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Design of a Web-Based Attendance System Using the Agile Method at biMBA AIUEO Klender Unit

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Abstract: Attendance tracking for teachers and students at biMBA AIUEO Klender Unit is currently conducted manually using paper forms, rendering the process susceptible to physical document loss and time manipulation through timestamp camera applications. This conventional approach also poses compliance risks regarding Government Regulation Number 17 of 2025 and Minister of Communication and Digital Affairs Regulation Number 9 of 2026 concerning electronic system governance in child protection. This study aims to design and develop a web-based attendance system that integrates facial recognition technology to prevent fraudulent teacher attendance, while ensuring that student attendance records remain entirely under the supervision and operational authority of teacher accounts. The system was developed using the Agile software engineering framework, combined with qualitative data collection through observation, interviews, and literature study, alongside quantitative descriptive evaluation [cek metode: if the journal explicitly requires the term 'numerical method', replace with: alongside numerical quantitative evaluation] to determine the validity rates of Black-box Testing and user satisfaction levels via User Acceptance Testing. The application was constructed using Laravel, PHP 8.2+, and MySQL, enhanced with geofencing verification, automated WhatsApp Gateway notifications, DOMPDF-based report generation, and Progressive Web App accessibility. Black-box Testing demonstrated that all 18 test scenarios were completely valid (100%), while User Acceptance Testing across user categories achieved an overall average score of 91.6%, categorized as "Very Good." This study confirms that the proposed system effectively eliminates attendance manipulation loopholes, complies with statutory child protection regulations, and improves administrative monitoring and reporting efficiency for biMBA AIUEO Klender Unit.

Keywords: Attendance System; Agile; Laravel; MySQL; Facial Recognition; Child Protection.

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1. Introduction

Rapid advancements in information technology have substantially facilitated human work, particularly through software engineering and web-based information systems. In education and organizational management, information technology plays a pivotal role in improving processing speed, data accuracy, and administrative management in real time. A central administrative component in this context is the attendance tracking system, as consistent attendance from both educators and students remains vital to instructional effectiveness. An effective administrative framework must ensure data transparency while minimizing input errors commonly encountered in conventional record-keeping methods (Aan *et al.*, 2023). Nevertheless, the deployment of digital systems within early childhood educational settings must comply strictly with prevailing statutory regulations. Under Government Regulation Number 17 of 2025 concerning the Implementation of Electronic Systems in Child Protection (Government of the Republic of Indonesia, 2025) and its governing provision, Minister of Communication and Digital Affairs Regulation Number 9 of 2026 (Ministry of Communication and Digital Affairs, 2026), digital interactions involving minors under 18 years of age must prioritize child safety and data governance. Consequently, where attendance tracking involves young learners, execution must be directed and supervised by adult educators to ensure full alignment with child protection frameworks. In contrast to these ideal standards and legal mandates, operational management at biMBA AIUEO Klender Unit faces substantial practical challenges. As an educational center focusing on early reading and cognitive guidance, the institution relies heavily on teacher attendance punctuality and precision to deliver consistent daily learning services. However, attendance tracking for teachers is still conducted manually using paper logs and physical sign-in binders, a conventional approach that is also applied to student attendance recording. This reliance on manual documentation creates logistical vulnerabilities, including the risk of physical document damage or loss, as well as operational latency in managing attendance records. Similar limitations associated with paper-based attendance systems have been reported in other educational institutions, such as SDN Serua 03, where the lack of automated platforms impeded real-time supervisory tracking (Maulana *et al.*, 2024). This operational gap is further compounded by vulnerabilities surrounding record manipulation. Traditional recording mechanisms hinder management from promptly detecting dishonest practices, such as fabricating presence using third-party timestamp camera applications. Concurrently, efforts to directly engage young students in digital presence logging to verify actual attendance are constrained by legal restrictions regarding autonomous device usage by underage children. This demonstrates that biMBA AIUEO Klender Unit lacks an integrated electronic system capable of preventing teacher attendance fraud while simultaneously accommodating lawful, secure student attendance documentation strictly under teacher supervision within a shared platform. If left unresolved, fraudulent attendance logs and reliance on manual tracking will generate sustained negative repercussions. Inaccurate teacher records directly inflict financial losses on management through miscalculated payroll disbursements and unearned performance incentives, which subsequently degrades institutional instructional discipline. Moreover, permitting unsupervised digital device interactions by minors, combined with the absence of auditable administrative controls, risks non-compliance with the child protection requirements outlined in Government Regulation Number 17 of 2025 and Ministerial Regulation Number 9 of 2026 (Government of the Republic of Indonesia, 2025; Ministry of Communication and Digital Affairs, 2026). Therefore, transitioning from paper-based procedures to an automated, real-time digital architecture constitutes an urgent operational necessity.

