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Implementing an Android-based facial biometric attendance system in a resource-constrained school: Validity, practicality and effectiveness evidence

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Abstract: This study designed and evaluated an Android-based e-attendance application integrating facial biometric verification and WhatsApp notifications to address inefficiencies in manual attendance at MTsN 2 Payakumbuh, Indonesia. A design-and-development methodology using the Spiral Software Development Life Cycle (SDLC) was applied from May to November 2025, covering iterative requirements elicitation (observation and semi-structured interviews), planning, risk analysis with UML modelling, engineering, deployment, and customer evaluation. The system comprises a Laravel–MySQL web dashboard for administrators and a Flutter Android application for teachers. Attendance is verified through Face++ facial recognition, while parents receive automated attendance-status messages via a WhatsApp API. Product quality was assessed through expert validity testing (Aiken's V), user-practicality testing (Kappa Moment), and a one-group pre-test–post-test effectiveness evaluation (normalized gain). Results indicate high validity for both content and construct dimensions (mean = 0.97), very high practicality ($\kappa = 0.91$), and very high effectiveness with substantial improvement from pre-test (33.94%) to post-test (95.15%), yielding $g = 0.92$. These findings suggest the proposed solution is feasible for routine classroom use, improves administrative efficiency and transparency, and strengthens parent–school communication, while highlighting the need for broader trials and stronger long-term biometric governance. The design includes manual status adjustment and report export to Excel, supporting continuity during connectivity fluctuations common in typical resource-limited schools.

Keywords: facial recognition; e-attendance; biometric authentication; Android application; Spiral SDLC; WhatsApp notification

1. Introduction

Information and Communication Technology (ICT) has become an integral element in various aspects of human life (Ahmed et al., 2021; Al-Rahmi et al., 2020; Balaban et al., 2023; Bilan et al., 2023). The rapid development of ICT has significantly enhanced the efficiency and effectiveness of human activities. Technology not only assists in everyday tasks but also fosters innovation across multiple sectors. As an integral part of science and engineering development, technology is applied in product design, processes, and research to generate new knowledge (Aldoseri et al., 2024; Khanolkar et al., 2025; Mormina, 2019).

In the context of education, the rapid advancement of ICT has triggered significant transformations in education systems worldwide. Technological developments are closely linked to the need for continuous improvements in learning effectiveness and in the management of the educational system (Santally et al., 2020; Timotheou et al., 2023). In Indonesia, the education sector faces substantial challenges in adapting to technological developments to meet global demands for enhanced educational quality (Sain et al., 2024; Sukmayadi & Yahya, 2020; Widiastuti, 2025).

Technological innovations, particularly in informatics engineering education, have revolutionized learning methods. The advent of ICT tools, such as computers, mobile phones, and the internet, has accelerated the integration of technology into education, primarily to improve educational quality (Alenezi et al., 2023; Saif et al., 2022; Timotheou et al., 2023; C. Wang et al., 2024). Technology serves not only as a tool in the learning process but also as a medium that encourages increased student interaction and participation in educational activities (Alam & Mohanty, 2023; Pinto & Leite, 2020; Ullah & Anwar, 2020). The implementation of technology-based learning management systems (LMS) has proven to enhance administrative efficiency and transparency in decision-making within educational institutions (Saadati et al., 2023; Supiani et al., 2024; Yani et al., 2025).

However, despite widespread adoption of technology across educational systems, many educational institutions in Indonesia still rely on manual methods for administrative tasks, such as attendance tracking (Muhafidin, 2020; Silvia Berliana Ghany & Muhammad Fadlullah, 2025). The manual attendance process, which involves recording student attendance in paper registers, causes delays, human errors, and difficulties in obtaining accurate and timely reports (Chávez-Saldaña et al., 2026; Kakepoto et al., 2022). This issue becomes particularly challenging in educational settings focused on time efficiency, such as institutions with large student populations and tight schedules.

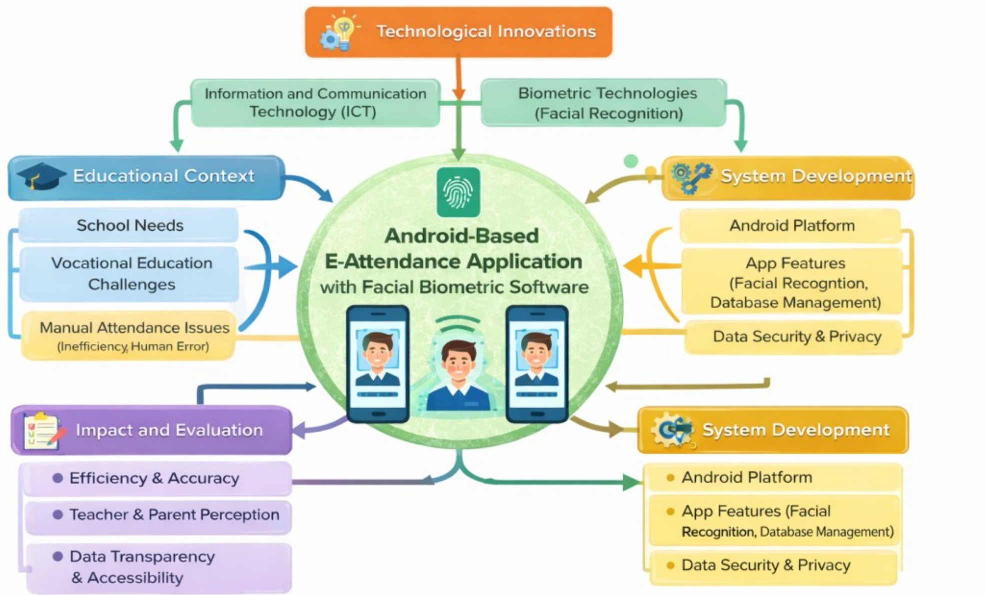


Figure 1. Conceptual framework for Android-based e-attendance application with facial biometric software

Figure 1 provides a visual representation of the structure of this research on the Android-based e-attendance application that integrates facial recognition technology to verify student attendance at MTsN 2 Payakumbuh. The diagram highlights key components, including technological innovations (ICT and biometric technology), the educational context (secondary education in Indonesia), system development (Android platform, facial recognition, database integration), and impact evaluation (efficiency, accuracy, and user perceptions). This framework serves as a roadmap for understanding the application's functionality and its role in improving administrative efficiency, reducing errors, and enhancing transparency in attendance management. The integration of facial biometric systems within an Android-based platform addresses challenges faced by educational institutions with outdated manual attendance processes, especially in settings with limited technology infrastructure (Soyemi et al., 2025; Ukamaka Betrand et al., 2023).

Recent statistics indicate that over 60% of schools in Southeast Asia report challenges with manual attendance systems, which often lead to inefficiencies and errors (Darmawan & Dharmapatni, 2024; Jakobsen et al., 2025; Puckdeevongs et al., 2020). These studies propose solutions to address these challenges and enhance data management quality in educational settings, making them a valuable contribution to both the academic and practical realms of educational technology. Prior research has shown that the application of electronic attendance systems (e-attendance) can address these issues (Ali et al., 2024; Darojah et al., 2025; Ocumen et al., 2020). E-attendance systems automate student attendance tracking, reduce human errors, and provide faster, more accurate reports. One of the latest innovations in attendance systems is the use of biometric technologies, such as facial recognition, to securely and efficiently verify student attendance (Hernandez-de-Menendez et al., 2021; Hoo & Ibrahim, 2019; Rukhiran et al., 2023). Biometric facial recognition technology offers a practical solution to enhance security and convenience in the attendance process, especially in educational settings that require efficiency and accuracy in documenting student attendance (Bondugula et al., 2025; Gaur et al., 2024).

