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Optimization of Web-Based Data for Muhammadiyah Al-Qur'an Education Parks in Sidoarjo Regency Using the R&D and Waterfall Methods

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ABSTRACT

Objective: *This research aims to develop a web-based information system for optimizing data at Muhammadiyah Quran Education Parks (TPQ) in Sidoarjo Regency. The background of this research is based on the problem of managing TPQ institutional data, which is still manual, separate, and difficult to access in an integrated manner, making monitoring, validation, and reporting difficult.* ***Method:*** *The research method uses a Research and Development (R&D) approach with the Waterfall development model.* ***Results:*** *The research results show that the information system built is able to integrate data on students, teachers, curriculum, activities, and institutional administration online. This system simplifies data management, improves reporting efficiency, and supports transparency and accountability in the guidance of TPQ by the Muhammadiyah Tabligh Council of Sidoarjo Regency.* ***Novelty:*** *The novelty of this research lies in the development of a web-based information system that integrates multiple aspects of TPQ data management, providing a solution to the challenges of manual and separate data handling, and improving overall efficiency and accountability in TPQ administration.*

INTRODUCTION

TPQ is a non-formal educational institution that plays an important role in shaping the character and spirituality of young Muslim generations. Within the Muhammadiyah environment, the existence of TPQs has become an integral part of cultural proselytization and religious education at the grassroots level. However, in practice, many TPQs face serious challenges in managing institutional data, student administration, teacher staffing, curriculum, and activity reporting. In Sidoarjo Regency, there are dozens of TPQs (Islamic Quranic Study Centers) under the auspices of the Muhammadiyah Tabligh Council, but not all of them have an integrated and digitalized data management system. The still-manual data management, scattered across each TPQ, causes difficulties in monitoring, data accuracy, and information synchronization. This condition impacts the weak validation of institutional data, low reporting efficiency, and a lack of transparency in the overall TPQ development process.

Current technological developments are a demand in the Islamic world to adapt and innovate, with digital transformation now becoming a necessity that must be realized in every institution, including TPQ [1]. The digitalization of Islamic education can improve management quality, accelerate information services, and strengthen public transparency and accountability [2]. The issue of data presentation to ensure data synchronization across all Muhammadiyah TPQs in Sidoarjo Regency requires the

implementation of a web-based application to optimize the management of TPQ data. This web application can be easily accessed by all TPQ administrators and members, anytime and anywhere, as long as they are connected to the internet. Additionally, the presentation of TPQ data will become more transparent and coordinated between one TPQ and another, allowing TPQ administrators and members to receive up-to-date information about TPQ data.

The R&D method is an approach used to create new products or improve existing ones based on received feedback [3], [4]. In creating the TPQ application, collaboration between the central TPQ coordinator and the programr is needed to gather direct feedback from users, ensuring that the resulting application meets the needs of the central TPQ institution within the Muhammadiyah environment. Additionally, the R&D method of this study refers to Muthohor's research [4], which does not include the code creation step, only product design. This step is important for creating an application that meets user needs, but the code creation step is still necessary. Meanwhile, the Waterfall method is a linear and structured software development model [3]. This method does not accommodate user feedback during the development process. Because the development of this TPQ application is still in its early and simple stages, the linear and structured Waterfall method is very appropriate to apply. Based on this explanation, it can be concluded that the Waterfall method is very suitable for creating a new and simple TPQ Muhammadiyah data optimization application. However, considering the importance of user feedback in the development of this application, the author combines the Waterfall method with R&D to ensure that the resulting application truly meets user needs, thus enabling the sustainable effectiveness of the institution's management, coaching, and reporting. The combination of R&D and Waterfall methods in this study refers to Arafah's research [5], which also combines these two methods in a receipt information system. Arafah's research provides a clear overview of the integration of these two methods, making it easy to learn and apply in this study.

Therefore, this research aims to build and implement a web-based online information system capable of integrating data from all Muhammadiyah TPQs throughout Sidoarjo Regency, thus supporting the effectiveness of the institution's management, development, and reporting on a sustainable basis. This system can serve as a data integration medium for TPQs throughout Sidoarjo Regency, facilitate information access for administrators, streamline periodic reporting, and enhance the effectiveness of development efforts by the Muhammadiyah Tabligh Council. Additionally, combining R&D and waterfall methods as the research methodology can facilitate the achievement of this goal.

