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Implementation of a QR Code-Based Attendance System to Support Student Attendance Management at SMA Negeri 2 Cimalaka

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ABSTRACT

Student attendance is a routine administrative activity in schools, but manual recording can make attendance data difficult to consolidate and use for reporting. This study addressed the need for an integrated attendance workflow at SMA Negeri 2 Cimalaka, Sumedang, Indonesia. The objective was to implement a web-based attendance application that connects daily attendance recording with student data management and administrative tasks. The system was developed for three user roles: students, teachers, and administrators. Its functions include time-limited QR Code attendance, teacher-assisted attendance recording, student roster import, account activation, attendance correction, monitoring, and PDF report generation. Functional verification was conducted using automated tests covering the main business rules and data-processing components. The verification comprised 100 automated tests across 15 test suites, and all tests passed. The results indicate that the tested components operated according to their defined conditions. However, the evaluation did not include before-and-after measurements of attendance processing time, a formal user satisfaction survey, or dedicated load testing during a full school attendance session. Therefore, the findings establish functional operation rather than a measured improvement in efficiency or user satisfaction. Further evaluation should examine processing time, user experience, and system behavior under varying network conditions and concurrent attendance requests.

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Introduction

Student attendance is part of routine school administration. Attendance records are

used to identify student presence and to prepare information needed by teachers and school administrators. The move from paper records to digital systems has also become part of the wider use of information technology in schools (Nishom et al., 2023; Timotheou et al., 2023). For attendance management, a digital system can store attendance records in a central database and make the records available for later monitoring and reporting.

Before this system was implemented, SMA Negeri 2 Cimalaka in Sumedang used manual attendance records. Attendance information from different classes had to be collected and managed manually. The records were also kept in physical form. As a result, attendance data was not immediately available as a single digital record for monitoring and reporting. This situation led to the need for an attendance system that could handle the recording process as well as the related administrative work. Similar problems have been reported in previous studies. Herlina and Hidayatulloh (2017) developed a web-based student attendance system using QR Code for a junior high school where attendance was previously recorded using conventional books. (Vitriani et al., 2023) further demonstrated that web-based QR Code attendance provides a structured approach for real-time attendance data consolidation. Both studies show the use of QR Code as a practical mechanism for recording student attendance.

QR Code attendance, however, is only one part of the attendance process. A school system also has to deal with student data, user access, attendance monitoring, and records that cannot be produced through scanning. A recent implementation at SMK Muhammadiyah Campaka, Purwakarta, for example, combined web-based attendance for students and teachers with QR Code integration (Nusantara et al., 2025). Other recent studies have also highlighted the integration of dynamic QR Codes and role-based access for student attendance tracking in secondary schools (Endriartono et al., 2026; Juhriah & Leyla Rahmah, 2024; Sintiyawati et al., 2026).

This study addresses that issue at SMA Negeri 2 Cimalaka. The system was developed as a single web application with three user roles: student, teacher, and administrator. Students use the system to access attendance and attendance history. Teachers can display the attendance QR Code, monitor the attendance of students in their classes, and record attendance manually. Administrators manage student data, student account activation, attendance corrections, and attendance reports. The QR Code used for attendance is generated as a time-limited session and is replaced every five minutes. Manual attendance is retained because not every attendance case can be handled through QR scanning.

The administrative functions are also part of the implementation. Student data can be imported from Excel files and used as the basis for attendance records. Attendance corrections require a reason and are recorded in an audit trail. Attendance data can then be used to produce PDF reports. These functions connect the attendance process with the data management tasks that follow it. The system is therefore intended to support the complete attendance workflow used by the school rather than only the QR Code scanning step.

The contribution of this work is consequently not the introduction of QR Code as a new attendance technology. QR Code-based attendance has already been reported in previous studies. The focus here is the implementation of a school attendance workflow that combines QR Code attendance, teacher-assisted attendance, student roster management, account activation, administrative correction, monitoring, and reporting in one system. The system was implemented according to the operational requirements identified at SMA Negeri 2 Cimalaka. The evaluation in this study is limited to implementation and functional testing. No before-and-after measurement of attendance processing time and no formal user satisfaction survey were conducted. Therefore, the study does not use those measures to claim a quantitative improvement in efficiency or user satisfaction.