Despite the growing body of research on electronic attendance systems, most studies focus on the use of fingerprint or facial recognition biometrics for general applications in security or banking sectors (Abdul-Al et al., 2024; Khan et al., 2023; J. S. Wang, 2021). In contrast, research on the use of facial biometric technology in educational institution attendance systems, particularly at the secondary school level, remains limited. Furthermore, many existing studies do not consider the limitations faced by educational institutions in smaller, more traditional settings, which often have limited facilities and suboptimal technology infrastructure (Mhlanga, 2024; Ndibalema, 2022; Ntorukiri et al., 2022).

This study introduces an innovative approach by developing an Android-based e-attendance application that uses facial recognition technology to verify student attendance at MTsN 2 Payakumbuh. The novelty of this research lies in applying facial biometric systems to replace outdated manual attendance methods and integrating the application with the Android platform, making it accessible to various stakeholders, including teachers and parents. The study also provides a solution to reduce human error and improve the efficiency and transparency of attendance management. Based on the background and issues outlined, this study is anticipated to address the following research questions:

RQ1. How to design an Android-based e-attendance application that uses facial biometric verification at MTsN 2 Payakumbuh?
RQ2. What is the impact of using a facial recognition-based biometric attendance system on the efficiency and accuracy of student attendance data at MTsN 2 Payakumbuh?
RQ3. How do users, including teachers and parents, perceive the Android-based e-attendance system and facial recognition technology in the context of secondary schools?

This study makes a significant contribution to the development of attendance systems in the education sector, particularly at the secondary school level, by leveraging facial biometric technology that is more efficient and accurate than manual methods or systems based on other devices. In practice, this research provides an application that can expedite classroom attendance processes, reduce human error, and improve transparency in student attendance records. Additionally, this study contributes to the literature on the application of biometric technology in education, specifically in Indonesia, and opens opportunities for further development of Android-based e-attendance applications in other educational institutions. This research is expected to serve as a reference for educational institutions to optimize their attendance systems and improve operational efficiency.

2. Methods

2.1. Time and location of research

This study was conducted from May to November 2025 at MTsN 2 Payakumbuh (West Sumatra, Indonesia). The site was selected because it represents a secondary-school context in which manual attendance practices remain dominant and generate operational problems (time loss, reporting delays, and potential recording errors), consistent with the issues described in the Introduction (Xu et al., 2020). The study covered (i) requirements elicitation and system design, (ii) iterative development and risk-driven refinement, and (iii) field-based testing to assess feasibility and early effectiveness.

2.2. Research design

This research adopted a design-and-development approach using the Software Development Life Cycle (SDLC) Spiral model to support iterative refinement in the face of technical and implementation risks (Christanto & Singgalen, 2023; Pinciroli et al., 2022). The Spiral model was selected because biometric attendance systems require repeated improvement cycles to handle variability in real use (lighting, device heterogeneity, user behaviour) and to mitigate risks related to accuracy, usability, and operational constraints (Sari et al., 2022; Stepanov, 2021). Each iteration consisted of: (1) customer communication, (2) planning, (3) risk analysis, (4) engineering, (5) construction and release, and (6) customer evaluation, enabling systematic improvements based on stakeholder feedback and test results (Mumtaz et al., 2022; Zorzetti et al., 2022). Figure 2 shows the Spiral SDLC model used in this study.

Figure 2. Spiral software development life cycle model

2.3. Requirements elicitation and research stages (spiral cycles)

The Spiral SDLC was executed through iterative cycles to ensure that system requirements were continuously validated and refined based on real school conditions and stakeholder feedback (Coston et al., 2025; Olorunshola & Ogwueleka, 2021). The process began with customer communication, where requirements were elicited from key stakeholders (teachers and school administrators) through direct observation of routine attendance practices and semi-structured interviews. This stage focused on identifying core operational problems, such as time-consuming manual recording, delays in reporting, and notification bottlenecks, and translating them into functional requirements, including attendance capture, identity verification, reporting, and automated parent notification. Next, the planning stage formalized the system objectives, development timeline, deployment constraints, and technical resources, including minimum device specifications and server or database requirements, resulting in a structured requirements list, an early workflow definition, and an implementation schedule.

The risk analysis stage then addressed technical and operational uncertainties, such as variability in face capture quality, unstable connectivity, user adoption barriers, and privacy concerns associated with biometric data. To reduce ambiguity and maintain traceability between requirements and implementation, system behaviour and structure were modelled using UML diagrams (use cases, activities, sequences, and classes). After this, the engineering stage converted the validated designs into functional software modules and produced a working prototype for testing and refinement. The prototype was then introduced in the construction and release stage, which included deployment in the school environment, system configuration, development of user guidance, and basic orientation sessions for teachers and administrators to ensure consistent use during evaluation. Finally, customer evaluation gathered structured feedback after real usage, documenting usability issues, operational constraints, and failure cases; these findings were used as inputs for subsequent Spiral iterations to strengthen system reliability, usability, and contextual fit.

2.4. Product testing and evaluation protocol

The evaluation was structured to address content validity, practical usability, and early effectiveness, in line with the study's goals of improving efficiency, accuracy, and transparency.

2.5. Validity testing

Instrument validity (e.g., questionnaire items and evaluation indicators) was examined using (Aiken, 1985) method to ensure that each item adequately represented the intended construct. As presented in Equation (1).

$$v = \frac{\sum s}{n\,(c-1)} \quad (1)$$

Aiken's V index is used to determine the suitability of an item in relation to the indicator it is supposed to measure. The validity results are categorized as shown in Table 1.

Table 1. Aiken's V validity categories

Value	Criterion
≥ 0.6	Valid
< 0.6	Invalid

2.4.1. Practicality testing

Practicality was assessed using user questionnaires and analyzed with the Kappa Moment to quantify the extent to which the system was perceived as practical and usable in routine school operations. As shown in Equation (2), the Kappa value was calculated by comparing the observed agreement (P) with the expected agreement (P_e), thereby indicating the degree of agreement beyond chance. Higher Kappa values reflect stronger agreement among users regarding the practicality of the developed system. The interpretation of Kappa values followed the decision categories presented in Table 2.

$$k = \frac{P - P_e}{1 - P_e} \tag{2}$$

Table 2. Kappa moment decision categories

Interval	Category
0.81–1.00	Very High
0.61–0.80	High
0.41–0.60	Medium
0.21–0.40	Low
0.01–0.20	Very Low
≤ 0.000	Not Practical

2.4.2. Effectiveness testing

Effectiveness was examined using the normalized gain (G-Score) proposed by (Hake, 1998) to measure the improvement between pre-implementation and post-implementation scores. In this study, the effectiveness score reflects teacher-reported perceptions of attendance administration performance, particularly with respect to efficiency and accuracy, on a standardized 0–100 scale. As shown in Equation (3), the G-Score was calculated to determine the proportion of improvement achieved, and the results were interpreted according to the categories in Table 3.

$$G = \frac{S_f - S_i}{100 - S_i} \tag{3}$$

Table 3. Effectiveness interpretation category

Effectiveness category	G-score threshold
High-g (High effectiveness)	G > 0.7
Medium-g (Moderate effectiveness)	0.3 < G < 0.7
Low-g (Low effectiveness)	G < 0.3

2.6. Data analysis

Data were analyzed using descriptive and index-based statistics in accordance with the three evaluation dimensions of this study: content validity, practicality, and effectiveness. Content validity was assessed using Aiken's V at the item level to determine the extent to which each instrument item represented the intended construct, and the results were interpreted using the criteria in Table 1. Practicality data from user responses were analyzed using the Kappa Moment formula to measure the degree of agreement regarding the system's usability and suitability for routine school operations, with interpretation based on Table 2. Descriptive summaries were also used to present the results for each evaluated aspect.

For effectiveness testing, pre-implementation and post-implementation scores were compared using the normalized gain (G-Score) to measure the magnitude of improvement after system implementation. In this study, effectiveness refers to improvement in teacher-reported perceptions of attendance administration performance, particularly in terms of efficiency, accuracy, and usability. The gain scores were interpreted according to the criteria in Table 3, and mean scores and score differences were also reported to indicate the direction and extent of change. Since this study was intended to examine feasibility and early implementation in a real school setting, the findings were interpreted as preliminary evidence of improvement rather than definitive proof of causal impact.

