
Design of a Web-Based QR Code Attendance System with Real-Time Notifications at Darul Arqom Junior High School Karanganyar

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Keyword

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Abstract

The rapid development of information technology has encouraged educational institutions to implement digital transformation in administrative management, including student attendance systems in Islamic boarding schools. SMP Darul Arqom Karanganyar still uses a manual paper-based attendance system that often causes recording errors, delays in attendance recapitulation, difficulties in monitoring student attendance, potential data manipulation, and delays in delivering attendance information to parents. These problems indicate that the attendance management process is inefficient and requires a more integrated digital solution. This study aims to design and develop a web-based attendance system using QR Code technology integrated with real-time notifications to improve the efficiency, accuracy, and transparency of student attendance management. The novelty of this research lies in integrating QR Code-based attendance validation with automatic real-time notifications for parents in a system specifically designed for the Islamic boarding school environment. Unlike previous attendance applications that mainly focus on digital attendance recording, the proposed system emphasizes attendance transparency, fraud prevention, and direct communication between schools and parents. The system was developed using the Agile Development method through iterative sprint-based stages, including planning, design, development, testing, evaluation, and implementation. The system utilizes the CodeIgniter framework, MySQL database, and QR Code technology for attendance validation. The results show that the system accelerates the attendance process, minimizes fraudulent attendance practices, improves attendance data accuracy, and assists administrators in monitoring attendance data efficiently. In addition, the system increases information transparency through direct real-time notifications to parents. Therefore, the system can support administrative digitalization and student discipline management in Islamic boarding schools.

1. Introduction

Advances in information technology have brought significant changes to various sectors, including education [1]. Residential educational institutions such as Islamic boarding schools are required to adapt to technological

developments, particularly in administrative management and the monitoring of students' activities[2]. One important aspect of this management is the student attendance system, which serves as an indicator of discipline and a means of monitoring daily activities. However, the attendance process, which is still conducted manually, is considered ineffective because it is prone to recording errors, data manipulation, and delays in conveying information to relevant parties[3].

In the boarding school environment, monitoring student attendance is of utmost importance because it is directly linked to character development and discipline. Manual attendance systems often present various challenges, such as proxy attendance, errors in data compilation, and difficulties in monitoring by school administrators [4]. Furthermore, conventional record-keeping is time-consuming and increases the administrative burden on boarding school administrators [5]. Therefore, a digital attendance system is needed to improve efficiency, data accuracy, and transparency regarding student attendance information[6].

One technology that can be implemented in modern attendance systems is the QR code. This technology enables the attendance validation process to be carried out quickly by scanning a unique code using a mobile device. The use of QR codes is considered more efficient than conventional methods or other attendance devices such as fingerprint scanners because the implementation costs are lower and they are easy to use[7]. Additionally, QR code-based systems can minimize attendance manipulation because each student has a unique identification code [8]. This technology also supports contactless attendance, making it more practical for use in educational settings with a large number of users [9].

The implementation of a web-based attendance system is a relevant solution for supporting the digitization of boarding school administration. Web-based systems allow for flexible data access via various devices without the need to install additional applications [10]. Boarding school administrators can monitor attendance in real-time, centrally manage attendance data, and generate automated reports more quickly and accurately [11]. Additionally, web-based systems support integration with other technologies, such as automated notifications and cloud-based data storage[12].

Real-time notification features are a key component in enhancing information transparency between the boarding school and students' guardians. With automatic notifications, guardians can quickly receive information on student attendance without having to wait for manual reports from school administrators[13]. This system makes it easier for parents to monitor their children's attendance in real time and increases family involvement in the educational process. This system makes it easier for parents to monitor their children's attendance in real time and increases family involvement in the educational process [14].

In the system development process, selecting the right framework is a key factor in supporting application performance and management. The CodeIgniter framework was chosen because it has a lightweight, fast structure and implements the Model-View-Controller (MVC) concept, which facilitates system development and maintenance [15]. CodeIgniter's modular architecture allows for more flexible development of additional features, such as a monitoring dashboard, attendance statistics reports, and integration with external API services [16]. CodeIgniter's modular architecture allows for more flexible development of additional features, such as a monitoring dashboard, attendance statistics reports, and integration with external API services [17].

Darul Arqom Junior High School in Karanganyar, as a pesantren-based educational institution, has a structured schedule of student activities and requires an effective attendance monitoring system. However, the current manual attendance system is unable to provide timely, accurate, and integrated information [18]. This situation often leads to delays in reporting and makes it difficult for administrators to effectively monitor student attendance [19]. Therefore, a web-based attendance system utilizing QR Code technology with real-time notification support is needed to enhance administrative efficiency and the transparency of attendance information[20].

Based on these issues, this study aims to design and develop a web-based QR Code attendance system with real-time notifications at SMP Darul Arqom Karanganyar. The developed system is expected to assist boarding school administrators in the automated management of attendance, improve the accuracy of attendance data, and strengthen communication between the school and students' guardians[21]. In addition to supporting administrative efficiency, the implementation of this system is also expected to be part of the digital transformation of boarding school management toward modern and integrated educational governance [22].