The objective of this study is to implement a web-based student attendance system using QR Code according to the operational requirements of SMA Negeri 2 Cimalaka. The implementation covers user authentication, QR Code attendance, teacher-assisted attendance recording, student data management, account activation, attendance correction, monitoring, and reporting. Functional testing is used to examine whether the implemented functions operate according to the defined scenarios.

Method

This study used an implementation-based approach to develop and apply a web-based student attendance system at SMA Negeri 2 Cimalaka (Pressman & Maxim, 2020; Sommerville, 2016). The work was carried out through five stages: requirements identification, system design, implementation, functional testing, and system application. Requirements were identified by observing the existing attendance process and discussing the operational needs of the school (Creswell & David Creswell, n.d.). The identified requirements covered three user roles, namely students, teachers, and administrators, together with attendance recording, student data management, account activation, attendance correction, and reporting. The system was implemented as a web application using Next.js, React, and TypeScript for the application layer (Eko Nugroho et al., 2026), Tailwind CSS for the user interface, and a relational database for storing user, student, and attendance data.

The attendance workflow was implemented using a time-limited QR Code session, while teachers were provided with a manual attendance function for cases that could not be handled through QR scanning. Functional verification was then performed using automated tests for the main business rules and data-processing components (Fariz Cahyo Hudi & Maisyarah Karyanti, 2023; Fatih & Chandra, 2025; Hidayat & Putri, 2019). The tests covered account activation, student data import, attendance scheduling, QR session management, attendance correction, attendance-history queries, and PDF generation. Each test case evaluated the function output against predefined assertions. The results were summarized descriptively according to whether the tested function satisfied the expected condition. The study did not include before-and-after measurements of attendance processing time or a formal survey of user satisfaction; therefore, these measures were not used to determine the effectiveness of the system.

Results and Discussion

1. System Implementation and User Roles

The implemented system provides a web-based attendance workflow for SMA Negeri 2 Cimalaka. Access is divided into three roles: student, teacher, and administrator. Each role has functions related to a different part of the attendance process. Students can access their attendance status, scan the active QR Code, and view their attendance history. Teachers can display the attendance QR Code, monitor attendance for their classes, and record attendance manually. Administrators manage student data, account activation, attendance corrections, and attendance reports.

The three roles are connected through the same attendance data. Student records provide the basis for class attendance lists, while attendance records can be viewed according to the user's access level. This separates daily attendance activities from administrative functions without creating separate systems for each role (Dennis et al., 2021; Krug, 2000). The main functions available to each role are summarized in Table 1.

Table 1. Main functions by user role.

Role	*Main function*
Student	Account activation, system login, QR Code attendance, and attendance history
Teacher	Display attendance QR Code, monitor class attendance, and record attendance manually
Administrator	Manage student and teacher data, activate accounts, correct attendance records, and generate reports



Fig. 1. Documentation of community service (PKM) activities at SMA Negeri 2 Cimalaka.

The student interface is intended for use from a mobile browser because QR Code attendance requires access to the device camera. The teacher interface provides the QR Code display and the class attendance page. The administrator interface is used for roster management, account activation, attendance correction, and reporting. The separation of these functions follows the attendance workflow identified during the requirements stage.

The implementation and socialization of the system were conducted directly at SMA Negeri 2 Cimalaka through user training and operational briefing for teachers and administrators, as documented in Figure 1.

2. QR Code Attendance Workflow

The main attendance process uses a QR Code displayed on the teacher's device or on a shared classroom screen. The QR Code is generated as a time-limited attendance session and is replaced every five minutes. When a student scans the displayed code, the system verifies the active session before recording the attendance entry. This prevents an old QR Code from remaining valid indefinitely.

The student completes the process through the QR scanning page in a mobile browser. The camera is used to read the QR Code, after which the attendance request is submitted to the system. The recorded attendance can then be viewed in the student's attendance history. Figure 2 shows the QR scanning interface used in this process.



Fig. 2. Student QR Code scanning interface.

The five-minute session period is part of the attendance logic rather than a property of the QR image itself. A new session replaces the previous one, so the code displayed during one attendance period is not intended to remain valid for later periods. The implementation therefore uses a rotating QR Code instead of a static code for daily attendance.