2.7. Ethical considerations and data protection

Because the system involves facial biometric capture, data governance was applied through: (1) data minimization (collecting only what is required for attendance verification), (2) access restriction to authorized school staff, and (3) secure storage and controlled retention for attendance records. Participant information was handled to prevent unnecessary exposure of identifiable biometric data in reporting outputs. These measures align with responsible ICT use in education and reduce the privacy risks highlighted in recent discussions of technology adoption (Li & Zhang, 2025; Marshall et al., 2022; Mhlongo et al., 2023).

3. Results

The study on the design and implementation of an Android-based e-attendance application utilizing facial biometric verification for MTsN 2 Payakumbuh follows the Spiral Software Development Life Cycle (SDLC), which comprises the following key stages: Customer Communication, Planning, Requirement Analysis, and Engineering. These stages ensure that the final system aligns with the needs of its users, namely teachers, admins, and parents.

3.1. Customer communication

Before designing the e-attendance application, a thorough data collection process involving observations and interviews was conducted. These data collection methods provided insights into the existing manual attendance process, which was slow, error-prone, and lacked real-time feedback for parents. Observations revealed that attendance records were stored in physical books, causing delays and errors, while interviews with teachers, parents, and staff indicated a need for a more efficient, digital solution. Based on these findings, the study proposed a transition to a biometric-based attendance system.

3.2. Requirement analysis

The primary users of the e-attendance application are teachers, who need an easy-to-use application to take attendance quickly and accurately. Their needs include a user-friendly interface, real-time attendance status updates for parents, and the ability to generate attendance reports. Admins are secondary users, responsible for managing data entry, such as adding teachers, students, and classes, as well as generating reports. The third group of users, tertiary users, are parents who receive notifications about their child's attendance status, as demonstrated in Table 4.

Table 4. User requirements for the e-attendance application

No	Requirement	Primary User (Teacher)	Secondary User (Admin)
1	User Interface	User-friendly Android interface	User-friendly Admin dashboard
2	Attendance Process	Records attendance	Inputs, edits, and deletes teacher, class, and student data
3	Attendance Speed and Ease	Quick and easy attendance process	Manages and updates attendance records
4	Attendance Report	Views and modifies attendance reports	Views reports for monitoring and management
5	Notification System	Notifies parents about student attendance status	Manages notification delivery for users
6	Data Summary	Summarizes attendance data	Generates attendance summaries and reports
7	Data Import/Export	N/A	Imports student data via Excel, manages credentials

3.3. Planning and estimating

Following the identification of user needs, the next phase of the study focused on establishing clear goals and estimating the tasks required for the design and implementation of the e-attendance application. The primary objective of this phase was to create an Android application that would streamline attendance-taking, reduce human error, and provide real-time attendance notifications to parents. In addition, the design aimed to optimize the time teachers spent on administrative tasks, thereby enabling a more efficient start to lessons. To achieve these objectives, the following steps were meticulously planned, as outlined in Table 5. These steps provided a comprehensive framework for the application's development, ensuring that each critical aspect was addressed from data collection through final testing.

Table 5. Planned steps for the development of the Android-based e-attendance application

Step	Task
1	Data collection from the school to understand current attendance practices, including the number of teachers, students, and classes, as well as the existing manual attendance process.
2	Development of a new flowchart for the attendance process, which includes data input by the admin, teachers' use, and the report output for both teachers and parents.
3	Designing the application logic using PHP for the admin dashboard (Laravel framework) and Dart for the Android app (Flutter framework).
4	Developing the user interface (UI) for both the admin dashboard and the teacher-facing Android application.
5	Integrating a facial biometric sensor using the Face++ API in the backend (Laravel framework).
6	Implementing WhatsApp notification functionality via an API to send real-time attendance status updates to parents.
7	Testing the functionality and performance of the application to ensure it meets the required standards.
8	Conducting customer evaluation to obtain feedback from users and assess their experience with the app during the attendance process.

In addition to these development steps, Table 6 outlines the minimum hardware and software specifications required to run the application effectively. These specifications ensure that the appropriate technology supports both the admin dashboard and the teacher-facing application.

Table 6. Minimum specifications for components required to run the e-attendance application

Component	Minimum specifications
Computer	Intel Core i3 / Ryzen 3 processor with Windows OS
Android Device	Android version 8 or higher (recommended version 10 or above)
Network	Stable LAN, wireless networks, or other internet service providers for stable performance

3.4. Risk analysis

This phase focused on identifying potential risks to the successful implementation of the e-attendance system and formulating strategies to mitigate them. Technical risks include bugs or crashes during the attendance process, as well as server failures that might prevent data from being processed and stored in real time. To address these concerns, mitigation strategies such as comprehensive testing, periodic updates, and regular performance checks were implemented. Additionally, non-technical risks were considered, particularly the possibility that some teachers and admin staff might be unfamiliar with Android-based applications, leading to errors in attendance marking or data entry. To mitigate this, simple user guides and short training sessions were provided, alongside an intuitive user interface designed for ease of use.

Operational risks, including the challenge of unstable or interrupted internet connectivity, were also considered. The system was designed to allow manual attendance entry, ensuring data could be synchronized once the internet connection was restored. Furthermore, iOS availability was identified as a potential limitation, as the application is currently designed for Android devices only. However, since all teachers in the study were using Android devices, this limitation was manageable. There is potential to extend support to iOS devices if necessary, ensuring the application remains accessible to a wider user base.

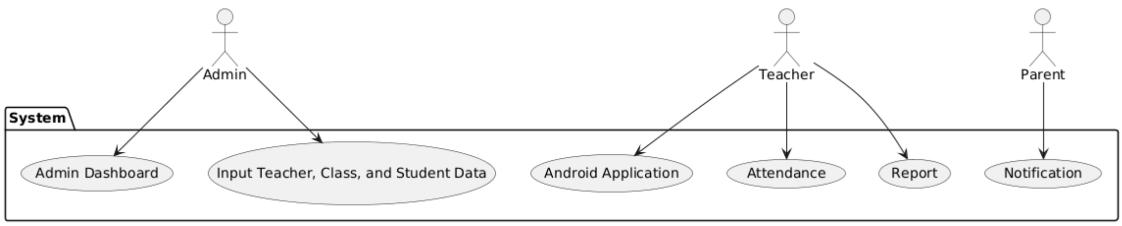


Figure 3. Use case diagram for the e-attendance application system

Figure 3 represents the use case of the e-attendance application system, showcasing the interactions between the system and its primary users: the admin, teacher, and parent. The admin is responsible for managing the data through the admin dashboard, including inputting teacher, class, and student information. Teachers interact with the Android application to mark attendance and generate reports. Parents, on the other hand, receive notifications regarding their child's attendance status. This diagram highlights the flow of actions within the system, ensuring each user can perform their specific tasks efficiently.

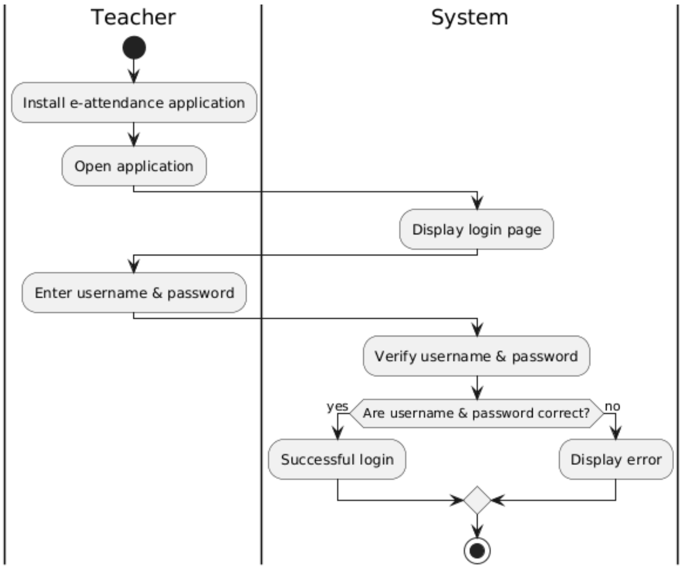


Figure 4. Activity diagram for teacher login process

The activity diagram in Figure 4 illustrates the login process for a teacher using the e-attendance application. The teacher begins by installing and opening the application, which then displays the login page. The teacher enters their username and password, which the system verifies. If the credentials are correct, the system allows a successful login; otherwise, it displays an error message. This flow ensures that only authorized users can access the application.