To overcome these challenges, a comprehensive web-based attendance management system is required. The proposed solution encompasses the development of an online presence platform integrating mobile device cameras, positioning educators as the primary authorized users. Teachers are required to record their attendance digitally through verifiable biometric checks to prevent manipulation; concurrently, educators are granted authorized credentials to verify and log student attendance directly within the classroom environment. System development adopts the Agile software engineering framework to accelerate continuous deployment cycles and enhance product reliability iteratively. Within this context, the study addresses three primary problems: the persistence of paper-based attendance logs, susceptibility to fraudulent attendance via mock timestamp applications, and the lack of a real-time monitoring dashboard supported by facial recognition and automated reporting mechanisms. The scope of this research is strictly confined to biMBA AIUEO Klender Unit, covering the operational attendance workflow of registered teaching staff and enrolled students. In strict accordance with Government Regulation Number 17 of 2025 and Ministerial Regulation Number 9 of 2026, the application does not permit autonomous system operation by underage pupils; all student presence records are managed, verified, and submitted exclusively through authenticated teacher accounts. Grounded in research gaps identified across prior web-based attendance platforms (Nurelasari, 2020; Tanjung & Venica, 2023), this study aims to: 1) design a robust paperless attendance system resolving current operational deficiencies; 2) implement an integrated student presence logging workflow operated exclusively under teacher authority to ensure legal compliance with national child protection mandates; and 3) construct an automated attendance monitoring system enabling real-time managerial oversight via facial recognition

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technology and instant monthly report generation. This study provides theoretical contributions by enriching the literature on applied software engineering, specifically regarding Agile methodologies deployed for real-time presence solutions aligned with statutory child electronic data governance. Practically, the platform benefits biMBA AIUEO Klender Unit by curbing employee attendance fraud, accelerating administrative report synthesis, and creating a compliant environment for monitoring student participation.

2. Related Work

2.1 State-of-the-art Research

The majority of recent studies on attendance information systems utilize web-based architectures built upon the Laravel framework and MySQL relational databases, representing a widely adopted technology stack for rapid and secure web development. Maulana *et al*. (2024) developed a web-based teacher attendance system using Laravel and MySQL for SDN Serua 03 to replace paper-based workflows that were susceptible to recording inaccuracies and hindered real-time managerial monitoring. Tanjung *et al*. (2023) designed an employee attendance platform for Diskominfo West Java Province employing the Prototype method with Laravel, PostgreSQL, and REST API integration, which optimized the administrative processing of daily attendance, leave permits, and cumulative delay recaps. Nurwanto *et al*. (2025) applied the Waterfall model alongside Laravel and MySQL at PT Binayasa Putrabatara, producing a system that supported real-time logging and facilitated automated report generation without functional errors during Black-box testing. Similar implementations of Laravel- and MySQL-based attendance architectures have been evaluated across various educational and commercial contexts (Christina *et al*., 2019; Hamdana *et al*., 2025; Mulia, 2020), with findings confirming that automated web frameworks effectively reduce manual data entry burdens while demonstrating robust functional validity. Beyond standard tabular web forms, several studies have enhanced attendance verification by integrating supplementary sensing modalities. Arifin *et al*. (2024) combined GPS-based location tracking with selfie-photo verification in a Laravel application for PT Kaltim Methanol Industri, achieving a 91% user satisfaction rating in addressing employee presence fraud. Zen and Wijaya (2023) integrated RFID Arduino hardware with Laravel 9 for student attendance tracking at SMKN 9 Medan, while SMS Gateway modules were introduced to deliver automated notification dispatches to parents regarding student presence. Mobile applications have also been introduced as alternatives to web interfaces, such as the Android-based student attendance tool developed by Christina *et al*. (2019). Akbar *et al*. (2026) proposed an anti-fraud attendance system utilizing dynamically rotating QR codes paired with photographic capture for SMP Negeri 204 Jakarta to prevent buddy-punching practices. Furthermore, Indomarco and Mulyana (2025) implemented face and geo-location classification, Aizah and Santoso (2024) developed automated WhatsApp Gateway notification modules for SDN 2 Seletreng, and Firdaus (2025) integrated web-based facial recognition with SMS dispatch. These investigations confirm that biometric verification (facial recognition, GPS geofencing) and automated messaging gateways (SMS and WhatsApp) effectively mitigate attendance manipulation and accelerate notifications, although most existing implementations address these technologies only as isolated features.

2.2 Comparison with Previous Studies

To establish the context of this study within the existing literature, Table 1 compares the development methodologies, technology stacks, verification mechanisms, and primary limitations of representative prior studies with the system proposed in this research.

Table 1. Comparison with Previous Studies

Study	Method	Technology Stack	Verification Mechanism	Main Limitation
Maulana *et al*. (2024)	Not specified	Laravel, MySQL	Manual form input	No biometric verification; single user role (teacher)
Tanjung *et al*. (2023)	Prototype	Laravel, PostgreSQL, REST API	Manual form input	No real-time location or face verification
Arifin *et al*. (2024)	Not specified	Laravel, MySQL	GPS and selfie photo	No dedicated child-supervision workflow
Zen & Wijaya (2023)	Not specified	Laravel 9, RFID Arduino	RFID tag scan	Requires dedicated physical RFID hardware per user
Akbar *et al*. (2026)	Not specified	Web-based, QR generator	Rotating QR code and photo	No automated WhatsApp notification or PWA access

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Aizah & Santoso (2024)	Not specified	Web-based	Manual form input	No biometric verification; notification-only focus
Firdaus (2025)	Not specified	Web-based, Face API, SMS Gateway	Face recognition and SMS	Direct student device interaction required; no adult-supervised workflow
Proposed System	Agile	Laravel, PHP 8.2+, MySQL, PWA	Geofencing, time-lock validation, and facial recognition selfie	Single-unit scope; absence of liveness detection mechanism