QR scanning is not the only way to record attendance. The system also provides a manual attendance function for teachers. This function is used when a student cannot complete the scanning process or when the attendance status needs to be recorded directly by the teacher. The available attendance statuses include on-time, late, permitted, sick, dispensation, and absent. The manual path is discussed further in the following subsection.

The QR Code workflow depends on access to a device camera and a network connection. These requirements are part of the operating conditions of the implemented system. They were not evaluated as performance measures in the functional verification. In particular, the available test evidence does not establish QR scanning performance across different phone models, lighting conditions, browsers, or network conditions. Those cases remain suitable for additional testing in the school environment.

3. Teacher Attendance Monitoring and Manual Recording

The teacher interface provides two functions used during the attendance process: monitoring class attendance and recording attendance manually. The attendance page displays the students in the selected class together with their current attendance status. This allows the teacher to see which students have already been recorded and which students still require an attendance status.

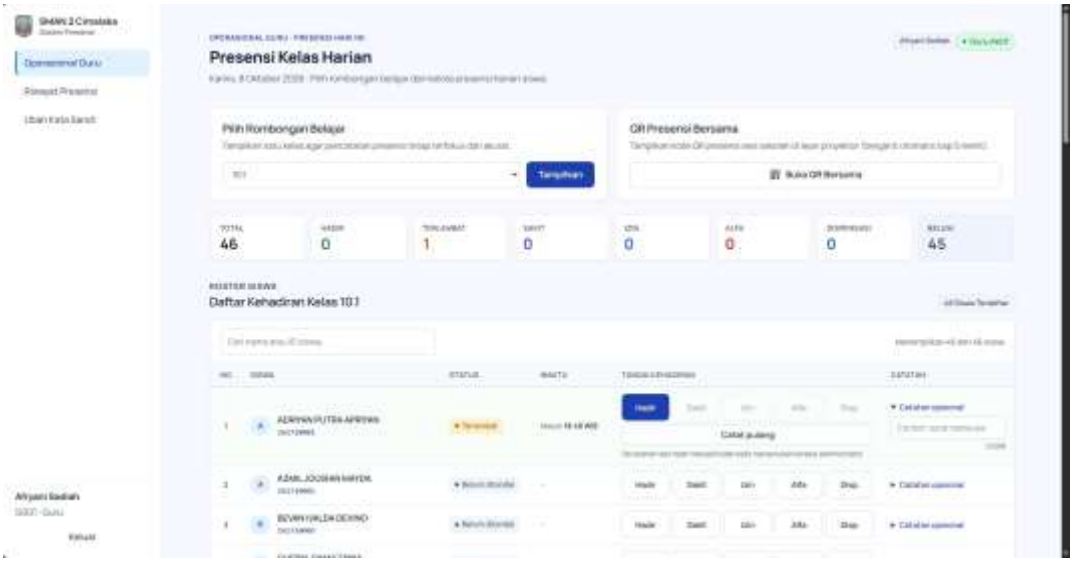


Fig. 3. Teacher dashboard for attendance monitoring.

Figure 3 shows the class attendance page used by the teacher. The page combines the attendance list with controls for changing a student's status. The teacher can use this page to record attendance directly when QR Code scanning is not suitable for a particular student. The same interface also provides access to the QR Code used for student attendance.

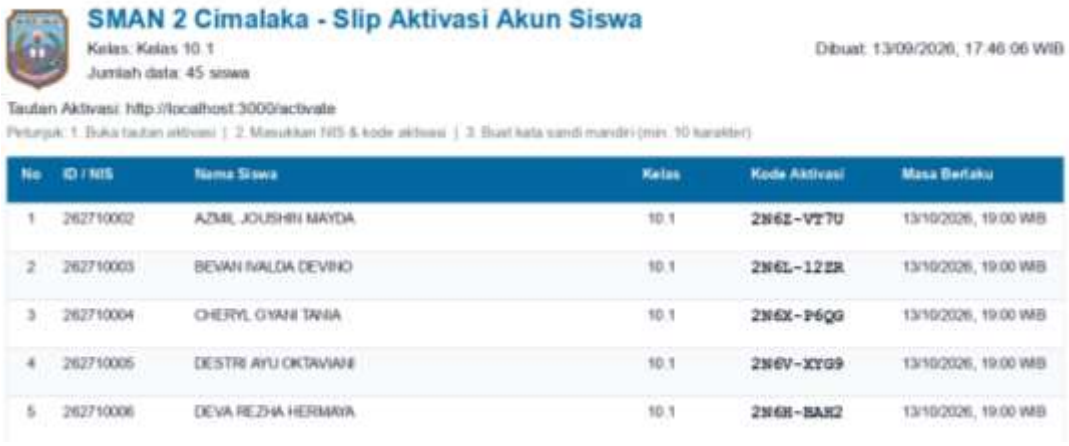
Manual recording function supports several attendance conditions, including present, sick, permitted, absent, and dispensation. This provides an alternative to QR scanning for cases that cannot be represented by a successful scan. The two recording paths therefore serve different parts of the same attendance process: students use the QR Code for regular attendance, while teachers can enter the attendance status when direct intervention is required.

