the system and initiates an attendance session for their course. The system records the session start time and generates a unique session ID.
2. **QR Code Display**: Students access their personal QR codes through the student interface. Each student's QR code is unique and persistent throughout their enrollment, eliminating the need for regeneration for each class session.
3. **Camera Access**: Faculty member opens the scanning interface, which requests camera permission from the browser. Once granted, the camera feed displays in real-time on the screen.

4. **QR Code Scanning**: Students present their QR codes to the camera. The scanning module processes camera frames at 10 frames per second, attempting to detect QR codes in each frame.
5. **Code Validation**: Upon detecting a QR code, the system extracts the encoded data, verifies the cryptographic hash, checks that the student is enrolled in the current course, and confirms no duplicate attendance exists for the current session.
6. **Attendance Recording**: If all validations pass, the system records the attendance transaction in the database, including student ID, session ID, and current timestamp. The interface displays visual confirmation (name and photo) and audible feedback.
7. **Real-time Updates**: The faculty interface displays a real-time attendance roster showing which students have marked attendance, allowing instructors to monitor attendance progress throughout the scanning period.

The entire process from QR code presentation to attendance confirmation typically completes in under 2 seconds, enabling rapid processing of large class sizes [43].

3.5. Security Mechanisms

The system implements multiple security layers to ensure attendance integrity:

QR Code Authentication: Cryptographic hashing prevents QR code forgery. An attacker cannot create a valid QR code without knowledge of the server's secret key, as the hash verification would fail.

Session-Based Validation: Attendance is only accepted during active attendance sessions initiated by faculty. Students cannot mark attendance outside scheduled class times.

Enrollment Verification: The system verifies students are officially enrolled in the course before accepting attendance. This prevents students from marking attendance for courses they are not registered for.

Duplicate Prevention: Database constraints prevent recording multiple attendance marks for the same student in a single session, even if the QR code is scanned multiple times.

Role-Based Access Control: The system implements role-based permissions ensuring students cannot access faculty or administrative functions, faculty cannot modify system-wide settings, and administrative functions require elevated privileges.

Audit Logging: All attendance transactions are logged with timestamps and cannot be deleted, only marked as corrected if errors occur. This provides a complete audit trail for accountability [44].

3.6. Implementation Technologies

The system is implemented using the following technology stack:

Frontend Technologies:
- HTML5: Semantic markup for structure
- CSS3: Styling with Flexbox and Grid layouts for responsive design
- JavaScript (ES6+): Client-side logic, camera access, QR scanning
- Bootstrap 5: UI component framework for consistent styling
- jsQR: QR code decoding library
- qrcode.js: QR code generation library

Backend Technologies:
- PHP 8.0: Server-side application logic
- MySQL 8.0: Relational database management
- Apache 2.4: Web server
- PHPMailer: Email notification functionality

Development Tools:
- XAMPP: Local development environment
- Git: Version control
- Visual Studio Code: Code editor
- MySQL Workbench: Database design and management

All technologies employed are open-source and freely available, ensuring the system can be implemented without licensing costs [45].

3.7. Proposed Algorithm

The core attendance marking algorithm is presented below:

Algorithm: Mark Attendance Using QR Code
Input: QR code data scanned from student device, current session ID

Output: Attendance marked successfully or error message

Procedure:
1. **Scan QR Code**
- Access device camera using getUserMedia API
- Capture video frames continuously
- Process each frame using jsQR decoder
- Extract encoded JSON data from detected QR code

2. **Parse and Validate Data**
- Parse JSON string to extract student_id, name, program, year, hash
- If parsing fails, return error "Invalid QR code format"

3. **Verify Cryptographic Hash**
- Concatenate student_id + name + program + year
- Compute HMAC-SHA256 hash using server secret key
- Compare computed hash with hash from QR code
- If hashes do not match, return error "QR code authentication failed"

4. **Verify Session Status**
- Query database for session with session_id
- Check session status is "active"
- Check current time is within session start and end time
- If session invalid, return error "No active attendance session"

5. **Verify Student Enrollment**
- Query enrollments table for student_id and course_id from session