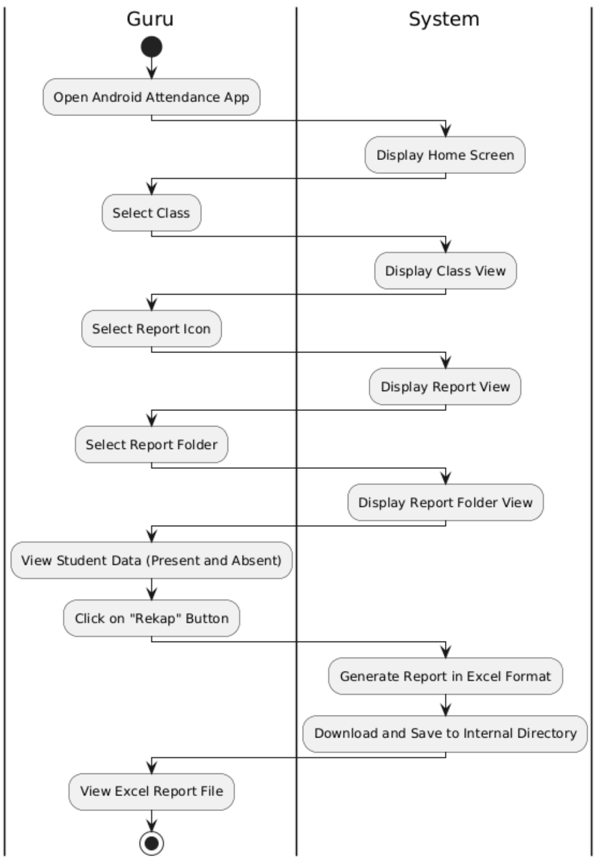


Figure 5. Activity diagram for report and recap process

Figure 5 illustrates the steps a teacher follows in the e-attendance application to generate and view attendance reports. The teacher begins by opening the app and selecting the relevant class. After selecting the report icon and folder, the system displays the appropriate views. The teacher then views the student data for both present and absent students. After clicking the “Rekap” button, the system generates the report in Excel format, which the teacher can download and save to the internal directory. Finally, the teacher can view the Excel report file, completing the process.

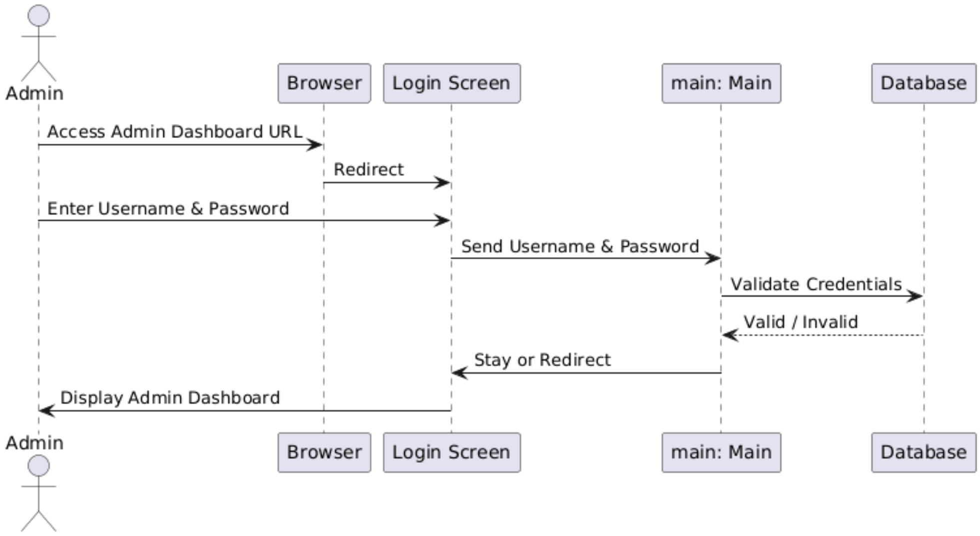


Figure 6. Sequence diagram for the admin login process

The sequence diagram in Figure 6 depicts the login process for the admin accessing the admin dashboard. The admin first enters the URL in the browser, which redirects to the login screen. After entering the username and password, the credentials are sent to the main system, which verifies them against the database. Depending on the validation result, the system either allows the admin to stay on the login screen or redirects them to the admin dashboard. The diagram demonstrates the flow of actions and interactions between the admin, the browser, the login screen, the main system, and the database.

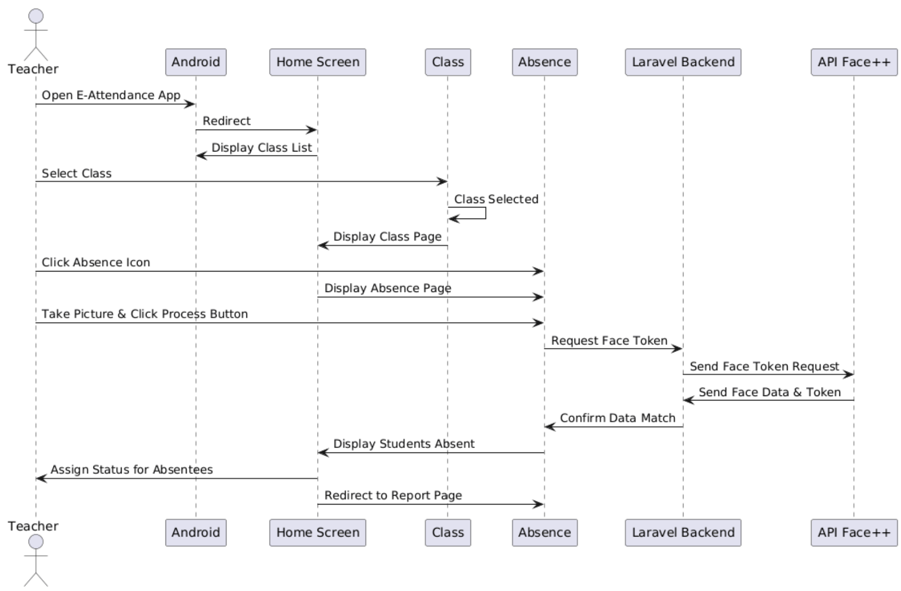


Figure 7. Sequence diagram for the attendance process

Figure 7 illustrates the interaction flow for the teacher marking attendance in the e-attendance application. The teacher starts by opening the app, selecting the class, and clicking the attendance icon. The system then displays the attendance page, where the teacher takes a photo and clicks the process button. The system sends the face token request to the backend, which communicates with the Face++ API to verify the data. Upon successful verification, the system displays the list of absent students, allows the teacher to assign attendance statuses, and redirects to the report page for further action.

3.5. Engineering

In this phase, the proposed design was implemented into a working e-attendance system consisting of two integrated components: (1) a web-based admin dashboard and (2) an Android-based teacher application. The admin dashboard was developed using PHP with the Laravel framework and connected to a MySQL database for centralized data storage and reporting. The teacher-facing application was built with Dart and the Flutter framework to support attendance management on Android devices.

The system's main functional integrations include biometric attendance verification and automated parent notifications. Facial recognition was implemented via the Face++ API, enabling the application to match captured student faces with stored biometric profiles to determine attendance status. After attendance is recorded or updated, notifications to parents are delivered via a WhatsApp API, ensuring timely communication of attendance outcomes.