2.3 Research Positioning and Novelty

Prior research indicates that while web architectures using Laravel are prevalent, most platforms rely on a single verification modality, such as GPS with selfies (Arifin *et al.*, 2024), RFID tags (Zen & Wijaya, 2023), rotating QR codes (Akbar *et al.*, 2026), or face recognition with SMS dispatch (Firdaus, 2025). Critically, none of these systems incorporate an adult-supervised operational workflow designed to prevent direct digital device interaction by underage children, as mandated by Indonesian child protection regulations (Government of the Republic of Indonesia, 2025; Ministry of Communication and Digital Affairs, 2026). The present study addresses this research gap by developing a real-time attendance system that simultaneously manages two distinct user entities—teachers as operational staff and enrolled minors at the early childhood education level (biMBA AIUEO Klender Unit). Built using the Agile framework and MySQL, the system delivers an integrated architecture combining facial recognition verification, GPS geofencing, server-side time-lock mechanisms to eliminate retrospective data alteration, automated WhatsApp Gateway notifications, DOMPDF-based report generation, and Progressive Web App accessibility. Crucially, all student attendance operations remain strictly under teacher authentication. This architectural combination and its explicit compliance with child protection mandates constitute the primary novelty distinguishing this research from prior work.

2.4 Theoretical Foundations and Technological Framework

An information system comprises hardware, software, databases, procedures, and personnel operating synergistically to capture, process, store, and disseminate structured information for organizational decision-making (Aan *et al.*, 2023). In contemporary administrative workflows, web-based systems provide dynamic data exchange capabilities, allowing multiple authenticated stakeholders to access centralized databases concurrently without paper records (Aizah & Santoso, 2024). Within biometric attendance frameworks, real-time data processing executes computational algorithms instantaneously, enabling immediate attendance logging to the server and triggering automated asynchronous external dispatches via messaging APIs (Firdaus, 2025). The technical foundation of the proposed application relies on PHP as an open-source server-side scripting language to dynamically process client requests and generate responsive web interfaces (Pratiwi *et al.*, 2024). The application is built upon Laravel, a modern PHP framework implementing the Model-View-Controller (MVC) architectural pattern. This pattern decouples data management, user presentation, and routing logic, while offering built-in security mechanisms against cross-site request forgery (CSRF) and SQL injection vulnerabilities in accordance with Open Web Application Security Project guidelines (Pratiwi *et al.*, 2024; Stuttard & Pinto, 2021). Relational data persistence is managed through MySQL, chosen for its data throughput efficiency, concurrent multi-user handling, and seamless integration with Laravel's Eloquent object-relational mapping. Development was conducted using the Agile software engineering framework to balance structured initial requirement definitions with adaptive iterative cycles. The project organized functional and non-functional specifications into a prioritized product backlog, supported by Unified Modeling Language (UML) and Entity Relationship Diagram (ERD) abstractions. Iterative sprints converted architectural designs into executable modules, including facial recognition pipelines and geofencing validations, concluding with Black-box testing to verify component reliability. This iterative cadence minimized functional redundancies and accommodated user feedback more effectively than traditional linear methodologies. Furthermore, because early childhood education serves as a critical developmental milestone requiring structured, safe environments and holistic cognitive-motor stimulation (Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2022), administrative automation must strictly uphold child-protective data governance.

3. Methodology

3.1 Research Method

This research employed the Agile software engineering framework coupled with qualitative domain analysis and quantitative testing evaluation metrics. The Agile model was chosen because its iterative lifecycle supports dynamic requirement refinements, proactive risk mitigation, and continuous software quality

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enhancements throughout development sprints. The qualitative component captured operational workflow requirements and regulatory compliance parameters at biMBA AIUEO Klender Unit, whereas the quantitative component governed empirical verification via Black-box behavioral testing and User Acceptance Testing (UAT) to evaluate system performance and functional accuracy.

3.2 Data Collection Method

Data collection was conducted using three primary techniques. First, direct observation was performed on-site at biMBA AIUEO Klender Unit to evaluate existing manual attendance procedures, operational bottlenecks, physical record vulnerabilities, and logistical dependencies. Second, structured interviews were conducted with key administrative stakeholders, notably the Head of Program (Kepala Program), to formulate functional system specifications, access rights hierarchies, and compliance protocols. Third, a literature study was conducted to examine theoretical and technical frameworks concerning facial recognition, Progressive Web Applications (PWA), WhatsApp Gateway APIs, and validation methodologies using Black-box testing and User Acceptance Testing.

3.3 Requirement Analysis

Requirement analysis established the operational criteria and behavioral boundaries of the proposed platform, categorized into functional specifications and environmental software prerequisites. Operationally, the system manages three distinct user roles: 1) Admin / Head of Program (KP), authorized to manage teacher and student master datasets, supervise attendance activity through real-time dashboards, and generate validated monthly reports; 2) Teacher, authorized to record self-attendance via facial biometrics and geofencing, while managing the digital attendance logging of enrolled students in the classroom; and 3) Parent or Guardian, designated as a read-only role with restricted access limited exclusively to monitoring the attendance records of their respective children. To enforce data integrity and eliminate retrospective data falsification, the system implements server-side time-lock and token validation mechanisms that automatically lock attendance forms after predefined operational timeframes. The non-functional requirements specifying the development, hosting, and client operational environments are detailed in Table 2.