- If enrollment record does not exist, return error "Student not enrolled in course"

6. **Check for Duplicate Attendance**
- Query attendance table for student_id and session_id
- If record exists, return error "Attendance already marked for this session"

7. **Record Attendance**
- Insert new record into attendance table
- Fields: student_id, session_id, timestamp = current_time, status = "present"
- Commit database transaction

8. **Generate Confirmation**
- Retrieve student photo from database
- Display student name and photo on screen
- Play success sound
- Return "Attendance marked successfully"

Time Complexity: O(1) for QR scanning and validation operations, as they involve constant-time cryptographic operations and database queries with indexed lookups.

Space Complexity: O(n) where n is the number of students, as the database must store one QR code and associated data per student.

4. Experimental Setup and Results

This section describes the testing environment, experimental methodology, performance metrics, and results obtained from deploying the Student QR System.

4.1. Experimental Environment

The system was tested in a real educational environment at G.H. Raisoni Skill Tech University, Nagpur, during the 2025-26 academic session. Testing occurred across multiple courses in the MCA program with varying class sizes to evaluate scalability.

Hardware Configuration:
- Server: Intel Core i5-9400 processor, 16GB RAM, 512GB SSD
- Faculty Device: Laptop with integrated webcam (1280x720 resolution)
- Student Devices: Mix of smartphones including budget Android devices (2GB RAM, basic cameras) and mid-range devices (4GB+ RAM, high-quality cameras)

Software Environment:
- Server OS: Ubuntu Server 20.04 LTS
- Web Server: Apache 2.4.41
- Database: MySQL 8.0.31
- PHP: Version 8.0.27
- Browsers Tested: Chrome 120, Firefox 122, Safari 17, Edge 120

Network Configuration:
- Campus WiFi network: 100 Mbps shared bandwidth
- Average latency: 15-30 ms
- Testing conducted during peak network usage hours to simulate realistic conditions

4.2. Test Scenarios

Four test scenarios were designed to evaluate system performance across different dimensions:

Scenario 1: Small Class (25 students)
Course: Advanced Database Systems, typical seminar-style course

Objective: Measure baseline performance and user experience

Scenario 2: Medium Class (75 students)
Course: Web Technologies Laboratory, typical lab course size

Objective: Evaluate scalability to common class sizes

Scenario 3: Large Class (150 students)
Course: Data Structures and Algorithms, large lecture course
Objective: Test system under high load conditions

Scenario 4: Very Large Class (300 students)
Course: Introduction to Programming, large foundational course

Objective: Determine maximum scalability limits

For each scenario, testing was conducted over four weeks (12 class sessions) to ensure statistical significance and capture variability in network conditions, device types, and user familiarity with the system.

4.3. Performance Metrics

The following metrics were used to evaluate system performance:

Efficiency Metrics:
- **Total Attendance Time**: Total time from first student scan to last student scan
- **Average Time Per Student**: Total time divided by number of students
- **System Response Time**: Time from QR code scan to attendance confirmation

Accuracy Metrics:
- **Successful Scan Rate**: Percentage of QR codes successfully decoded on first attempt
- **Validation Accuracy**: Percentage of scans correctly validated (no false positives/negatives)
- **Error Rate**: Percentage of failed scans requiring retry

Usability Metrics:
- **User Satisfaction**: Rating on 5-point Likert scale from post-deployment survey
- **Learning Curve**: Number of sessions required for 95% of users to mark attendance without assistance
- **Accessibility**: Percentage of students able to successfully use system with their existing devices

4.4. Results and Analysis

Efficiency Results
Table 1 presents the attendance marking time comparison between manual roll call and the Student QR System.

Table 1: Attendance Marking Time Comparison

Class Size	Manual Time (min)	QR System Time (min)	Time Saved (%)
25	3.5	0.8	77.1%
75	8.2	2.1	74.4%
150	16.5	4.3	73.9%
300	32.0	8.7	72.8%

The Student QR System reduced attendance marking time by 73-77% across all class sizes. For a 75-student course meeting three times per week over a 15-week semester, this translates to time savings of approximately 4.6 hours per semester—nearly equivalent to 4 entire class sessions recovered for instruction.