3.5.1. Admin dashboard implementation

The admin dashboard provides authentication, data management, and monitoring functionality. Figure 8 highlights the authentication gateway and the main dashboard workspace used to manage teacher, class, and student data. Once attendance data are submitted from the teacher application, the admin can review results and export reports in Excel format through the report interface, as shown in Figure 9. This dashboard acts as the centralized control layer for maintaining data integrity, user access, and reporting workflows.

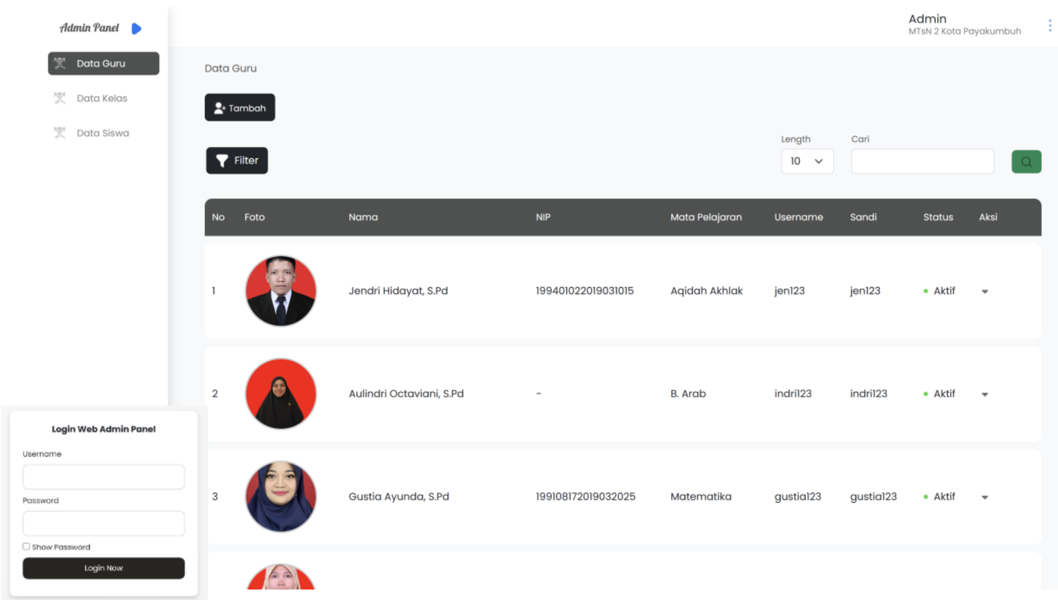


Figure 8. Admin login page and admin dashboard home screen

Figure 8 presents two key interfaces of the e-attendance Admin Panel: the admin login page and the admin dashboard home screen after a successful login. On the login page, the admin enters a username and password to authenticate and restrict access to authorized users. After logging in, the system displays the dashboard, which provides main navigation menus (e.g., Teacher Data, Class Data, and Student Data) and operational features such as Add, Filter, record length settings, and Search. The "Teacher Data" table summarizes essential teacher information, including photo, name, identification number (NIP), subject, username, password, account status, and action controls, indicating that the dashboard functions as a centralized control centre for user management and data monitoring to support a structured and efficient attendance administration process.

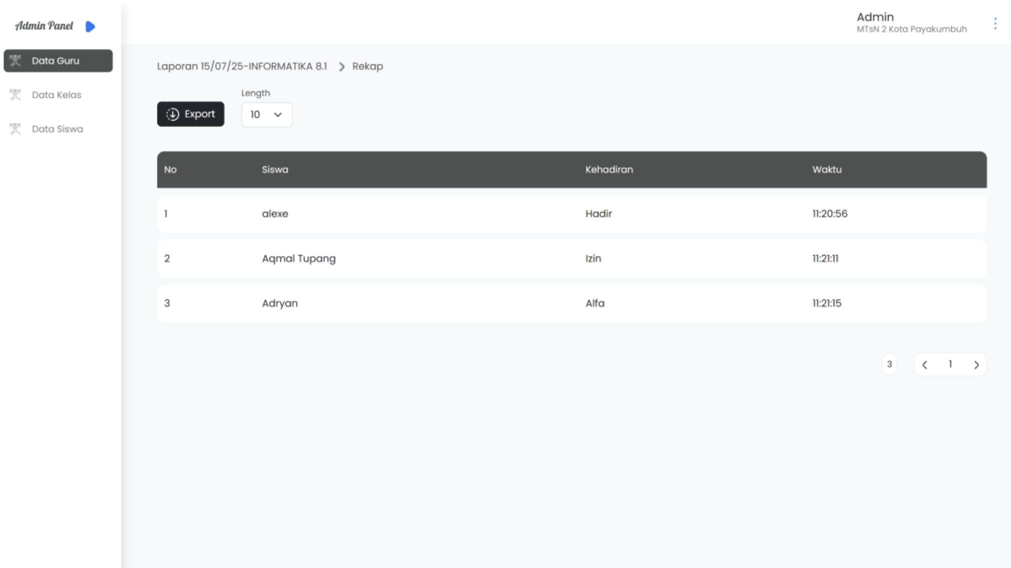


Figure 9. Admin report interface and export function

Figure 9 shows the Admin Dashboard report view in the e-attendance system, where the admin can monitor attendance results submitted by teachers through a web browser by entering the URL: https://epresensimtsn2pyk.my.id/. After accessing the dashboard in a web browser, the admin can open a specific attendance report (per class and date) and view a table containing student names, attendance status (e.g., present, permission/leave, absent), and the recorded attendance time. The interface also provides operational controls, such as export (to download the report, typically in Excel format), record length selection, and pagination, indicating that the dashboard is designed not only for monitoring but also for documenting and efficiently managing attendance data for administrative purposes.

3.5.2. Android teacher application implementation

The Android application supports operational attendance activities performed by teachers. Figure 10 summarizes the core user flow: secure login, class selection, attendance capture, and report review. Panel (a) shows the login screen where teachers enter their username and password to securely access the system. After authentication, panel (b) displays the home screen listing the classes assigned to the teacher, allowing the teacher to select a specific class for attendance. Panel (c) illustrates the attendance capture interface, where the teacher takes student photos (with indicators such as the required number of images) and can use supporting features like flash, camera switching, and a manual attendance option when needed. Finally, panel (d) shows the attendance report view, where student attendance results are displayed (e.g., "present"), enabling the teacher to review attendance outcomes and proceed to recap/export functions for reporting purposes.