2. Research Method

2.1 Research Phases

This study employs the Agile Development method due to its flexible, iterative, and adaptive nature, allowing the system to accommodate changes in user requirements throughout the development process [23]. The Agile method was selected because the web-based attendance system requires continuous evaluation and refinement to meet the operational needs of boarding school administrators and students' guardians. The development process was divided into three sprint iterations, where each sprint focused on implementing and evaluating specific system features. At the end of every sprint, user feedback was collected and used as the basis for system improvement in the next iteration. The research phases are described as follows:

1. Problem Identification

The initial phase involved observing the student attendance process at SMP Darul Arqom Karanganyar, which is still conducted manually using paper-based records. Several problems were identified, including delays in attendance recording, difficulties in attendance recapitulation, limited monitoring of student attendance, the risk of attendance data manipulation, and delays in delivering attendance information to parents. In addition, attendance documents and Standard Operating Procedures (SOPs) were collected as supporting data for system requirements analysis.

2. Planning

During this phase, system requirements were identified and organized into a product backlog based on user priorities. The planned system features included user authentication, QR Code-based attendance validation, attendance monitoring dashboards, attendance recapitulation, and real-time notification integration for students' guardians. The development process was divided into several short sprints to facilitate gradual feature implementation and evaluation. In addition, the development environment was prepared using the CodeIgniter framework and MySQL database.

3. Design

The design phase translated system requirements into technical system models using the Unified Modeling Language (UML). The design process included creating Use Case Diagrams, Activity Diagrams, and Entity Relationship Diagrams (ERDs) to describe system workflows and data relationships. The system architecture was designed using the Model-View-Controller (MVC) concept provided by the CodeIgniter framework to ensure a structured, maintainable, and scalable development process [24], Interface prototypes were also developed and evaluated during each sprint to ensure usability and user convenience.

4. Development

System development was conducted incrementally in three sprint iterations. The first sprint focused on login authentication and user management features. The second sprint implemented QR Code attendance scanning and attendance validation. The third sprint focused on attendance reporting and real-time WhatsApp notification integration. Each completed feature was directly tested and evaluated before proceeding to the next sprint iteration. The system also integrated a MySQL database for attendance data storage and management.

5. Testing and Evaluation

Testing was conducted at the end of every sprint iteration to ensure all implemented features functioned properly before proceeding to the next development stage. Testing activities included

validating login functionality, QR Code scanning, attendance data storage, dashboard functionality, and notification delivery processes. Sprint evaluations involved direct feedback from administrators and boarding school staff regarding usability, interface clarity, system performance, and feature effectiveness. The evaluation results were analyzed and used as the basis for feature refinement and system improvements in subsequent iterations. This iterative evaluation process reflects the adaptive characteristics of Agile Development.

6. Implementation

The final phase involved deploying the system on a server environment so that the application could be accessed online by administrators, boarding school staff, and students' guardians. The system was then implemented directly in the student attendance process at SMP Darul Arqom Karanganyar. Final evaluations were conducted to ensure all features operated optimally and fulfilled user requirements. The implementation results demonstrated that the system could support attendance management more efficiently, improve attendance monitoring, and accelerate the delivery of attendance information to parents in real time.

2.2 System Architecture Design

The system architecture design was carried out using the Unified Modeling Language (UML) to visualize workflows and user interactions within the system [25].

2.2.1 Use Case Diagram

The Use Case Diagram illustrates the interactions between users and the QR Code attendance system. There are three main actors: the administrator, the homeroom teacher, and the student's guardian. The administrator is responsible for managing attendance data and reports; students check in using the QR Code; and the student's guardian receives notifications and monitors the student's attendance.

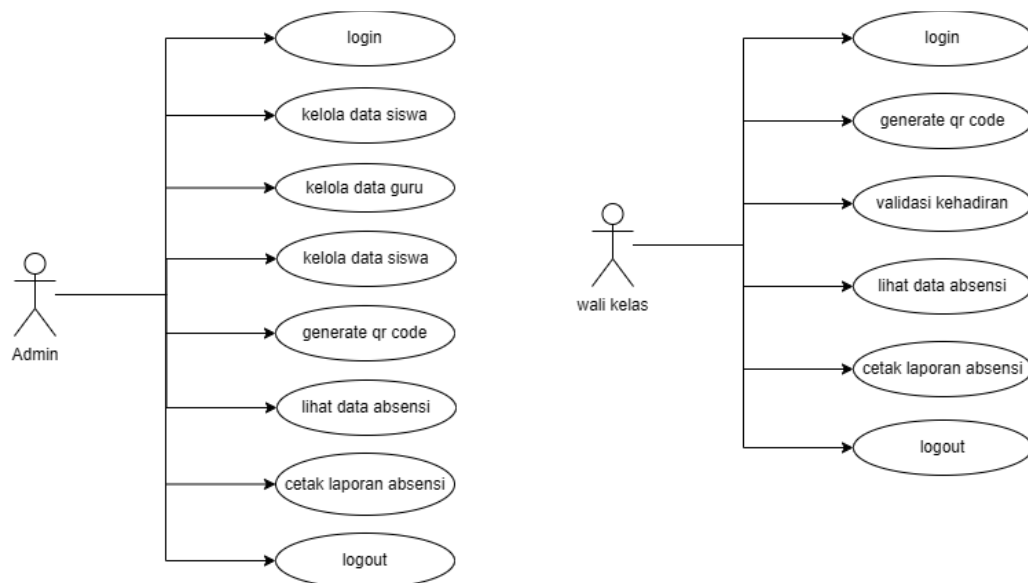


Figure 1. Use Case Diagram

2.2.2 Activity Diagram

The Activity Diagram illustrates the attendance process flow, starting with the user login process, QR code scanning by students, validation of attendance data by the system, data storage in the database, and the sending of real-time notifications to parents. If the validation process is successful, the system will display the attendance status and automatically update the attendance report.