Teacher interface is also useful for checking the attendance list during the attendance period. A student who has not completed a QR Code scan can remain visible in the class list until the teacher records the appropriate status. This makes the teacher page a working attendance list rather than only a QR Code display page.

The implementation does not treat manual recording as a separate attendance system. Both QR-based and teacher-recorded attendance are stored as part of the same attendance workflow. This is important for the subsequent monitoring, correction, and reporting functions because the attendance record does not depend on how the original status was entered.

4. Student Data Management and Account Activation

Student data is managed by the administrator and serves as the basis for the attendance records used by the system. The import process accepts student roster data from an Excel file. Before the data is stored, the administrator can map the spreadsheet columns, review the imported records, and validate the data. Records that do not meet the required conditions are identified during this process (Styefani & Utomo, 2025).



SMAN 2 Cimalaka - Slip Aktivasi Akun Siswa

Kelas: Kelas 10.1
Jumlah data: 45 siswa

Dibuat: 13/09/2026, 17.46.06 WIB

Tautan Aktivasi: http://localhost:3000/activate

Petunjuk: 1. Buka tautan aktivasi | 2. Masukkan NIS & kode aktivasi | 3. Buat kata sandi mandiri (min. 10 karakter)

No	ID / NIS	Nama Siswa	Kelas	Kode Aktivasi	Masa Berlaku
1	262710002	AZMIL JOUSHIN MAYDA	10.1	2N6Z-V2TU	13/10/2026, 19.00 WIB
2	262710003	BEVAN WALDA DEVINO	10.1	2N6L-12ZR	13/10/2026, 19.00 WIB
3	262710004	CHERYL GYANI TANIA	10.1	2N6X-P6QG	13/10/2026, 19.00 WIB
4	262710005	DESTRI AYU OKTAVIANI	10.1	2N6V-XYG9	13/10/2026, 19.00 WIB
5	262710006	DEVA REZHA HERMAYA	10.1	2N6R-BAR2	13/10/2026, 19.00 WIB

Fig. 4. Student data management and account activation output.

Figure 4 shows the output of the student account activation process. After the student records have been prepared, the administrator can generate activation information for the students. The activation code is provided to the student and is used to connect the existing student record with the account used to access the system.

Separation between roster management and account activation is useful in the school workflow. Student information can first be prepared as administrative data before access to the application is given to the student. This also allows account activation to be handled as part of the existing student administration process rather than requiring students to create accounts independently.

Activation mechanism uses a one-time code. The system does not store the activation code as plaintext. Instead, the code is processed into a cryptographic digest before it is stored (Muhammad Hilmiawan Sulthoni et al., 2025). This means that the activation information distributed to students is not kept in its original form in the database. The activation process is therefore tied to the student record while remaining separate from the student's regular attendance activity.

Import and activation functions also establish the data used by the teacher attendance page. Once the student records are available in the system, they can be used to construct class attendance lists and associate attendance records with the corresponding student. The student data process therefore takes place before the daily attendance transaction and supports the later monitoring and reporting functions.

5. Attendance Correction and Reporting

Attendance records may require changes after the initial attendance entry has been recorded. The system provides an administrative correction function for this purpose. Corrections are handled separately from the daily attendance process performed by students and teachers.

An administrator must provide a reason when changing an attendance record. The correction is then recorded in an audit trail together with the change. This provides a record of the administrative action and allows a later review of why an attendance status was changed.