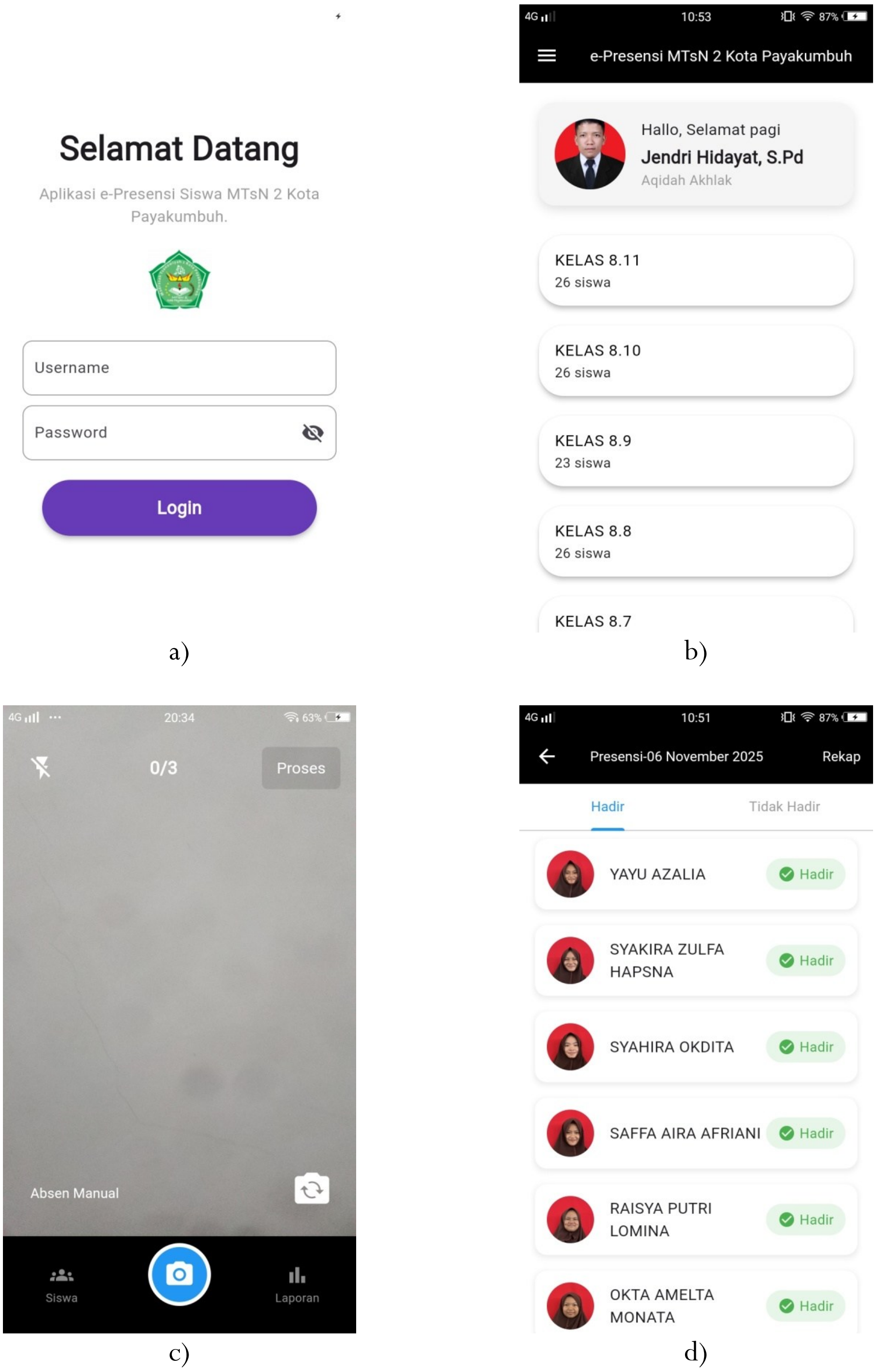


Figure 10. Android e-attendance application interfaces (login, class list, attendance capture, and attendance report)

3.6. Construction and release

This phase focused on deploying the e-attendance system in the school environment and confirming that end users could consistently operate both components during routine attendance activities. The release package consisted of two integrated deliverables: (i) a web-based admin dashboard accessible via a standard browser and (ii) an Android teacher application distributed through an installation link. To support operational readiness, the deployment included account provisioning by the admin, a short hands-on orientation for teachers, and a simplified usage guide covering the essential workflows of data management, attendance execution, and report generation. The main objective of this phase was to ensure that the system could function reliably in real classroom conditions with minimal technical intervention.

3.6.1. Admin dashboard deployment and operational workflow

The admin dashboard was deployed as a web-based interface intended for use on a computer or laptop with an internet connection. After authentication, the admin carries out three core operational functions: (1) master data setup, including the creation and maintenance of teacher, class, and student records (with optional bulk import where applicable); (2) access management, ensuring valid credential distribution and activating/deactivating authorized accounts; and (3) attendance monitoring and reporting, which enables review of class-based attendance submissions and export of reports in Excel format for documentation. The report and export feature is illustrated in Figure 11, while the end-to-end operational workflow from login to task execution is summarized in Figure 12.

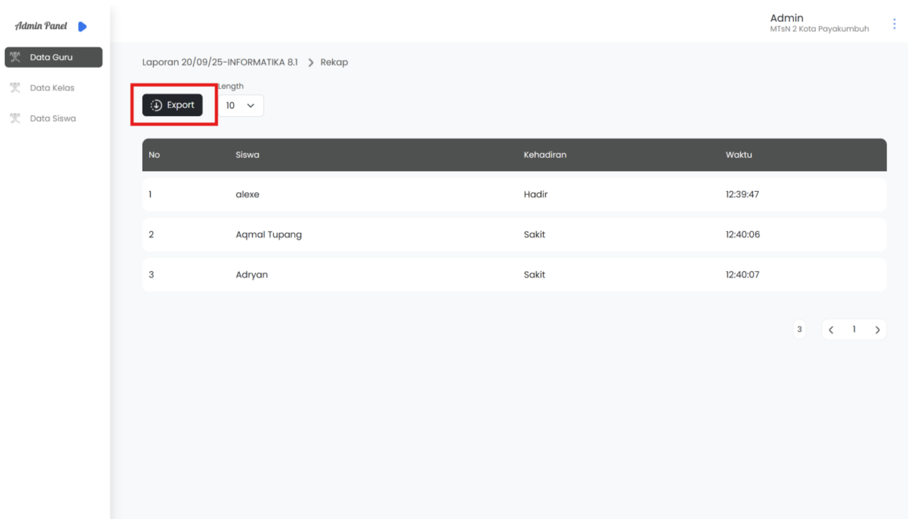


Figure 11. Admin Attendance Report and Export Interface

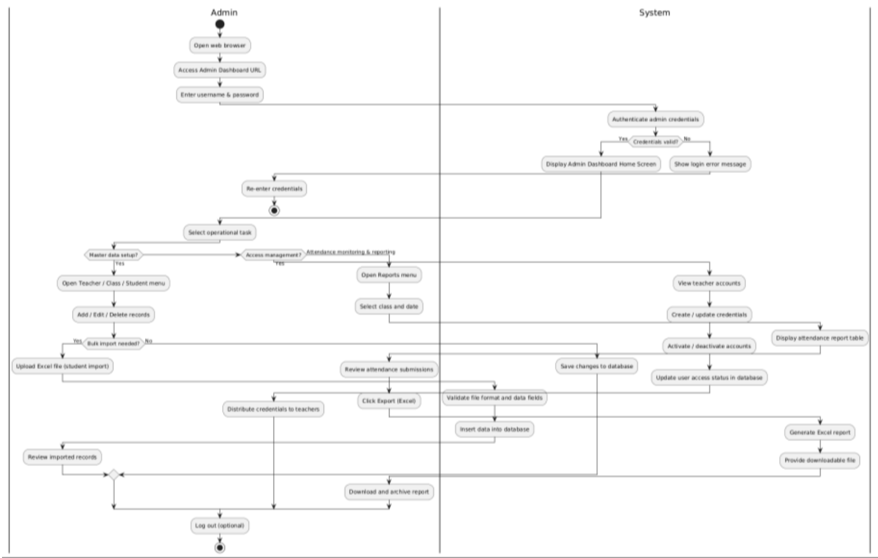
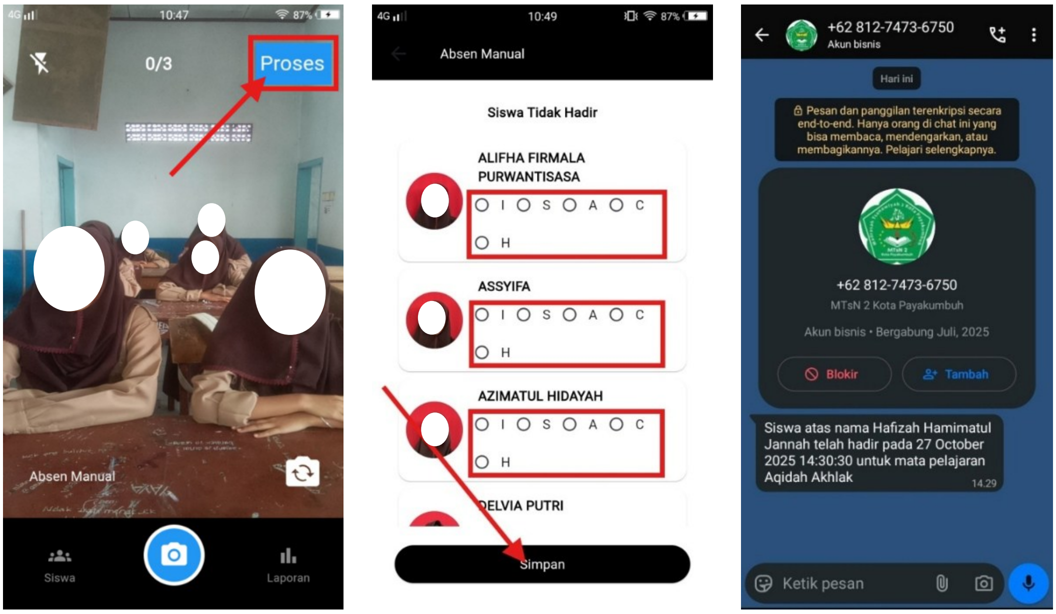