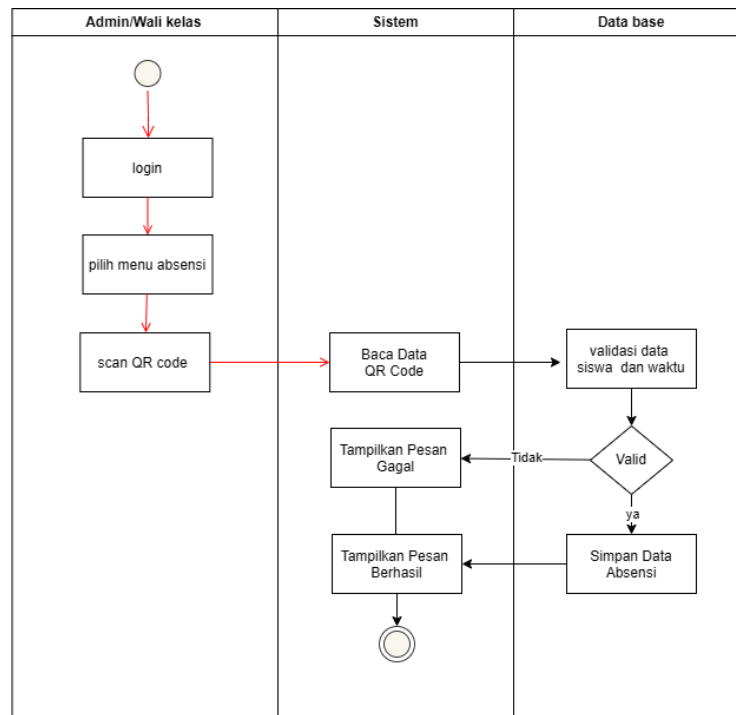


Figure 2. Activity Diagram of the Attendance Process

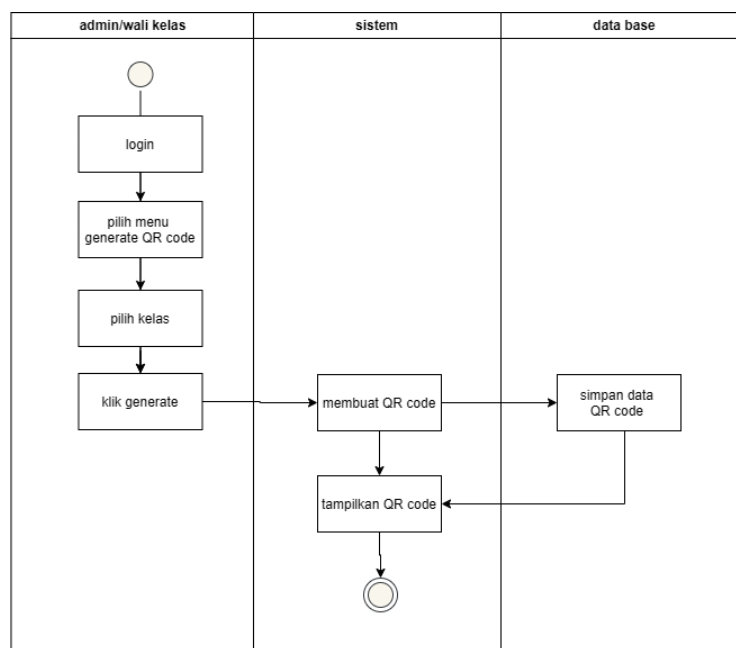


Figure 3. Activity Diagram of the QR Code Generation Process

2.3 System Testing Method

System testing was conducted using the Black Box Testing method to ensure that all system functions operate in accordance with user requirements[26]. Testing was performed without examining the application's internal code structure, but rather focused on evaluating the system's inputs and outputs. Several features tested included the user login process, QR code scanning, attendance data validation, push notification delivery, as well as attendance data storage and recapitulation processes. Testing success was determined based on the conformity between the actual system results and the predefined test scenarios. Through this method, the system is expected to operate stably, accurately, and according to the operational needs of SMP Darul Arqom Karanganyar.

In addition to functional testing, usability testing and User Acceptance Testing (UAT) were also conducted to evaluate user satisfaction and system acceptance. Usability testing focused on assessing the ease of use, interface clarity, accessibility, and efficiency of the system when used by administrators and boarding school staff. Meanwhile, User Acceptance Testing involved administrators and students' parents as end users to ensure that the developed system met user expectations and operational requirements. Feedback obtained from the usability testing and UAT processes was used as the basis for system improvements and feature refinement. The evaluation results indicated that the system was easy to use, functioned properly, and was able to support attendance management and real-time attendance information delivery effectively.