Table 2 Software and Hardware Environment Specifications

No	Component	Specification	Primary User
1	Operating System (Desktop/Laptop)	Windows 10/11 (64-bit), macOS, or Linux	Head of Program (Admin)
2	Operating System (Mobile)	Android 10+ / iOS 14+	Teacher (User)
3	Web Browser Engine	Google Chrome, Mozilla Firefox, or Microsoft Edge	Head of Program and Teacher
4	Web Server Package	XAMPP Stack (Apache)	Developer
5	Database Management System	MySQL Relational Database	Developer
6	Application Framework	Laravel MVC Framework	Developer
7	Programming Language	PHP 8.2 or higher	Developer
8	Dependency Manager	Composer Dependency Manager	Developer
9	Integrated Development Environment	Visual Studio Code	Developer

3.4 System Design

The attendance architecture for biMBA AIUEO Klender Unit is constructed as a responsive web application leveraging Laravel and Bootstrap 5. It modernizes administrative reporting through real-time multi-factor verification, integrating precise geolocation (GPS coordinates matched against authorized geofencing boundaries) and photographic evidence capture. The architecture automates administrative workflows across the three primary user roles to deliver an auditable, transparent, and tamper-resistant tracking ecosystem. The structural boundaries, authorized permissions, and interactions across system actors are delineated in Figure 1.

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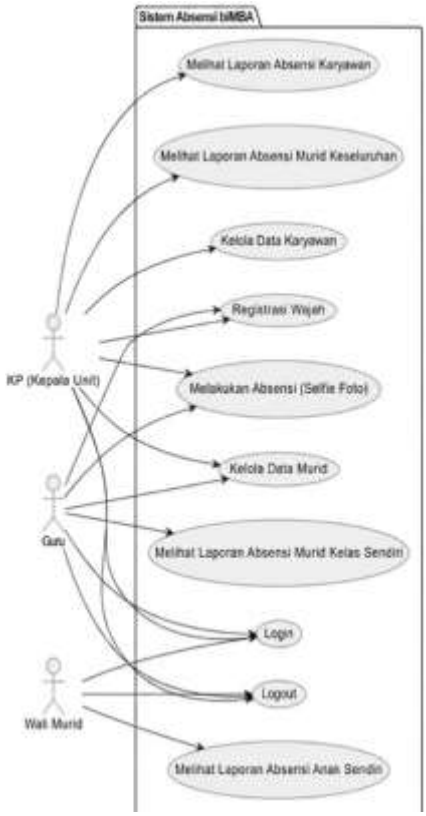


Figure 1. Use Case Diagram of the Proposed Attendance System

As illustrated in Figure 1, the Head of Program serves as the central administrative authority exercising complete managerial oversight, including system authentication (login and logout), centralized reporting generation for staff and students, master data management, biometric facial data registration, and facial-recognition attendance recording. Teachers focus on daily classroom logistics, encompassing student facial data registration, daily teacher check-in and check-out, student attendance logging, and class-level report monitoring. Parents or Guardians, representing the student tracking module, possess strictly restricted access confined to account authentication and real-time read-only inspection of their child's attendance log. System login functions as an obligatory security gateway across all three actors before accessing downstream functional modules. The operational workflows across individual user roles are modeled through sequential activity diagrams. The educator workflow is illustrated in Figure 2.

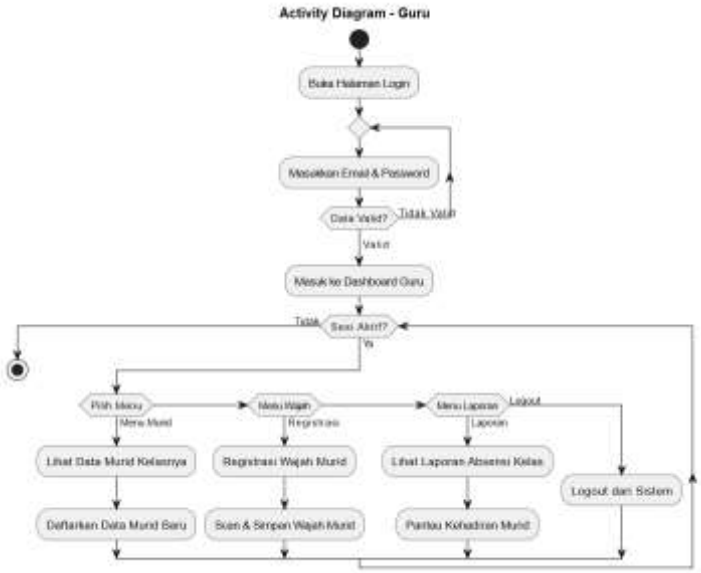


Figure 2. Teacher Operational Activity Diagram

As shown in Figure 2, the teacher's workflow initiates at the authentication interface where registered credentials (email and password) are submitted. The system validates the input; invalid attempts redirect back

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with error notifications, whereas authenticated credentials launch the Teacher Dashboard. From the dashboard, educators can navigate through specialized modules: 1) the "Students" module to inspect enrolled student profiles or register newly admitted children; 2) the "Facial Biometrics" module to scan, extract, and store facial feature vectors for automated recognition; and 3) the "Reports" module to monitor classroom attendance history. The operational cycle terminates upon selecting the logout action, which invalidates the active session token.