Various previous studies on resolving various issues in TPQ (Islamic Quranic Learning Centers) by utilizing the latest technology have been conducted, including data processing for TPQ in specific TPQs [1], [2], [6], [7], [8], [9], [10], [11], [12], [13], [14], practicing writing hijaiyah letters and tajwid rules in specific TPQs [15], [16], [17], [18], learning to read the Quran [19], [20], improving the competence of TPQ teachers [21], Islamic religious learning [22], [23], [24], [25], [26], creating TPQ report cards [27],

Muhammadiyah Aisyiyah Higher Education (PTMA) scholarships [28], and fingerprint attendance in TPQ [29]. Previous research on problem-solving in TPQ (Islamic Quranic Learning Centers) was conducted to highlight the novelty of this study in terms of the domain of optimizing data from TPQ Muhammadiyah.

Previous research on combining R&D and Waterfall methods was conducted by Arafah [5], who combined the two methods and applied them to the development of a receipt information system. Another study by Sachsono [3] also combined both methods and applied them in designing an e-learning system based on a Learning Management System (LMS) at SMAN 28 in Tangerang Regency. Previous research on combining R&D and Waterfall methods provides a foundation for the novelty of this study, particularly in terms of integrating the two methods and applying them to the TPQ Muhammadiyah data optimization application. Previous studies were used as references in this web-based information system research for optimizing TPQ Muhammadiyah data in Sidoarjo Regency.

Based on previous research, it can be concluded that research on central TPQ data recording within the Muhammadiyah environment in Sidoarjo Regency has not been conducted before. This is a novelty in this research. Additionally, another novelty of this research is the use of a research method that combines R&D and Waterfall methods applied to the TPQ Muhammadiyah data optimization application. The combination of these two methods in the implementation of the TPQ Muhammadiyah information system with the data optimization domain has also not been done before by previous researchers.

The structure of this paper consists of an Introduction section, which explains the research problem of creating an optimization application for TPQ Muhammadiyah data by combining the R&D and Waterfall methods. The Research Methods section outlines the combined R&D and Waterfall methods used in this study. The Results and Discussion section outlines the design, development results of the TPQ application, testing, and calculation of the TPQ application validation questionnaire. The Conclusion section presents a comprehensive summary of the research, from the problems studied to the results obtained, and provides suggestions for further research.

RESEARCH METHOD

The research method used in creating the TPQ Muhammidyah data optimization application is a combination of the R&D and Waterfall methods. The R&D method is used to determine user needs and system requirements, while the Waterfall method is used to develop the system [5]. The combination of R&D and Waterfall methods in this study can be seen in Figure 1.

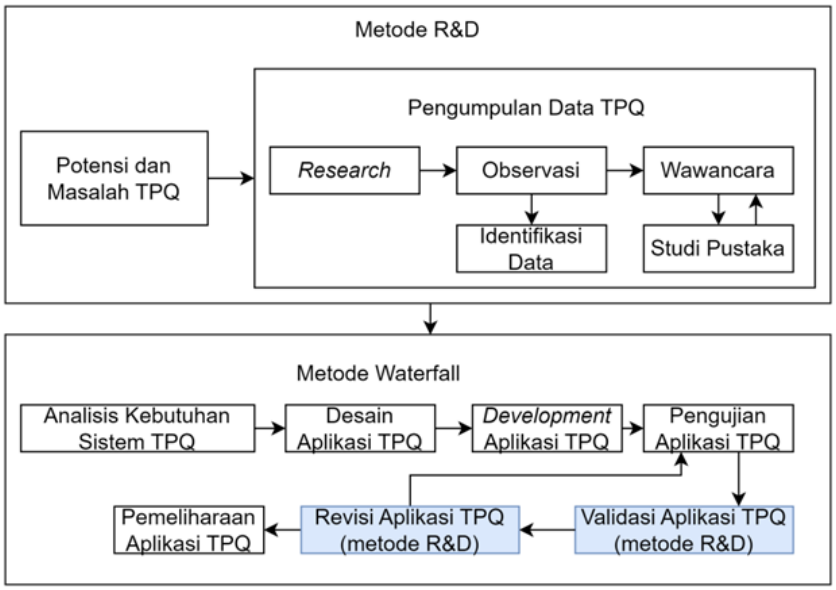


Figure 1. Research method for optimizing TPQ Muhammadiyah data in Sidoarjo Regency.