3. Results and Discussion

3.1 User Interface and System Implementation

The developed system provides several main features to support digital attendance management at SMP Darul Arqom Karanganyar. The system implementation focuses on QR Code-based attendance validation, attendance monitoring, attendance reporting, and real-time notification delivery to students' parents. The following interfaces represent the core functionalities of the proposed system.

3.1.1 QR Code Generation Page

The QR Code Generation Page is used to automatically generate a unique QR Code for each student based on the student data stored in the database. The generated QR Code functions as a digital identity used during the attendance process. This feature minimizes manual attendance recording and reduces the possibility of attendance manipulation because each QR Code is uniquely associated with a specific student.

The implementation of QR Code technology improves the efficiency of attendance validation since students only need to scan their QR Codes during attendance activities. In addition, the generated QR Codes can be printed or stored digitally for easier use during check-in and check-out processes.

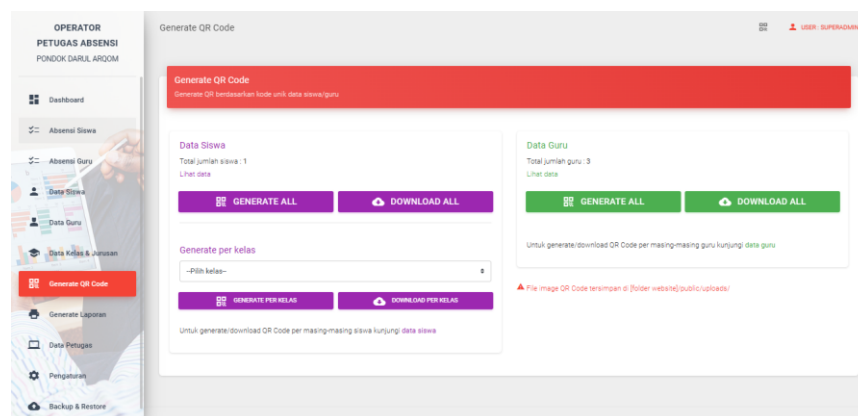


Figure 4. Generate QR Code Page

3.1.2 QR Code Attendance Scanning Page

The QR Code Attendance Scanning Page is the core feature of the proposed system. This page is used by administrators or boarding school staff to validate student attendance through QR Code scanning. During the attendance process, the system automatically identifies the student and records the attendance time in real time.

The implementation of QR Code scanning significantly accelerates the attendance process compared to the previous manual system. The feature also improves attendance accuracy and minimizes fraudulent attendance practices because attendance data are validated automatically by the system. The scanning process supports both check-in and check-out attendance activities.

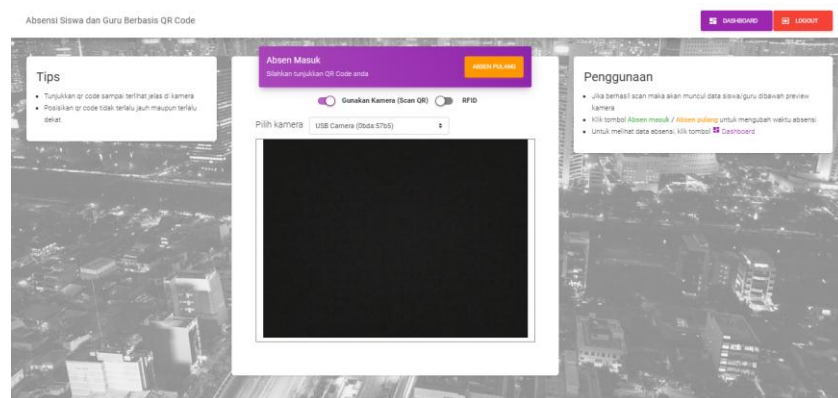


Figure 5. QR Code Attendance Validation Process

3.1.3 Attendance History and Monitoring Page

The Attendance History and Monitoring Page is used to display attendance records that have been stored in the database. The information presented includes student names, classes, attendance dates, attendance times, and attendance status. Administrators can search and filter attendance data to simplify attendance monitoring and recapitulation processes.

This feature improves administrative efficiency because attendance data can be accessed and monitored directly without requiring manual record checking. In addition, the digital attendance history supports more accurate attendance tracking and reporting.

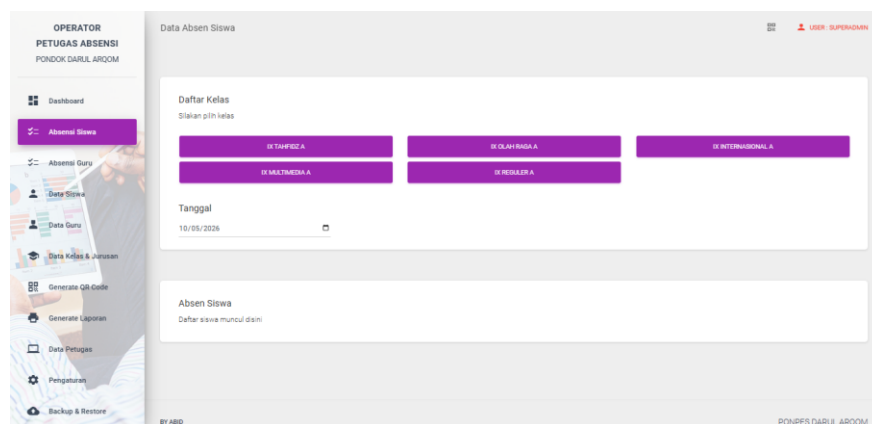


Figure 6. Attendance History and Monitoring Page

3.1.4 Attendance Report Page

The Attendance Report Page provides attendance summaries based on specific periods, classes, or student names. The system automatically generates attendance reports that can be viewed and printed by administrators.