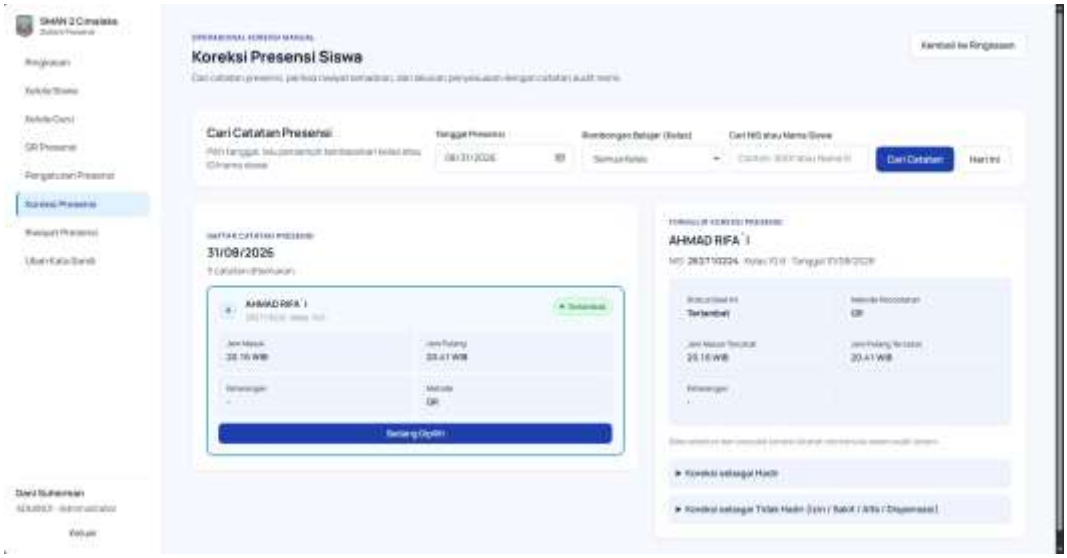


Fig. 5. Administrative attendance correction interface.

Figure 5 shows the administrative interface used to review and correct attendance records. The interface provides information about the selected attendance record and the available correction action. The correction process is therefore not limited to changing the displayed status; it also requires an explanation for the change.

The attendance records stored by the system can also be used to produce PDF reports. The report function provides a printable form of the stored attendance data for administrative use. The attendance report is generated in A4 landscape format and contains the selected attendance period, class information, attendance summary, and detailed attendance records.

The correction and reporting functions extend the attendance workflow beyond the initial QR Code scan, generating consolidated reports (Jaswa Ariansya & Titania Aulia Azahra, 2026). Attendance data can be reviewed, corrected when necessary, and subsequently prepared as an administrative document. This connects the daily attendance process with the activities required after attendance has been recorded.

6. Functional Verification

Functional verification was performed to check whether the main software components followed their defined rules. The verification focused on account activation, student data processing, attendance scheduling, QR session management, attendance correction, attendance-history queries, and PDF generation. The tests were implemented as automated test cases and evaluated the output of each function against predefined conditions.

Table 2. Automated functional verification of core system components.

No.	*Component*	*Verification focus*	*Expected condition*	*Result*
1	Account activation	Code format, hashing, and expiration	Activation codes follow the defined format and invalid or expired codes are rejected	Passed
2	Student data import	Excel parsing, column mapping, NIS validation, and duplicate handling	Student data is processed according to	Passed

			the defined validation rules	
3	Attendance schedule	Check-in and check-out time boundaries	Attendance status follows the configured schedule rules	Passed
4	QR session	Session rotation and token handling	QR sessions follow the defined five-minute validity period	Passed
5	Attendance correction	Reason validation and correction processing	A correction requires a non-empty reason and follows the defined correction rules	Passed
6	Attendance history	Date-range and record-limit validation	History queries follow the configured query limits	Passed
7	Activation slip PDF	Document structure and pagination	Activation slips follow the defined document structure	Passed
8	Attendance report PDF	Table structure and summary calculation	Attendance reports contain the expected structure and summary data	Passed

The verification results show that the tested components produced the expected results under their defined test conditions. The tests covered both input validation and processing rules. For example, the attendance tests examined the configured time boundaries, while the QR session tests examined the five-minute rotation logic. The Excel parser tests covered column mapping, student identification validation, and duplicate handling. The PDF tests examined document structure and pagination.