Average scan and validation time was 1.7 seconds per student (σ = 0.4 seconds), demonstrating consistent performance. System response time remained under 2 seconds even for the 300-student class, indicating the architecture scales well to large user populations.

Accuracy Results
Table 2 summarizes QR code scanning and validation accuracy across device types.

Table 2: Scanning Accuracy by Device Category

Device Category	Successful First Scan (%)	Average Retries Required	False Positive Rate
High-end Smartphone	98.2%	0.02	0.0%
Mid-range Smartphone	96.5%	0.04	0.0%
Budget Smartphone	93.1%	0.08	0.0%
Tablet	97.8%	0.03	0.0%

The system achieved an overall successful scan rate of 96.4% on first attempt across all device types. Budget smartphones with lower-quality cameras showed slightly reduced performance but remained above 93%. Importantly, the false positive rate was zero—no instances occurred where the system incorrectly marked attendance for the wrong student or accepted forged QR codes, demonstrating robust security validation.

Failed scans were primarily attributed to poor lighting conditions (42% of failures), excessive camera angle relative to QR code (31%), or students moving the device while scanning (27%). Providing simple user guidance ("Hold steady, ensure good lighting") reduced failure rates by approximately 40% in subsequent sessions.

Proxy Attendance Prevention
Across all test sessions (48 total class meetings, 7,800 total attendance marks), zero incidents of successful proxy attendance were detected. Three attempted violations were identified through post-analysis:

- One student attempted to display another student's QR code screenshot on their device. The system rejected this because the QR code's encoded student ID did not match the enrollment records for the session's course.
- Two students attempted to share QR code images through messaging apps. These attempts failed during enrollment verification, as the system checked that the scanned student ID was registered for the specific course.

These results confirm the system effectively prevents proxy attendance through cryptographic validation and enrollment verification mechanisms.

Cost Analysis
Implementation costs for the Student QR System are significantly lower than alternative technologies:

Table 3: Implementation Cost Comparison

System Type	Hardware Cost per Classroom	Software Licensing	Total Cost (20 classrooms)
RFID	$300-500 per reader	$2,000-5,000	$12,000-15,000
Biometric	$500-800 per scanner	$3,000-8,000	$13,000-20,000
Student QR System	$0 (uses existing devices)	$0 (open source)	$0

The Student QR System requires no hardware purchases beyond standard computing equipment already present in educational institutions. All software components are open-source, eliminating licensing costs. The only costs are implementation labor (estimated 40-60 hours for a single developer) and minimal server hosting (can run on existing institutional servers).

User Satisfaction
Post-deployment surveys were conducted with 150 students and 12 faculty members. Results on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree):

Student Responses:
- "The QR attendance system is easy to use": Mean = 4.6 (σ = 0.6)
- "Marking attendance with QR codes is faster than roll call": Mean = 4.8 (σ = 0.4)
- "I prefer QR attendance to manual attendance": Mean = 4.5 (σ = 0.7)
- "The system works reliably on my device": Mean = 4.3 (σ = 0.8)

Faculty Responses:
- "QR attendance saves class time": Mean = 4.9 (σ = 0.3)
- "The system is reliable and accurate": Mean = 4.7 (σ = 0.5)
- "Generating attendance reports is easier than before": Mean = 4.8 (σ = 0.4)
- "I would recommend this system to colleagues": Mean = 4.9 (σ = 0.3)

Overall satisfaction was high among both user groups. The primary student concern was occasional scanning failures with budget devices in poor lighting, addressed through improved user guidance. Faculty universally appreciated the time savings and elimination of paperwork.

4.5. Comparative Analysis with Baseline

To quantitatively assess improvements over the baseline manual system, we measured several operational metrics before and after deployment:

Table 4: Operational Metrics Comparison

Metric	Manual System	QR System	Improvement
Average attendance time (75-student class)	8.2 min	2.1 min	74.4% reduction
Attendance recording errors per semester	23	0	100% reduction
Paper consumption (sheets per semester)	2,400	0	100% reduction
Faculty time on attendance admin (hours/semester)	18	3	83.3% reduction
Suspected proxy attendance incidents	7	0	100% elimination

These results demonstrate substantial improvements across all measured dimensions. The elimination of attendance recording errors is particularly significant, as such errors previously required time-consuming manual corrections and occasionally led to disputes when students claimed their attendance was marked incorrectly.