This feature assists administrators in simplifying attendance data management and reducing the time required for attendance recapitulation. Compared to manual attendance reporting, the digital reporting feature provides faster, more accurate, and more organized attendance documentation.

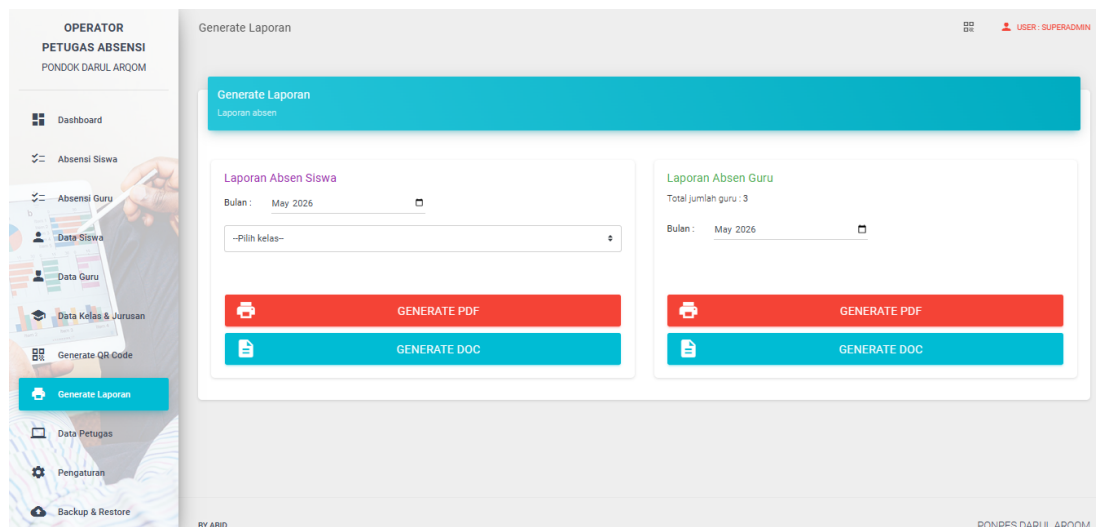


Figure 7. Attendance Report Page

3.1.5 Real-Time WhatsApp Notification Page

The Real-Time WhatsApp Notification Page is used to automatically send attendance information to students' parents after the attendance validation process is completed. Notifications contain attendance status and attendance time information, enabling parents to monitor student attendance directly.

This feature represents the main novelty of the proposed system because it improves communication transparency between the school and parents. Real-time notification delivery also supports better student discipline monitoring and allows parents to receive attendance information more quickly compared to conventional attendance systems.

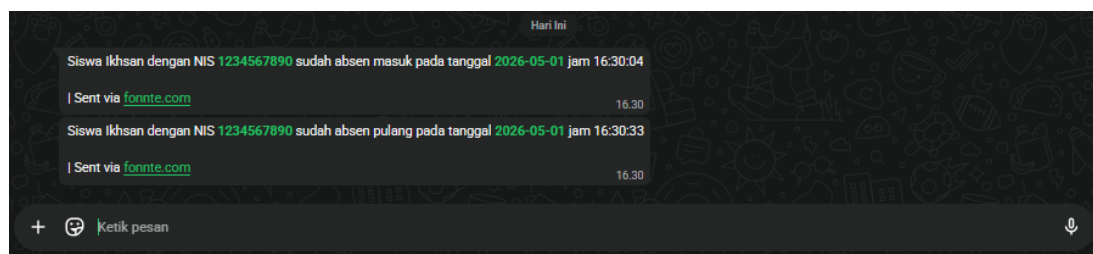


Figure 8. Real-Time WhatsApp Notification Page

3.2 System Effectiveness Discussion

The implementation of the QR Code-based attendance system successfully improved the efficiency and accuracy of attendance management at SMP Darul Arqom Karanganyar. Compared to the previous manual attendance process, the developed system accelerated attendance recording and reduced the risk of recording errors and attendance manipulation. The integration of QR Code technology simplified attendance validation because each student used a unique QR Code during attendance activities. In addition, the automatic attendance recording process improved data accuracy and facilitated attendance monitoring by administrators.

The implementation of real-time WhatsApp notifications also provided significant benefits for parents because attendance information could be received immediately after students completed the attendance process. This feature increased information transparency and strengthened communication between the school and parents regarding student discipline monitoring. Based on usability testing and User Acceptance Testing (UAT), administrators and parents stated that the system was easy to use, efficient, and capable of supporting attendance management activities effectively. Therefore, the proposed system can serve as an effective solution for supporting administrative digitalization and improving student attendance management in Islamic boarding schools.