Figure 1 shows the optimal data research method for TPQ Muhammadiyah in Sidoarjo Regency, which combines the R&D method with the Waterfall software development model. The process begins with the application of the R&D method to identify the potential and problems at TPQ thru data collection, including research, observation (followed by data identification), interviews, and literature studies. The results of this data collection serve as input for the requirements analysis stage in the Waterfall model. Subsequently, application development follows the sequential stages in the Waterfall model, namely system requirements analysis, application design, development, and TPQ application testing. After the testing stage, the R&D method is used again in the application validation stage thru field trials involving TPQ users directly to ensure that the application meets quality, efficiency, and effectiveness standards. If the test results show any shortcomings, the TPQ application is revised based on the feedback received. The results of this revision can proceed to the application maintenance stage or return to the application testing stage to ensure that the improvements are appropriate. Thus, the merging of methods occurs at two main nodes: (1) R&D output in the form of data collection, which serves as direct input for needs analysis in Waterfall, and (2) the insertion of an R&D stage for validation-revision after testing in Waterfall, providing dynamic feedback for both retesting and maintenance. This integration ensures application development is based on empirical findings from R&D methods while also adhering to the structured and systematic work procedures of the Waterfall model. Here's an explanation of each process in Figure 1.

1. Potential and Problems of TPQ

This stage aims to identify opportunities that can be developed and the problems faced by TPQ. Potential includes resources, strengths, or aspects that can be improved, while problems encompass obstacles in management, learning, and administration. The

potential found in the Muhammadiyah TPQ in Sidoarjo Regency is the availability of TPQ data stored in each TPQ institution in the area. The problems faced are that data management is still done manually and is scattered across each TPQ, making the monitoring process difficult, reducing data accuracy, and hindering information synchronization. This condition impacts the weak validation of institutional data, low reporting efficiency, and a lack of transparency in the overall TPQ coaching process.

Identifying these potentials and problems is an important basis for determining the specifications of the system to be developed, as recommended by the R&D method in the preliminary study phase.

2. Data Collection

The data collection methods used to obtain information for this research are:

a. Research

Initial research activities to understand the context and needs of TPQs in general. This process includes an initial study of field conditions, document review, and preliminary analysis of application requirements.

The research phase was conducted to obtain an initial overview of the data management conditions in each Muhammadiyah TPQ in Sidoarjo Regency before field observations were carried out. This activity includes reviewing the institution's profile documents to identify the TPQ's identity, year of establishment, number of students, number of male or female teachers, facilities, and flagship activities. Additionally, administrative documents for students were examined, such as registration forms, academic records, attendance records, and graduation records, as well as data documents for teaching staff, including qualifications, teaching schedules, workload, and training history. The review also included an examination of the reporting format to the Regional Leadership of Muhammadiyah (PDM) to identify the completeness, uniformity, and frequency of data reporting. The purpose of this document review was also to identify the data storage media used in each TPQ, whether they still rely on manual methods based on books and physical archives, use simple digital files like spreadsheets, or have already utilized computerized data management systems. From the research results, initial information was obtained regarding the diversity of data recording formats and methods among TPQs, weaknesses in the input and reporting process, and potential technical obstacles in implementing an integrated digital system. This information serves as the foundation for developing observation and interview instruments, and is also the main reference point for the system requirements analysis stage in the application development process.

b. Observation

Direct observation of the learning process, administration, and operational activities at the TPQ. Observation is conducted to obtain factual data that cannot be obtained solely thru interviews or documents. In the study on data optimization of Muhammadiyah TPQ in Sidoarjo Regency, observation was focused on the data recording flow for students, TPQ institution data, data collection for teaching staff, and the reporting mechanism to PDM. The observation also includes the media and means used to store data, both in

manual form (books and physical archives) and in simple digital formats like spreadsheets.

Additionally, researchers observed the readiness of supporting infrastructure, such as the availability of computer devices, internet networks, and the competence of managers in operating information technology. The observation was conducted participatively, where the researcher interacted directly with the managers and ustaz or ustazah during routine activities, such as new student registration, attendance recording, monthly report preparation, and learning schedule management. Thru this observation, important information was obtained regarding technical obstacles that emerged, variations in work methods between TPQs, and the gap between ideal procedures and practices that occurred in the field. This finding serves as input for the system requirements analysis and the design of a more efficient and integrated TPQ data management application.

c. Interviews

Structured or semi-structured dialogs with managers, teachers (ustaz or ustazah), and relevant parties at the TPQ were used to gather in-depth information regarding needs, constraints, and expectations for the application to be built. In the research on data optimization for Muhammadiyah TPQs in Sidoarjo Regency, interviews were conducted directly at each TPQ to obtain detailed information regarding the current administrative system, procedures for recording student data, data collection for ustaz or ustazah, reporting mechanisms to PDM, and the challenges faced during this process. The interviews also focused on identifying variations in data management formats and media across TPQs, the level of information technology utilization, and the readiness of human resources and infrastructure to adopt an integrated digital system.