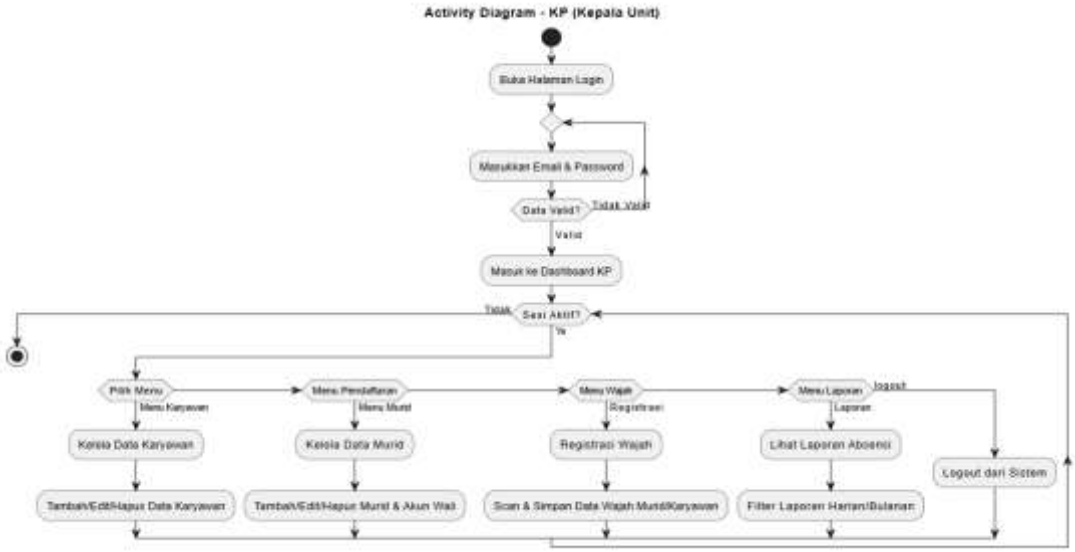


Figure 3. Head of Program Operational Activity Diagram

As delineated in Figure 3, the administrative workflow for the Head of Program begins with portal authentication. Upon credential verification by the application layer, the user enters the administrative dashboard. Within this interface, administrative operations are partitioned into specialized functional menus: 1) Employee Management, facilitating full CRUD operations (create, read, update, delete) for instructional staff; 2) Student and Guardian Registration, enabling demographic management; 3) Biometric Management, allowing administrative facial descriptor extraction for staff and students; and 4) Attendance Reporting, enabling filtered analytical views of daily and monthly presence recaps. The administrative session concludes when the user initiates session termination via logout.

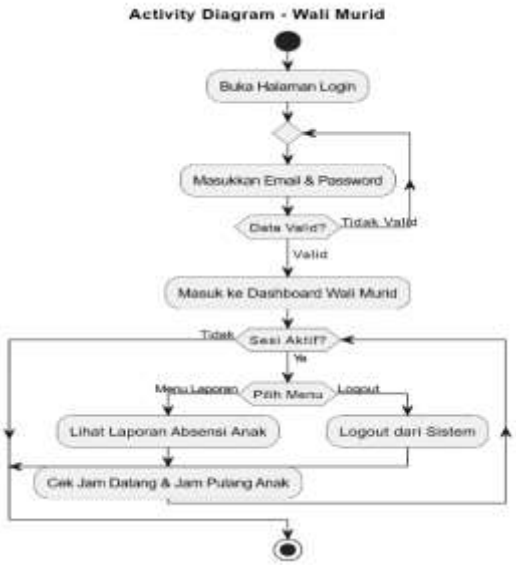


Figure 4. Parent or Guardian Operational Activity Diagram

The guardian workflow illustrated in Figure 4 begins with credential entry on the login interface. Upon successful validation against the database, the parent enters the Guardian Dashboard. From this dedicated portal, users navigate directly to the Attendance Record module to inspect the timestamps of their child's arrival and departure in real time. To maintain system security and comply with statutory child protection guidelines, all parent interactions remain strictly read-only, concluding when the user logs out of the portal.

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The relational database architecture supporting the attendance platform is structured across five primary relational schemas, as depicted in Figure 5.