In addition to improving attendance efficiency, the proposed system also considers several security aspects related to QR Code implementation. To minimize the risk of QR Code duplication and unauthorized attendance access, each QR Code generated by the system is uniquely associated with a specific student identity stored in the database. During the attendance validation process, the system verifies the scanned QR Code against registered student data before recording attendance information. Furthermore, the attendance process can only be performed by authorized administrators or boarding school staff through authenticated system access. These mechanisms help reduce the possibility of attendance manipulation and unauthorized attendance recording. However, this study has not yet implemented advanced security mechanisms such as dynamic QR Codes, encryption techniques, or biometric verification. Therefore, future research is recommended to integrate additional security approaches to further enhance attendance validation reliability and prevent QR Code misuse.

3.2.1 Black-Box Testing

Table 1. Black Box Testing Results

No	Modules Tested	Test Scenario	Test Steps	Expected Results	Status
Authentication Module					
1	Valid User Login	Testing the login process with a valid account	Enter a valid username and password, then click the "Login" button	The system redirects the user to the dashboard page based on user access rights	Valid
2	Invalid User Login	Testing system security against invalid credentials	Enter an incorrect username or password	The system denies access and displays a login failure message	Valid
3	System Logout	Testing the logout process	Click the "Logout" button on the dashboard	The system exits the dashboard and returns to the login page	Valid
Student Data Module					
4	Add Student Data	Testing the process of adding student data	Fill out the student data form and click the "Save" button	Student data is successfully stored in the database	Valid

No	Modules Tested	Test Scenario	Test Steps	Expected Results	Status
5	Edit Student Data	Testing the process of updating student data	Modify student data and click the "Update" button	The system updates student data according to the changes	Valid
6	Delete Student Data	Testing the process of deleting student data	Click the "Delete" button on student data	The system removes student data from the database	Valid
QR Code Module					
7	Generate QR Code	Testing the QR Code generation process	Select student data and click the "Generate QR Code" button	The system successfully generates a unique QR Code for the student	Valid
8	Scan Valid QR Code	Testing the valid QR Code scanning process	Scan the QR Code of a registered student	The system reads the QR Code and records attendance	Valid
9	Invalid QR Code Scan	Testing validation for unregistered QR Codes	Scan an invalid or incompatible QR Code	The system rejects the QR Code and displays an error message	Valid
Attendance Module					
10	Attendance Data Storage	Testing attendance data storage in the database	Scan student QR Codes	Attendance data is automatically stored in the database	Valid
11	Attendance History	Testing attendance history display	Open the attendance history page	The system displays attendance data according to the database	Valid
12	Filter Attendance Data	Testing the attendance search and filtering feature	Select a filter based on date or student name	The system displays data according to the selected filter	Valid
Push Notification Module					
13	Sending Attendance Notifications	Testing real-time notification delivery	Student successfully checks in	The system automatically sends notifications to the student's guardian	Valid
14	Notification Content Validation	Testing the accuracy of notification message content	View notifications received by guardians	Student name, attendance time, and attendance status are displayed correctly	Valid
15	Notification Speed Test	Measuring notification delivery time	Calculate the time between QR Code scanning and notification receipt	Notifications are received in less than 10 seconds	Valid
Report Module					
16	Print Attendance Report	Testing the attendance report printing feature	Select report data and click the "Print" button	The system displays the report ready for printing	Valid
17	Export Attendance Data	Testing the attendance data export process	Click the "Export" button on the report page	The system successfully downloads the attendance report file	Valid

The notification performance testing was conducted in the operational environment of SMP Darul Arqom Karanganyar using a web server connected to a stable internet network with an average bandwidth of

approximately 20 Mbps. The testing process involved scanning QR Codes through administrator devices connected via Wi-Fi and mobile internet networks. Notification delivery time was measured from the moment the QR Code was successfully scanned until the WhatsApp notification was received by parents. Based on several testing scenarios conducted during normal network conditions, the notification delivery process required less than 10 seconds on average. Network stability and internet connection quality significantly influenced notification delivery speed; however, during the testing process, the system consistently delivered notifications successfully without major delays.

3.2.2 User Acceptance Testing (UAT)

User Acceptance Testing (UAT) was conducted to determine whether the developed system meets user requirements and can be properly implemented in the operational environment of SMP Darul Arqom Karanganyar. The testing involved several users, including administrators, boarding school staff, and student guardians who directly interacted with the system features[27].

The UAT process was carried out by allowing users to test the system functionalities directly based on predefined scenarios. The aspects evaluated include ease of use, suitability of features, system performance, notification delivery, and overall user satisfaction. The test results indicate that the developed QR Code attendance system successfully fulfilled user needs and functioned according to the expected operational workflow.