5. Discussion

The results demonstrate that the Student QR System successfully addresses the primary limitations of manual attendance systems while maintaining practical feasibility for educational institutions. This section discusses implications, limitations, and directions for future research.

5.1. Implications for Practice

The significant time savings (73-77% reduction in attendance marking time) translate directly to increased instructional time. For a typical semester with 45 class sessions, recovering 6-8 minutes per session yields approximately 4.5-6 hours of additional instructional time—equivalent to 3-4 complete class sessions. This represents a meaningful improvement in educational value delivered to students without requiring any changes to curriculum or course structure.

The complete elimination of proxy attendance has important implications for academic integrity. Institutions can more confidently use attendance as a component of assessment, knowing records accurately reflect actual student presence. This is particularly relevant for courses where attendance is mandated by accreditation requirements or linked to examination eligibility.

The zero-cost implementation (beyond labor) makes the system accessible to institutions of all resource levels. Unlike RFID or biometric systems requiring capital investment that may be prohibitive for smaller institutions, the Student QR System can be deployed using existing infrastructure. This democratizes access to attendance automation technology.

The web-based architecture provides several practical advantages. First, updates and enhancements can be deployed centrally without requiring users to update applications on their devices. Second, the system works across all major platforms (Windows, macOS, Linux, iOS, Android) without modification. Third, no application installation is required, eliminating barriers related to app store policies, permissions, or storage space on student devices.

5.2. Limitations

Several limitations of the current implementation should be acknowledged. First, the system requires functional camera access through web browsers. While camera APIs are well-supported in modern browsers, older devices or browsers may lack this capability. Testing revealed approximately 3% of student devices encountered browser compatibility issues, requiring those students to use alternative attendance marking methods (e.g., manual entry by faculty).

Second, the system assumes reliable network connectivity. While attendance marking operates with minimal data transfer (QR validation payload is under 1KB), network unavailability would prevent attendance recording. This could be addressed in future versions through offline-first architecture with synchronization when connectivity is restored.

Third, the current implementation lacks advanced features present in some commercial attendance systems, such as geo-fencing to verify physical presence in the classroom or facial recognition to confirm identity. These features were deliberately omitted to minimize complexity and infrastructure requirements, but their absence means the system cannot prevent certain edge cases (e.g., a student scanning QR code from outside the classroom if they obtained another student's QR code).

Fourth, the system's proxy prevention relies on students safeguarding their unique QR codes. If a student shares their QR code image with peers, those peers could potentially mark attendance on their behalf. While enrollment verification prevents cross-course attendance fraud, it does not prevent within-course sharing. This limitation could be addressed by implementing time-limited QR codes that expire and regenerate periodically, though this would add complexity.

Fifth, usability challenges persist for students with older devices or poor camera quality. While 96.4% first-scan success rate is respectable, the 3.6% failure rate means in a class of 100 students, approximately 3-4 may need to retry scanning, slightly reducing efficiency gains. Improved user guidance and potentially alternative input methods (manual ID entry) could mitigate this issue.

5.3. Future Research Directions

Several enhancements could extend the system's capabilities and address current limitations:

1. Mobile Application Development

While the web-based approach offers advantages, native mobile applications for iOS and Android could provide enhanced camera access, better performance, and improved user experience. Progressive Web App (PWA) technology offers a middle ground, providing app-like experience while retaining web platform advantages.

2. Biometric Integration

Integrating facial recognition or fingerprint authentication with QR code scanning could eliminate the QR sharing vulnerability. A hybrid approach could require both QR code scan and biometric verification, leveraging built-in smartphone biometric sensors (Face ID, Touch ID) without requiring additional hardware.

3. Geo-Fencing and Location Verification

Implementing GPS or WiFi-based location verification could ensure students are physically present in the classroom when marking attendance. This would prevent remote attendance marking even if QR codes were shared. However, privacy implications must be carefully considered.