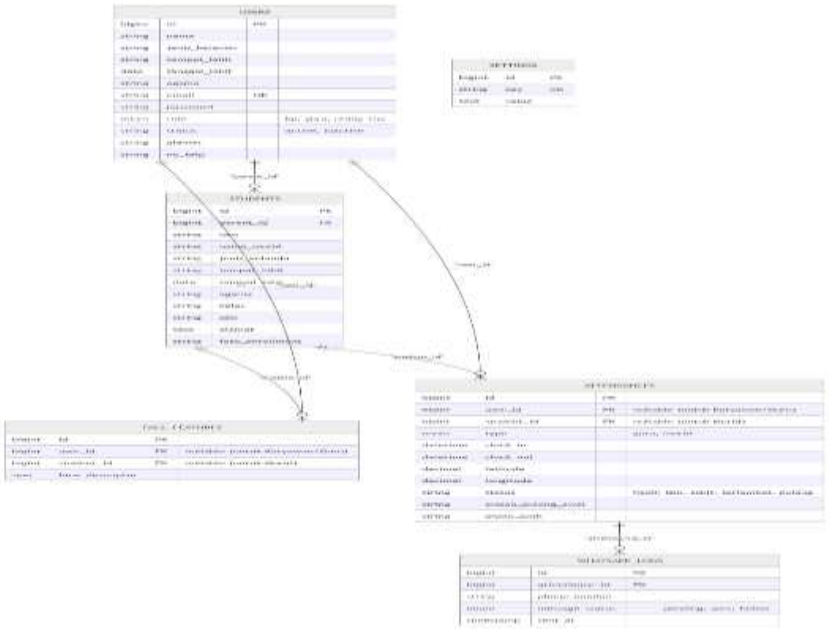


Figure 5. Entity Relationship Diagram of the Attendance Platform

The entity relationships mapped in Figure 5 govern data persistence through five core associations: 1) a one-to-many relationship between USERS (role: parent) and STUDENTS, wherein an authenticated parent account may link to one or more enrolled children via the foreign key parent_id in the students table; 2) a one-to-one relationship between USERS/STUDENTS and FACE_FEATURES, establishing that each registered individual possesses exactly one localized biometric descriptor record; 3) a one-to-many relationship between USERS/STUDENTS and ATTENDANCES, recording longitudinal presence logs across academic dates; 4) a one-to-many relationship between ATTENDANCES and WHATSAPP_LOGS, wherein every attendance submission triggers an asynchronous notification recorded in a dedicated message log table; and 5) an independent dynamic schema, SETTINGS, utilized to store operational configurations as key-value pairs. System verification and validation were conducted through two rigorous testing methodologies. Black-box Testing evaluated application functionality by testing functional boundaries, input handling, and output responses without inspecting internal source code. This testing confirmed operational integrity across user authentication, master data management, biometric attendance operations, and report generation. Concurrently, User Acceptance Testing (UAT) evaluated system adoption and satisfaction by administering a structured questionnaire to 20 representative users comprising teachers and parents. The evaluation instrument examined three standard dimensions: Usability, Reliability, and Usefulness. The instrument comprised 18 statements (six items per dimension) evaluated across a 5-point Likert scale ranging from 5 (Strongly Agree) to 1 (Strongly Disagree).
The collected UAT survey data were evaluated using quantitative descriptive analysis. The theoretical maximum score achievable for each evaluation dimension and the entire instrument was determined using Equation (1):

$$SkorMaksimum = R \times S \times Xmax \quad (1)$$

Where R denotes the total number of respondents (R=20), SS represents the number of survey items (S=6 per dimension, or S=18 overall), and $Xmax$ represents the maximum Likert scale value ($Xmax = 5$). Consequently, the maximum achievable score is 600 points per dimension and 1,800 points for the cumulative evaluation. The overall percentage of user acceptance was calculated using Equation (2):

$$Persentase = \frac{Skor\ Perolehan}{Skor\ Maksimum}\ x\ 100\% \quad (2)$$

The calculated percentage scores were categorized using the five-tier interpretative scale detailed in Table 3.

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Table 3. Score Interpretation Scale for User Acceptance Testing

Percentage Range	Category
81% – 100%	Very Good
61% – 80%	Good
41% – 60%	Fair
21% – 40%	Poor
0% – 20%	Very Poor

Functional validity from the Black-box testing suite was synthesized as an empirical percentage using Equation (3):

$$P = \frac{V}{S_t} \, x \, 100\% \tag{3}$$

Where P represents the functional validity percentage, V denotes the number of successfully validated test scenarios, and St represents the cumulative number of executed test scenarios (St=18). The development and evaluation cycle spanned approximately 11 weeks (May to August 2026), structured across iterative Agile sprints comprising product backlog prioritization, empirical requirements gathering, architectural modeling, iterative feature implementation, dual-stage testing, application deployment, and final synthesis.

4. Results and Discussion

4.1 Results

The implementation phase translates the architectural blueprints detailed in Section 3—encompassing the use case, activity, and entity relationship diagrams—into a functional web-based attendance platform for biMBA AIUEO Klender Unit. The application was constructed using the Laravel framework (PHP 8.2+), MySQL relational database, and Bootstrap 5 frontend framework. Core functional enhancements include facial recognition biometric matching for attendance confirmation, Progressive Web App (PWA) capabilities providing native-like mobile responsiveness, the DOMPDF library for automated report generation, and asynchronous WhatsApp Gateway integration for instant transaction dispatches. The authentication interface shown in Figure 6 operates as the mandatory entry point across all three user roles—Head of Program, Teacher, and Parent/Guardian—before downstream functionalities can be accessed. Credential verification matches the submitted email and bcrypt-hashed password against the users table. Unmatched records return explicit error prompts, whereas authenticated credentials trigger role-based redirection to the appropriate dashboard depending on the designated role attribute (kp, guru, or orang_tua). Direct URL routing to restricted dashboard views without an active session is intercepted and redirected to the login interface, ensuring strict privilege separation.



Figure 6. System Authentication Interface

The Head of Program Dashboard shown in Figure 7 delivers operational oversight through summary metric widgets. These widgets display the active teacher count, total enrolled students, and real-time student attendance percentages for the current operating date, alongside categorization tables detailing presence status (Present, Permitted, Sick) and class-level distributions. The underlying database queries aggregate records from the attendances and students tables filtered by the current server date. Consequently, manual

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ledger calculations are replaced with automated metric synthesis, allowing administrative staff to supervise institutional operations through a centralized interface.