Table 2. User Acceptance Testing (UAT) Results

No	Feature Tested	User Expectation	Test Result	Status
1	User Login	Users can access the system according to their access rights	System successfully redirects users based on role	Accepted
2	QR Code Attendance	Attendance process can be performed quickly and accurately	QR Code scanning successfully records attendance data	Accepted
3	Attendance Monitoring	Admin can monitor attendance data in real time	Dashboard displays attendance data correctly	Accepted
4	Attendance Reports	Users can generate attendance reports automatically	System successfully displays and exports reports	Accepted
5	WhatsApp Notifications	Parents receive attendance notifications automatically	Notifications successfully sent after attendance process	Accepted
6	Student Data Management	Admin can add, edit, and delete student data	Data management functions run properly	Accepted
7	Attendance History	Users can view attendance records easily	Attendance history displayed correctly	Accepted
8	System Accessibility	System can be accessed through web browsers smoothly	System accessible without major issues	Accepted

3.2.3 Usability Testing

Usability Testing was conducted to evaluate the level of user convenience, effectiveness, efficiency, and satisfaction when using the web-based QR Code attendance system. The testing involved 15 respondents consisting of administrators, school staff, and student guardians.

The usability assessment used a questionnaire based on a Likert scale with five categories, namely: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). The evaluated aspects include interface appearance, ease of navigation, system responsiveness, feature functionality, and overall user satisfaction.

Table 3. Usability Testing Results

No	Evaluation Aspect	Average Score	Category
1	Ease of Login Process	4.6	Very Good
2	Ease of QR Code Scanning	4.7	Very Good
3	User Interface Design	4.5	Very Good
4	Ease of Navigation	4.4	Good
5	Attendance Data Accuracy	4.7	Very Good
6	Speed of Notification Delivery	4.6	Very Good
7	Attendance Report Feature	4.5	Very Good
8	Overall User Satisfaction	4.6	Very Good

3.3 Previous Research

Based on the results of system implementation and testing, the application of QR Code technology in the web-based attendance system proved effective in improving the efficiency and effectiveness of student attendance management at SMP Darul Arqom Karanganyar. The improvement in attendance management effectiveness occurred because the QR Code validation process simplified attendance recording activities and reduced manual administrative procedures. Previously, attendance recording was conducted manually using paper-based records, which often caused delays, recording errors, and difficulties in attendance recapitulation. Through the implementation of QR Code scanning, attendance data could be validated automatically and stored directly in the database in real time, thereby accelerating attendance processing and improving data accuracy.

The real-time notification feature also contributed significantly to improving attendance transparency and communication effectiveness between the school and parents. Attendance information was automatically delivered immediately after the attendance validation process was completed, allowing parents to monitor student attendance more quickly compared to conventional attendance systems. The effectiveness of this feature can be explained through a sequential causal mechanism that connects attendance validation, information delivery, parental awareness, and student supervision. When a student successfully scanned a valid QR Code, the system automatically verified the attendance record and stored the data in the database. After the attendance status was successfully recorded, the system immediately triggered a WhatsApp notification and transmitted the verified attendance information to parents in less than 10 seconds under normal network conditions.

This automated process eliminated the need for manual attendance reporting and significantly reduced the delay between attendance recording and information dissemination. Consequently, parents received attendance information almost simultaneously with the occurrence of the attendance event, allowing them to obtain accurate and up-to-date attendance status without waiting for periodic attendance reports. The reduction in information delay played a crucial role in improving attendance transparency because both parents and school administrators could access the same attendance information within a very short period after attendance validation. In conventional attendance systems, attendance information was often communicated several hours or even days after the attendance event occurred, creating information asymmetry between schools and parents. Such delays frequently limited the ability of parents to respond promptly to attendance irregularities. Through the implementation of real-time notifications, information asymmetry was minimized because attendance information became available immediately after verification by the system. As a result, parents could identify cases of lateness, absence, or other attendance anomalies shortly after they occurred and take corrective action more rapidly than in conventional attendance management processes. The immediate availability of attendance information also strengthened parental involvement in student supervision. Early awareness enabled parents to communicate directly with students, provide

reminders regarding attendance obligations, and coordinate with school administrators when attendance problems were detected. This faster intervention mechanism contributed to more effective attendance monitoring because corrective actions could be performed before attendance issues became repetitive or more serious. Therefore, the effectiveness of real-time notifications was not solely related to rapid message delivery but also to the ability of the system to shorten the response time between attendance incidents and parental intervention. The combination of immediate information delivery and rapid parental response enhanced the overall effectiveness of attendance management and student supervision.

Furthermore, the integration of real-time notifications with automated attendance validation created a more accountable and transparent attendance monitoring process because each notification was automatically triggered immediately after successful QR Code validation and attendance recording in the database. This mechanism eliminated the need for intermediary manual reporting, reduced the possibility of information omission or reporting inconsistencies, and ensured that the attendance information received by parents accurately reflected the actual attendance status recorded by the system. The automatic linkage between attendance validation and notification delivery also generated a behavioral monitoring effect. Since students were aware that their attendance status would be communicated to parents almost immediately after attendance validation, opportunities for attendance manipulation were reduced and accountability was strengthened. This immediate parental awareness encouraged students to comply more consistently with attendance requirements because any absence or lateness could be identified and addressed shortly after it occurred. Consequently, the reduction in information delay indirectly contributed to improved attendance discipline through faster parental supervision and intervention. Consequently, the integration of QR Code validation, automated notification triggering, rapid information delivery, parental intervention, and increased student accountability formed a complete mechanism that explains how real-time notifications improved attendance transparency, parental involvement, and student discipline. This integration also strengthened trust between the school and parents by providing reliable and consistent attendance information in real time. Therefore, the notification feature became one of the most influential components in improving parental involvement, attendance transparency, and the overall effectiveness of student attendance monitoring. These findings are consistent with the previous research, which explained that real-time notifications improve the effectiveness of attendance information delivery to parents[28].