Figure 12. Admin dashboard deployment and operational workflow

3.6.2. Android Application Release and Classroom Execution Workflow

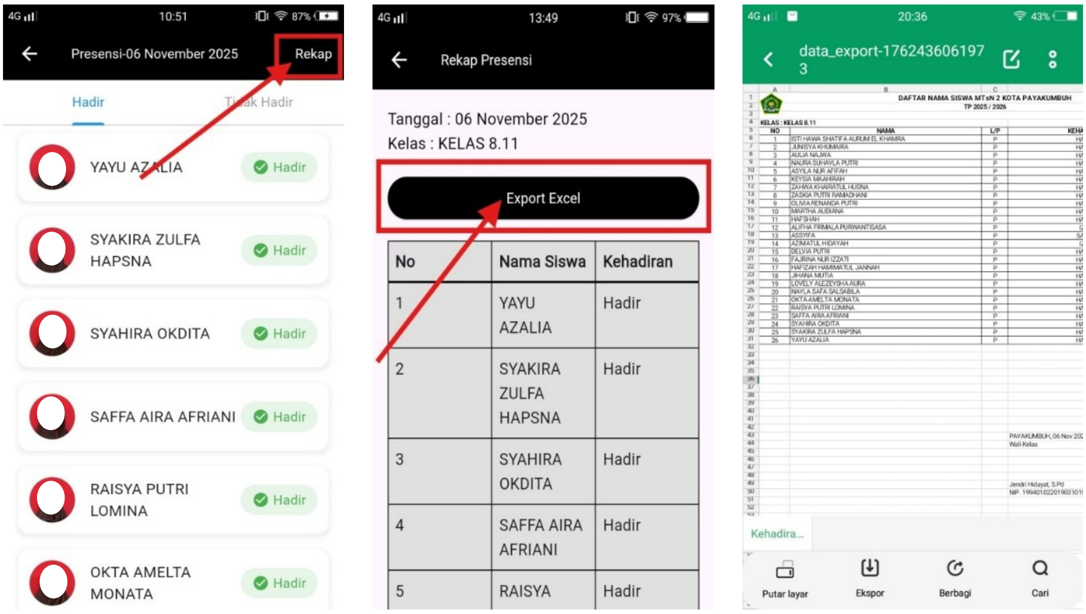
The teacher application was released for Android devices and used during classroom sessions to conduct attendance. Teachers log in with credentials provided by the admin, select the relevant class, and capture attendance via the camera interface. The system then processes attendance results, allowing teachers to confirm outcomes and assign appropriate attendance statuses when required. Parent communication is supported through automated WhatsApp notifications generated after attendance is recorded or updated, improving the timeliness of attendance monitoring. The core execution flow, including processing and notification output, is demonstrated in Figure 13. After attendance is completed, teachers can generate a recap report and export the summary in Excel format for archiving or submission; this recap workflow is shown in Figure 14.



a) b) c)

Figure 13. Attendance execution and processing interface

Figure 13 illustrates the operational attendance workflow in the Android teacher application. In panel (a), the teacher captures student photos and initiates processing by pressing the “Process” button once the minimum image requirement is met. The system then identifies students who are not automatically recognized as present; panel (b) shows the absent-student list where the teacher can assign the appropriate attendance status (e.g., permission/leave, sick, absent, truancy) and save the updates. Finally, panel (c) demonstrates the WhatsApp notification output, where parents receive an automated message confirming their child’s attendance status, ensuring timely communication and enabling parental monitoring.



a) b) c)

Figure 14. Attendance recap and report export process

Figure 14 presents the recap and reporting workflow after attendance has been recorded. Panel (a) shows the class attendance report view where the teacher accesses the "Recap" feature from the attendance list. Panel (b) displays the recap interface that summarizes attendance data by date and class and provides an "Export Excel" option to generate the report file. Panel (c) shows the exported attendance recap in Excel format stored on the device, indicating that the system not only records attendance but also produces a downloadable administrative output that can be archived or submitted for school documentation.

3.7. Customer evaluation

After the Construction and Release stage, a customer evaluation was conducted to assess the quality and readiness of the e-attendance system in terms of validity, practicality, and effectiveness. This evaluation aimed to ensure that the developed product is conceptually appropriate, feasible to use in school routines, and capable of improving the attendance process as intended. The assessment consisted of expert-based validation (content and construct validity), user-based practicality testing, and effectiveness testing using a pre–post evaluation design.

3.7.1. Validity Testing

Three independent experts conducted validity testing to assess whether the system's features, workflows, and outputs aligned with the intended objectives and user needs. Both content validity and construct validity yielded consistently high agreement scores across experts, indicating that the system is valid and suitable for implementation, as shown in Table 7.

Table 7. Content and construct validity results (expert review)

Validity type	Expert 1	Expert 2	Expert 3	Mean score	Interpretation
Content validity	1	0.91	1	0.97	Valid
Construct validity	1	0.91	1	0.97	Valid

3.7.2. Practicality testing

Practicality testing involved three representative users (teachers) who evaluated the system using a structured practicality assessment form. The overall practicality score was analyzed using Moment Kappa, as calculated in Equation (4), to measure the level of agreement beyond chance. The results indicate a very high level of practicality, suggesting that the system is easy to operate and feasible for classroom routines, as summarized in Table 8.

Table 8. Practicality test summary (user practicality assessment)

Respondent	Total Score	Maximum Score	Proportion (Po)
User 1	27	30	0.9
User 2	28	30	0.93
User 3	28	30	0.93
Total / Mean	83	90	0.92

- $P_o = 83/90 = 0.92$
- $P_e = (90 - 83)/90 = 0.077$
- $\kappa = (P_o - P_e)/(1 - P_e) = (0.92 - 0.077)/(1 - 0.077) = 0.91$ (4)

Based on the calculation in Equation (4), the practicality coefficient ($\kappa = 0.91$) indicates a very high level of practicality. This result shows that the system has strong usability and is operationally feasible for classroom implementation.

3.7.3. Effectiveness testing

Effectiveness was evaluated using a one-group pre-test–post-test design involving 11 teachers, measuring perceived performance in attendance procedures before and after the system was used. Improvement was quantified using the normalized gain score (G), as shown in Equation (5). The results indicate a substantial increase from the pre-test mean to the post-test mean, with a high gain value, suggesting that the system was highly effective in improving attendance-related procedures, as presented in Table 9.

Table 9. Effectiveness test results (Pre–Post Summary)

Measure	Pre-test mean (%)	Post-test mean (%)	Normalized gain (g)	Interpretation
Teacher effectiveness rating (n = 11)	33.94	95.15	0.92	Very high

$$G = \frac{(Post-Pre)}{(100-Pre)} = \frac{(95.15-33.94)}{(100-33.94)} = \frac{61.21}{66.06} = 0.92 \quad (5)$$

Based on the calculation in Equation (5), the normalized gain score was $G = 0.92$, which falls into the very high category. This indicates that the system showed strong effectiveness in supporting attendance operations.