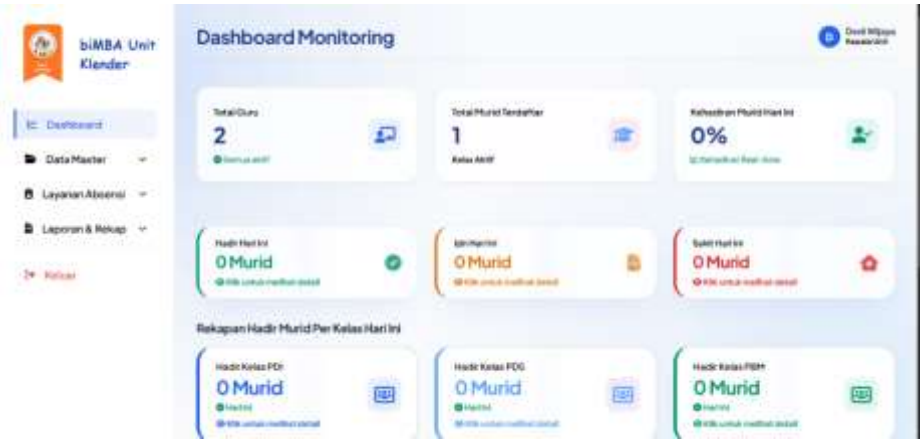


Figure 7. Head of Program Administrative Monitoring Dashboard

The core module mitigating fraudulent attendance practices is the self-attendance interface illustrated in Figure 8, which combines facial recognition biometrics with mobile GPS geofencing. During the initial registration phase, facial photographs captured via device cameras are processed to extract mathematical face descriptor vectors, which are stored within the face_features table through a 1:1 association with the user account. During daily attendance check-ins, the interface activates the camera to capture a live facial image, compares it against the stored descriptor, and upon positive verification, logs the timestamp, geographical coordinates (latitude and longitude), and image storage path within the attendances table. Furthermore, server-side temporal validation enforces automated form locking after operating thresholds elapse, preventing retrospective attendance falsification after reporting cycles close.

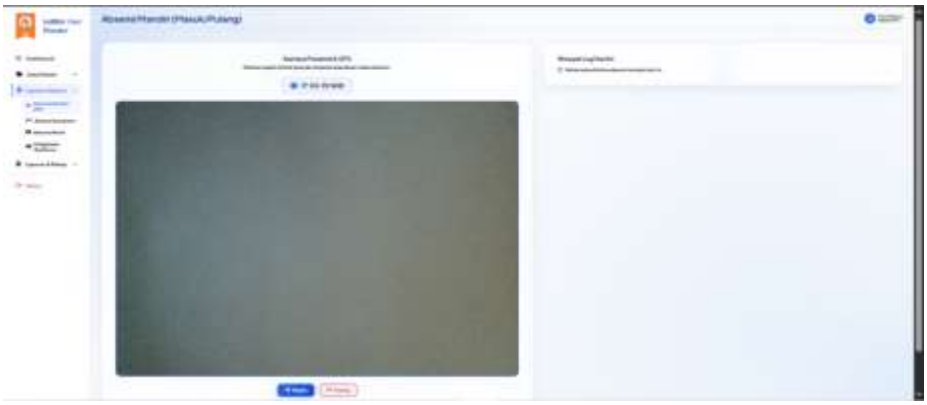


Figure 8. Facial Recognition and Geofencing-Based Self-Attendance Interface

Beyond the primary modules illustrated above, the platform incorporates administrative master data management for personnel and students, batch or individual student presence logging with standard condition options (Present, Permitted, Sick, Absent), automated PDF report rendering via DOMPDF, mobile PWA manifest installation, and queue-based asynchronous WhatsApp dispatches with transmission logging. System behavioral validation was conducted across 18 test scenarios distributed among four core modules: authentication, master data management, attendance operations, and administrative reporting. Table 4 summarizes the testing outcomes per functional module. All executed test scenarios performed in accordance with predefined criteria, yielding zero functional defects.

Table 4. Black-Box Testing Results Summary

Module	Number of Scenarios	Valid	Invalid	Validity (%)
Authentication (Login and Logout)	8	8	0	100%
Master Data Management	4	4	0	100%
Attendance Operations	3	3	0	100%
Monitoring and Reporting	3	3	0	100%
Total	18	18	0	100%

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Applying Equation (3) to the testing data confirms the cumulative functional validity:

$$P = (1818) \times 100\% = 100\%. \quad (4)$$

This empirical outcome verifies that all developed application routines—spanning role-based routing, database CRUD transactions, facial biometric attendance check-in, real-time metrics generation, and PDF report compilation—function in alignment with architectural specifications. The User Acceptance Test evaluated user adoption and satisfaction across 20 representative respondents comprising instructional staff and parents or guardians. With R=20 respondents, S=6 items per dimension, and a maximum Likert value of 5, the maximum theoretical score per dimension is 20×6×5=600 points, establishing a cumulative instrument maximum of 1,800 points (20×18×5). Across all evaluated dimensions, respondents returned a cumulative score of 1,650 points. Table 5 details the quantitative scores, percentage calculations, and interpretative categories across the evaluated dimensions.

Table 5. User Acceptance Testing Evaluation by Dimension

Aspect	Items	Score Obtained	Maximum Score	Percentage	Category
Usability	6	550	600	91.6%	Very Good
Reliability	6	548	600	91.3%	Very Good
Usefulness	6	552	600	92.0%	Very Good
Total	18	1650	1800	91.6%	Very Good

Applying Equation (2) to the cumulative evaluation score confirms the overall acceptance percentage:

$$Persentase = (1650 / 1800) \times 100\% = 91{,}6\% \quad (5)$$

The Usability score of 91.6% indicates that users found the interface intuitive, navigable, and easy to operate. The Reliability rating of 91.3% reflects stable operational execution, consistent response handling, and informative system feedback. Furthermore, the Usefulness evaluation of 92.0% demonstrates that stakeholders perceived substantial operational benefits from automated recording workflows and real-time monitoring.