Compared to previous studies, the findings of this research show several similarities and differences. Similar to the previous research, that QR Code technology can accelerate attendance recording and improve attendance data accuracy[29]. However, this study provides additional contributions through the integration of real-time WhatsApp notifications specifically designed for the Islamic boarding school environment. Unlike previous attendance systems that mainly focused on attendance digitization, the proposed system emphasizes communication transparency and direct parental involvement in attendance monitoring.

The findings of this study also support the previous research, which stated that the CodeIgniter framework provides a structured and adaptable system development architecture through the MVC (Model View Controller) concept [30]. In this study, the MVC architecture simplified feature development, database management, and system maintenance during Agile-based sprint iterations. This indicates that the use of CodeIgniter not only supported technical implementation but also improved development flexibility and scalability. The successful implementation of QR Code validation also aligns with the findings of previous study, who found that QR Code technology can reduce attendance manipulation and accelerate attendance validation processes [31]. In this study, each QR Code was uniquely integrated with student identity data stored in the database, enabling automatic and real-time attendance validation. This mechanism reduced manual verification processes and improved attendance data reliability compared to conventional attendance systems.

Furthermore, the implementation of real-time WhatsApp notifications supports the findings previous study, who reported that notification systems improve attendance transparency and student discipline monitoring[32]. However, this study demonstrates that the integration of notifications with QR Code

attendance validation creates a more comprehensive attendance management mechanism because attendance validation, data storage, and information dissemination are performed simultaneously within a single integrated system. This integration contributes to reducing administrative workload and improving monitoring efficiency for boarding school administrators.

From a practical perspective, the implementation of the proposed system provides important implications for educational institutions and Islamic boarding schools. The system can support administrative digitalization, reduce manual attendance management activities, improve attendance monitoring efficiency, and strengthen communication between schools and parents. In the Islamic boarding school environment, where student discipline monitoring is highly important, the implementation of real-time attendance notifications can help administrators and parents supervise student attendance more effectively and transparently. These findings are also in line with the previous research, which stated that web-based QR Code attendance systems improve attendance management efficiency and reduce errors in manual attendance recording[33].

Despite the advantages offered by the system, several limitations and implementation challenges still exist. The system implementation was conducted only at SMP Darul Arqom Karanganyar, so the findings may not fully represent the conditions of other educational institutions. In addition, the effectiveness of the notification feature depends on internet connectivity and the availability of users' devices. Another limitation is that the evaluation process mainly focused on functional testing and qualitative user feedback without involving broader quantitative performance measurements. Therefore, future research is recommended to conduct larger-scale implementations and incorporate quantitative evaluations of user satisfaction, communication effectiveness, and system performance.

4. Conclusion

Based on the results of the research and development process, the web-based QR Code attendance system with real-time notifications at SMP Darul Arqom Karanganyar was successfully implemented as a digital solution for student attendance management. The implementation of QR Code technology improved the effectiveness and efficiency of the attendance process compared to the previous manual method by accelerating attendance recording, reducing recording errors, minimizing attendance data manipulation, and simplifying attendance monitoring and reporting processes through automated data storage. The main contribution of this study lies in the integration of QR Code-based attendance validation with real-time WhatsApp notification features within a web-based system specifically designed for the Islamic boarding school environment. Unlike conventional digital attendance systems that mainly focus on attendance recording, the proposed system enhances communication transparency between the school and parents through automatic attendance notifications delivered immediately after the attendance process is completed. This integration supports more effective student discipline monitoring and strengthens parental involvement in supervising student attendance activities.

Based on the results of Black Box Testing, all main system features, including login authentication, student data management, QR Code generation, QR Code scanning, attendance data storage, attendance reporting, and real-time notification delivery, functioned properly according to user requirements. In addition, usability testing and User Acceptance Testing (UAT) indicated that administrators and parents considered the system easy to use, efficient, and helpful in supporting attendance monitoring activities. Parents also responded positively to the real-time notification feature because attendance information could be received more quickly and transparently compared to the previous manual system.

However, this study still has several limitations. The system implementation was conducted only within a single educational institution, and the evaluation process mainly focused on functional and usability aspects without involving broader quantitative measurements of user satisfaction or system performance. In addition, the effectiveness of the notification system was evaluated qualitatively through user feedback rather than using statistical measurement indicators. Therefore, future research is recommended to involve larger-scale

implementation across multiple educational institutions and to incorporate quantitative evaluation methods such as user satisfaction analysis, system usability scales, response time measurements, and communication effectiveness indicators. Future system development may also integrate biometric authentication, mobile application support, and cloud-based data management to further improve system security, scalability, and accessibility.

5. References

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