4. Discussion

This study developed and implemented an Android-based e-attendance system with facial biometric verification and WhatsApp-based parent notification at MTsN 2 Payakumbuh using an iterative

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Spiral SDLC approach. The system directly targeted persistent limitations of manual attendance, including time inefficiency, recording errors, and delayed reporting, which are widely reported in school administration contexts (Chávez-Saldaña et al., 2026; Kakepoto et al., 2022; Muhafidin, 2020; Silvia Berliana Ghany & Muhammad Fadlullah, 2025). The evaluation indicates strong readiness for operational use: experts rated both content and construct validity highly (mean = 0.97), teachers reported very high practicality (κ = 0.91), and perceived effectiveness increased substantially from pre-test (33.94%) to post-test (95.15%) with a high normalized gain (g = 0.92).

These findings are consistent with prior research showing that e-attendance systems improve administrative efficiency and reduce human error by automating attendance recording and reporting (Ali et al., 2024; Darojah et al., 2025; Ocumen et al., 2020). The present study extends this literature by operationalizing facial recognition in a secondary-school attendance workflow, addressing a gap in education-focused biometric implementation, as much prior biometric work is concentrated in broader security settings rather than classroom administration (Abdul-Al et al., 2024; Hernandez-de-Menendez et al., 2021; Hoo & Ibrahim, 2019; Jakobsen et al., 2025; Khan et al., 2023; Rukhiran et al., 2023). The positive practicality results suggest that facial recognition, when embedded in a simple Android flow, can be feasible for everyday use under typical school constraints (Thai et al., 2024; Wan Abdul Rahman & Roslan, 2023)

Triangulation across data sources strengthens the credibility of the outcomes. Observations and interviews identified concrete operational bottlenecks in manual attendance and the need for faster reporting and parent feedback, which were translated into functional requirements and refined iteratively through Spiral SDLC cycles (Mumtaz et al., 2022; Pinciroli et al., 2022; Sari et al., 2022; Stepanov, 2021). The evaluation results then confirmed alignment between intended constructs and system performance through expert validity assessment (Aiken, 1985), user-practicality measurement via agreement analysis, and effectiveness estimation using normalized gain (Hake, 1998). This convergence suggests the system improvements are plausibly linked to the implemented design rather than being solely a novelty effect.

A notable contribution is the integration of automated parent notification, which strengthens transparency and accelerates information flow to stakeholders. Prior studies emphasize that ICT adoption can enhance administrative transparency and improve decision-making by enabling timely reporting and communication (Saadati et al., 2023; Supiani et al., 2024; Yani et al., 2025). In this study, WhatsApp-based notifications provide immediate updates on attendance status, supporting parental monitoring and potentially reducing information gaps common in manual systems.

Nevertheless, the effectiveness findings should be interpreted cautiously due to the one-group pre-test–post-test design, which limits causal inference and is vulnerable to testing or maturation effects. Future studies should use control/comparison groups and multi-site evaluations to test generalizability. In addition, operational constraints such as network instability and biometric data governance remain important considerations; improvements in offline synchronization reliability, retention policies, and auditability would strengthen deployment in broader school settings (Li & Zhang, 2025; Marshall et al., 2022; Mhlongo et al., 2023). Overall, the results indicate that an Android-based facial biometric attendance system can be valid, practical, and highly effective for improving attendance administration in a secondary school context, supporting ongoing ICT-driven modernization in education systems (Sain et al., 2024; Santally et al., 2020; Timotheou et al., 2023).

5. Limitations

Several limitations should be acknowledged when interpreting the findings. First, the effectiveness assessment employed a one-group pre-test–post-test design, which limits causal inference because improvements may partially reflect testing effects, maturation, or contextual changes during implementation rather than the system alone. Second, the evaluation relied mainly on teacher-reported effectiveness scores, which may introduce response bias and do not fully capture objective operational metrics such as time saved per class session, error rates, or system uptime. Third, the study was conducted in a single school setting (MTsN 2 Payakumbuh) over a defined period (May–November 2025), which limits generalizability to schools with different infrastructure conditions, administrative policies, or user-readiness levels. Fourth, the system's performance is potentially sensitive to real-world conditions relevant to facial recognition, such as lighting variability, camera quality, and device heterogeneity. At the same time, the Spiral SDLC supports iterative refinement; the present study did not include a controlled benchmarking of face recognition accuracy under systematically varied conditions. Finally, because biometric data are involved, long-term deployment requires robust governance (consent, retention policies, and auditability). Although this study applied basic data protection measures, further alignment with evolving ethical and privacy standards is needed for broader-scale adoption.

6. Conclusion and future work

This study designed, developed, and deployed an Android-based e-attendance system using facial biometric verification and WhatsApp notification to address inefficiencies and transparency gaps in manual attendance practices at a secondary school in Indonesia. Using an iterative Spiral SDLC approach, the system was implemented as an integrated solution consisting of a web-based admin dashboard and a teacher-facing Android application. Evaluation results indicate that the system is valid (content and construct validity mean = 0.97; Aiken's V approach), highly practical for users ($\kappa = 0.91$), and highly effective in improving perceived attendance operation outcomes (pre-test mean 33.94% to post-test mean 95.15%; normalized gain $g = 0.92$). Overall, the findings suggest that facial recognition-enabled attendance, when embedded in a school-feasible Android workflow and coupled with automated parent communication, can support more efficient and accountable attendance administration.

Future research should strengthen evidence and scalability in at least four directions. First, effectiveness should be tested using comparative designs (quasi-experimental or randomized control) and multi-site deployments to improve causal inference and generalizability. Second, evaluation should incorporate objective performance indicators, including processing time, recognition accuracy (false accept/false reject rates), error correction frequency, and system reliability under network disruption. Third, the system can be enhanced with stronger offline-first mechanisms, including robust synchronization, conflict resolution, and local caching to ensure continuity during unstable connectivity. Fourth, long-term adoption requires more comprehensive biometric governance, including explicit consent workflows, retention periods, audit logs, and privacy-by-design refinements aligned with responsible ICT implementation in education. Finally, future iterations may consider cross-platform support (e.g., iOS) and broader stakeholder integration (school administrators and parent portals) to improve accessibility and institutional interoperability.

Author's declaration

Author contribution

M. Fahri Akbar: Conceptualization; Methodology; Software; System design and implementation; Data curation; Investigation; Validation; Formal analysis; Visualization; Writing original draft; Writing review & editing. **Firdaus Annas:** Conceptualization; Methodology; Investigation; Supervision; Writing review & editing. **Liza Efriyanti:** Validation (expert review); Methodology (instrument development and evaluation design); Writing review & editing. **Supriadi:** Supervision; Project administration; Resources; Writing review & editing.

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Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Conflict of interest

The author declares no competing interests.

Ethical clearance

Research permission was obtained from MTsN 2 Payakumbuh. Participation in interviews and evaluation activities was voluntary and based on informed consent. Given that the system involves facial biometric data, the study applied basic data protection measures, including data minimization, restricted access for authorized staff, and controlled storage of attendance-related records. All reporting was conducted using aggregated and anonymized information to prevent identification of individual students.

AI statement

The authors used a grammar-checking tool, such as Grammarly, to improve language clarity. The tool was not used to generate scientific content. All research content, analysis, tables, and figures were produced and verified by the authors.

Publisher's and Journal's note

Universitas Negeri Padang as the publisher, and the Editor of Jurnal Pendidikan Teknologi Kejuruan state that there is no conflict of interest towards this article publication.

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Nomenclature

s = $r - l_o$

v = Aiken's validity index

r = score assigned by an expert
l_o = lowest score on the rating scale
c = highest score on the rating scale
n = number of expert validators
k = Kappa Moment indicating product practicality
P = Observed Agreement (proportion of agreement calculated by the ratio of values agreed by the validators)
P_e = Expected Agreement (proportion of non-agreed values)
G = Normalized Gain Score
S_f = Post-Test Score
S_i = Pre-Test Score