4.2 Discussion

The Black-box testing outcomes presented in Table 4 and the favorable acceptance ratings in Table 5 confirm the realization of the three research objectives established in Section 1. First, the objective of eliminating attendance manipulation was attained by coupling facial recognition biometrics with GPS geofencing and server-side temporal locks, replacing conventional paper ledgers vulnerable to timestamp camera spoofing. Second, the objective of delivering a child-compliant presence workflow was achieved by establishing an administrative protocol where digital device interactions remain strictly under teacher authentication, treating minors and parents solely as subjects and information recipients in full compliance with Government Regulation Number 17 of 2025 and Ministerial Regulation Number 9 of 2026 (Government of the Republic of Indonesia, 2025; Ministry of Communication and Digital Affairs, 2026). Third, the objective of facilitating automated managerial oversight was realized through real-time statistical dashboards and on-demand DOMPDF generation. From an administrative efficiency perspective, the platform eliminates manual aggregation workflows by compiling monthly attendance data automatically, freeing staff time for core pedagogical duties. Operationally, real-time dashboard analytics enable immediate intervention regarding student or teacher absenteeism without waiting for end-of-month reconciliations. Regarding data accuracy, cross-referencing biometric facial descriptors with physical coordinates closes the spoofing vulnerabilities typical of timestamp camera applications.

From a transparency standpoint, parents can review their children's verified attendance records via dedicated portals or automated WhatsApp dispatches without relying on informal verbal updates. System security is reinforced through bcrypt password hashing, role-based access controls, and temporal token constraints that prevent unauthorized retrospective modifications. Mobile accessibility is optimized via PWA architecture, providing native-like responsiveness and offline asset caching on teachers' mobile devices without app store distribution barriers. Furthermore, decoupling WhatsApp notification dispatches through Laravel queue workers ensures continuous foreground application responsiveness during high-volume check-in periods. Nevertheless, operational limitations must be noted. Biometric facial matching precision remains influenced by ambient lighting conditions and camera sensor resolutions, occasionally necessitating repeated verification attempts in poorly illuminated environments. Similarly, automated WhatsApp notification delivery depends upon internet stability and third-party gateway availability. Finally, the current system focuses on

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presence tracking and reporting, omitting digital workflows for formal leave permit submissions and administrative approvals, which represents an area for future functional expansion.

5. Conclusion and Recommendations

This study successfully designed and implemented a web-based attendance system using the Agile software engineering framework for biMBA AIUEO Klender Unit, effectively addressing the operational vulnerabilities identified in Section 1. Constructed using the Laravel framework (PHP 8.2+) and a MySQL database, the platform integrates facial recognition biometrics, mobile GPS geofencing, and server-side temporal locking mechanisms. This combined architecture effectively eliminates attendance falsification risks previously associated with paper-based ledgers and mock timestamp camera applications. Empirical validation confirms the technical reliability and high adoption of the system; Black-box testing yielded a 100% functional validity rate across all 18 executed test scenarios, while User Acceptance Testing across 20 representative respondents achieved an overall acceptance score of 91.6%, categorizing the platform as "Very Good" across usability, reliability, and usefulness dimensions. The primary contribution and novelty of this research reside in the synergistic integration of biometric verification, automated administrative reporting, and strict regulatory compliance within an early childhood education environment. Unlike prior architectures evaluated in Section 2, which typically implemented single-modality verifications in isolation, the proposed platform incorporates facial matching, geofence validations, automated DOMPDF report compilation, asynchronous WhatsApp Gateway notifications, and Progressive Web App accessibility into an adult-supervised workflow. By restricting all digital presence transactions exclusively to authenticated teacher accounts, the system ensures that enrolled minors never interact directly with electronic recording devices, thereby fulfilling the child data protection mandates established in Government Regulation Number 17 of 2025 and Minister of Communication and Digital Affairs Regulation Number 9 of 2026 (Government of the Republic of Indonesia, 2025; Ministry of Communication and Digital Affairs, 2026).

Despite these positive outcomes, several operational and technical constraints must be acknowledged. Methodologically, the system was implemented and evaluated within a single educational branch, meaning that institutional generalizability across broader educational networks remains to be established empirically. Technologically, biometric matching accuracy remains susceptible to ambient lighting variations and camera hardware quality, and the system currently lacks passive or active liveness detection mechanisms to counteract advanced physical spoofing attempts using high-resolution photographs or video playbacks. Furthermore, WhatsApp notification delivery depends on stable internet connectivity and third-party gateway availability, and the platform does not yet incorporate administrative workflows for digital leave permit requests. Future research should prioritize integrating liveness detection algorithms into the facial recognition pipeline, implementing automated leave request and approval modules, and developing long-term presence analytics dashboards to track longitudinal staff discipline. From an infrastructure perspective, establishing automated database backup routines, off-site disaster recovery protocols, and refactoring the architecture to support multi-tenant scalability are highly recommended to accommodate potential institutional expansion across multiple operating branches without requiring software redesign.

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