Interviews serve to understand both the technical and non-technical aspects that influence data management, including work habits, coordination between managers, and undocumented internal procedures. The semi-structured approach allows for the use of consistent question guidelines while providing room for respondents to offer in-depth explanations. The information obtained from this interview complements the results of observations and literature studies, allowing for a more accurate analysis of system requirements.

d. Literature Review

A study of relevant literature, journals, research reports, and other written sources. Literature studies provide a theoretical foundation and help find appropriate solutions based on previous research. In the research on data optimization for Muhammadiyah TPQ in Sidoarjo Regency, a literature review was conducted by searching for scientific publications that discuss solving various problems in TPQ and similar non-formal educational institutions thru the utilization of the latest technology. The study focuses on research that addresses the topics of administrative digitalization, the development of a TPQ management information system, and the use of web-based or cloud computing applications to improve the efficiency of data management and institutional reporting.

The literature study also examines research that applies R&D methods to produce innovative products in the field of Islamic education, specifically those related to institutional management and data reporting systems. Additionally, a literature review was conducted on research that applied the Waterfall software development model, as well as research that integrated R&D methods with Waterfall. The analysis focused on how the integration of these two methods formed a structured development flow that was still based on empirical findings in the field, so that the resulting product could accurately and measurably meet user needs.

The results of this literature review serve as the basis for formulating the research methodology, developing application development steps, and determining system specifications that are appropriate for the characteristics of TPQ Muhammadiyah in Sidoarjo Regency. This study also helps identify relevant best practices to adopt, as well as anticipate potential constraints in the application development and implementation process.

e. Data Identification

This stage aims to recognize and inventory all data that will be used as the basis for designing the TPQ Muhammadiyah data optimization system in Sidoarjo Regency. The identified data is institutional data from TPQ (Islamic Quran Learning Centers) that was previously collected thru Google Forms filled out by each TPQ institution in Sidoarjo Regency. The results of the filling are automatically summarized in Excel spreadsheet format, which is then saved as a digital archive by the central TPQ coordinator.

The identification process is carried out to ensure the completeness, accuracy, and uniformity of data format, including information on the institution's profile, data on teaching staff (ustaz or ustazah), the number of students, the methods used, and available facilities. This data inventory also checks for duplication, format inconsistencies, or unfilled data, allowing for corrections to be made before the system design phase begins. Well-identified data is an important foundation for system development, as it determines the accuracy and reliability of the information that the application will produce.

3. Analysis of TPQ System Requirements

This stage aims to formulate software requirement specifications based on data obtained thru the R&D method stages. The results of the requirements analysis include formulating a list of features that the application will provide, functional requirements, and non-functional requirements. The main features designed include managing TPQ institutional data, teaching staff data, student data, facilities, curriculum, and online accessible summary reports. Based on the analysis results, the author decided to display the data online so that all TPQs in Sidoarjo Regency can view and monitor other TPQ data in an integrated manner. For database management using MySQL, which was chosen because it is open source, stable, and capable of handling large amounts of data efficiently.

From an infrastructure perspective, application development and testing were conducted using a computer with the following specifications: 10th generation Intel Core i5 processor, 8 GB RAM, 512 GB SSD storage, and Windows 10 Pro 64-bit operating

system. These specifications were chosen to ensure that the programming, testing, and database management processes could run smoothly without performance constraints. This needs analysis serves as the foundation for the application design phase, ensuring that the system built can meet the research objectives while also accommodating the operational needs of the Muhammadiyah TPQ in Sidoarjo Regency.

4. TPQ Application Design

The system design phase includes the design of software architecture, databases, and user interfaces (UI/UX), which serves as a guide for developers in implementing the application according to the identified needs. The system architecture design is carried out to map the main components of the application and their relationships, so that the data processing flow can be clearly understood. The database is designed using MySQL with a table structure customized to accommodate TPQ institutional data, teaching staff data, student data, facilities, curriculum, TPQ chairman or coordinator data, and reports.