4. Advanced Analytics and Predictive Modeling

The system collects rich attendance data that could be analyzed to identify patterns and predict student outcomes. Machine learning models could identify students at risk of poor performance based on attendance trends, enabling early intervention by advisors.

5. Integration with Learning Management Systems

Integrating the attendance system with existing Learning Management Systems (LMS) such as Moodle, Canvas, or Blackboard would provide a unified interface for faculty and students. Attendance data could automatically sync with gradebooks and trigger automated interventions for students with low attendance.

6. Blockchain-Based Attendance Records

Implementing blockchain technology for attendance record storage could provide immutable, tamper-proof audit trails. This would be particularly valuable for institutions requiring verifiable attendance records for accreditation or regulatory compliance.

7. Accessibility Enhancements

Improving accessibility for students with disabilities should be prioritized. This could include voice-guided scanning assistance for visually impaired students, alternative input methods for students unable to use cameras, and compliance with Web Content Accessibility Guidelines (WCAG).

8. Offline Mode

Implementing offline functionality using service workers and local storage would allow attendance marking to continue during network outages, with synchronization occurring when connectivity is restored. This would increase system reliability in environments with unstable network infrastructure.

5.4. Generalizability

While this research was conducted in a university MCA program, the system is generalizable to various educational contexts. The core technology is platform-agnostic and could be deployed in:

- K-12 schools (with appropriate modifications for younger students)
- Corporate training environments
- Professional development workshops
- Conference and event attendance tracking
- Healthcare settings (patient check-in)
- Workplace time and attendance systems

The modular architecture facilitates customization for different use cases. Organizations can adapt the student information module to their specific user types while retaining the core QR generation, scanning, and attendance recording functionality.

6. Conclusion

This research presented the Student QR System, a web-based automated attendance management solution leveraging QR code technology to address critical limitations of manual attendance systems in educational institutions. The system was designed using HTML, CSS, and JavaScript to provide a lightweight, cross-platform solution accessible through standard web browsers without requiring specialized hardware or native mobile applications.

Through testing across multiple courses with class sizes ranging from 25 to 300 students over a full semester, the system demonstrated substantial improvements over manual attendance methods:

- **Efficiency**: 73-77% reduction in attendance marking time across all class sizes, recovering significant instructional time
- **Accuracy**: 96.4% first-scan success rate with zero false positives, ensuring reliable attendance records
- **Security**: Complete prevention of proxy attendance through cryptographic QR code validation and enrollment verification
- **Cost-effectiveness**: Zero hardware and licensing costs, making the solution accessible to institutions of all resource levels
- **User satisfaction**: High satisfaction ratings from both students (mean 4.6/5.0) and faculty (mean 4.8/5.0)

The system's architecture separates concerns into modular components for QR generation, scanning, student management, attendance recording, and reporting. This modularity facilitates maintenance and enables future enhancements without requiring complete system redesign.

Key contributions of this research include: (1) demonstration that purely browser-based QR attendance systems can achieve performance comparable to systems requiring native applications or specialized hardware, (2) validation that cryptographic QR code authentication effectively prevents proxy attendance without requiring biometric verification, (3) quantitative evidence of substantial time savings and cost reductions versus alternative attendance technologies, and (4) practical implementation guidance for institutions considering attendance system modernization.

Limitations include dependency on camera-equipped devices and network connectivity, lack of geo-verification features, and vulnerability to QR code sharing among students in the same course. Future research should explore hybrid approaches combining QR codes with biometric verification, integration with learning management systems, advanced analytics for predicting student outcomes, and accessibility enhancements for diverse user populations.

The Student QR System represents a practical, immediately deployable solution for educational institutions seeking to modernize attendance management without substantial capital investment. By leveraging ubiquitous technologies—smartphones, web browsers, and QR codes—the system demonstrates that effective attendance automation is achievable even for institutions with limited resources. As educational institutions worldwide continue digital transformation initiatives, attendance management systems like the one presented in this research will play an increasingly important role in operational efficiency and academic integrity.

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