The verification was limited to the functions covered by the automated tests. It did not measure attendance processing time, user satisfaction, or system performance during a full school attendance session. Physical camera performance, projector readability, simultaneous QR scanning, and network conditions were also outside the scope of these tests. These conditions require separate testing in the school environment.

7. Discussion

The implementation shows that QR Code can be used as one part of a broader attendance workflow at SMA Negeri 2 Cimalaka. The system does not stop at recording a scan. Student data preparation, account activation, QR-based attendance, teacher-assisted recording, attendance correction, and reporting are connected within the same application. This arrangement follows the operational requirements identified during the implementation process.

The use of QR Code itself is not the main contribution of this work. Previous studies have already reported web-based attendance systems using QR Code. Herlina and Hidayatulloh (2017), for example, implemented QR Code attendance for junior high school students, while (Sintiyawati et al., 2026) developed a web-based dynamic QR Code attendance system for senior high school students. A more recent implementation by (Nusantara et al., 2025) combined student and teacher attendance with QR Code integration. The present implementation differs in its focus on combining QR attendance

with the administrative functions required at the target school, including student roster management, account activation, teacher-assisted attendance, attendance correction, and reporting.

The rotating QR session is another part of the implementation that needs to be considered in this context (Aryo Bagaskoro & Wantoro, 2025; Cinta et al., 2025). The QR Code is replaced every five minutes rather than being used as a permanent attendance code. This gives the attendance session a defined validity period. However, the implementation should not be interpreted as proof that proxy attendance or other forms of attendance abuse have been eliminated. The five-minute rotation is a technical rule implemented by the system, while its effectiveness against specific forms of misuse would require a separate evaluation.

The manual attendance function also has an operational role. QR Code scanning depends on the student's device and network connection, and some attendance cases require a status that cannot be represented by a successful scan. Allowing teachers to record attendance directly gives the school another way to complete the attendance record. In this implementation, the manual function is therefore part of the attendance workflow rather than a replacement for QR-based attendance.

The administrative functions extend the workflow beyond daily attendance recording. Student data imported from Excel becomes the basis for class attendance lists and user accounts. Attendance corrections require a reason and produce an audit record, while stored attendance data can be converted into PDF reports. These functions connect the initial student data preparation, daily attendance, administrative review, and reporting stages in one application.

The functional verification supports the behavior of the tested software components under their defined conditions. It does not provide evidence of a quantitative improvement over the previous attendance process. No before-and-after measurement of attendance processing time was collected, and no formal user satisfaction survey was conducted. For the same reason, the implementation cannot be used to claim a specific percentage of efficiency improvement, increased user satisfaction, or an improvement in student discipline.

Several implementation limitations remain. QR attendance requires camera access and a network connection. The available verification also does not establish performance across different mobile devices, browsers, lighting conditions, or network conditions. Concurrent scanning during a full school attendance session has not been evaluated through a dedicated load test. These conditions are relevant to the practical use of the system and should be examined in future evaluation.

Future work can therefore focus on measurements that are outside the scope of the current implementation. A before-and-after study could measure attendance processing time, while a usability study could collect feedback from students and teachers using formal frameworks (Dumoharis Lumbanraja et al., 2018; Rao & Setyadi, 2023; Vlachogianni & Tselios, 2023). Additional testing could also examine simultaneous attendance requests, different device and browser combinations, and operation under less stable network conditions. These evaluations would provide evidence for claims about operational impact that cannot be established from the current functional verification alone.

Conclusion

This study implemented a web-based student attendance system using QR Code at SMA Negeri 2 Cimalaka. The system integrates QR Code attendance, teacher-assisted attendance recording, student data management, account activation, attendance correction,

monitoring, and PDF reporting in one application. The implementation provides separate functions for students, teachers, and administrators according to their roles in the school attendance process.

Automated functional verification examined the main system components, including account activation, student data processing, attendance scheduling, QR session management, attendance correction, attendance-history queries, and PDF generation. The tested components produced the expected results under the defined test conditions. These results support the functional operation of the implemented system, but they do not establish a quantitative improvement in attendance processing efficiency or user satisfaction.

Further evaluation is needed to assess the system under actual attendance-session conditions. Future work should measure attendance processing time, collect feedback from students and teachers, and test the system under varying network conditions and concurrent scanning loads. Such evaluation would provide additional evidence of the system's operational benefits and limitations.

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