The system design includes several visual representations to clarify development concepts, such as flowcharts illustrating the logical flow of processes, use case diagrams mapping user interactions with the system, activity diagrams detailing activity flows more precisely, class diagrams defining data storage structures, and user interface (UI) designs considering usability and user experience (UX) aspects. This entire design is used as the main reference in the implementation phase, so that the resulting application can function according to specifications and meet the research objectives.

5. TPQ Application Development

This stage transforms the design into a working application. The initial data collected thru Google Forms (stored in Excel) was first mapped to a MySQL schema. The columns in Excel are adjusted to become core tables—for example, the number of students, the number of teachers, the curriculum, and the schedule—with simple relationship keys (e.g., NoSantri.id_tpq, NoUstaz.id_tpq). Before importing, the data was cleaned (removing duplicates, standardizing date or phone formats, filling in required empty values) and then saved as a CSV. The import was done thru phpMyAdmin or MySQL commands; after that, the number of rows was checked, a few records were spot-checked, and simple relationship tests were performed to ensure data integrity. From this point on, the centralized database is in MySQL, so future updates are done thru the application (no longer thru Excel files).

The web application is then directed to the MySQL database with connection settings (host, database name, user, password) in the configuration file. The main modules implemented include TPQ management, students, male or female teachers, methods & schedules, and reports. Each module provides CRUD (create, read, update, delete) operations with search and filtering (e.g., for each sub-district, for each TPQ). Also provided are CSV import or export options for lightweight data transfer and role-based access control (e.g., PDM admins see all TPQs; TPQ admins only see their own institution). After the module is running, a simple function test is performed, including adding sample data, modifying, deleting, and checking its appearance in reports.

Then, paid hosting was done when the program met the user's requirements, and a service supporting the PHP and MySQL programming languages was chosen. The steps are (1) creating a domain/subdomain (https://fktpqmusidoarjo.my.id/), (2) creating a MySQL database and user in the hosting panel, (3) uploading application files (via File Manager or FTP), (4) configuring the connection to the production database, (5) importing the .sql dump (initial data schema), (6) enabling SSL for secure access (https), and (7) final testing from the user's perspective, such as logging in, adding data, and viewing reports. On the hosting, automatic backups (annual) are enabled and a backup copy is saved before version updates. With this flow, the initial Excel data moves neatly into MySQL, the web application reads or writes to the central database, and all TPQs in Sidoarjo can access the data online thru a stable paid hosting service.

6. TPQ Application Testing

The testing phase is conducted to ensure that all application features function according to the established specifications, are free of errors (bugs), and are ready for use by users. This testing covers three main aspects: functionality testing, performance testing, and security testing. Functionality testing is performed using the blackbox testing method, where the examiner focuses only on the input and output without reviewing the program code. Each application module, such as TPQ data management, students, male or female teachers, curriculum, schedule, and reports, is tested with usage scenarios that represent the actual conditions in the field.

Additionally, a validation questionnaire for the application was conducted to obtain direct feedback from users, including TPQ managers and relevant parties. This questionnaire includes assessments of usability, interface clarity, access speed, and the suitability of features for operational needs. The scores and input from the questionnaire are used to determine the application's feasibility level, and also serve as a reference for making revisions. If any deficiencies or inconsistencies are found during testing, the application will be fixed and then retested before being declared fully suitable for use. This approach ensures that the application not only functions correctly but also meets the expectations and needs of users in the TPQ Muhammadiyah environment of Sidoarjo Regency.

7. TPQ Application Validation

The application validation stage is adopted from the R&D method procedure. Application validation is a trial stage in a real operational environment, directly involving TPQ users such as institution managers, male or female teachers, and other relevant parties. The goal is to verify that the developed application truly meets user needs, is efficient in data processing, and is effective in supporting TPQ management. During the validation process, users run all application features according to their daily workflow, identifying and recording any inconsistencies, weaknesses, or constraints that arise. The results of this observation include details of features that are not functioning optimally, display errors, compatibility issues, or performance limitations. These findings will be direct input for the next improvement stage, which is application revision.

8. TPQ Application Revision

The application revision stage is adapted from the procedures found in the R&D method. The application revision stage is carried out as a follow-up to the validation results, with a focus on improving and refining features, the interface, and application performance. The revision process includes adjusting program logic, optimizing database queries, improving interface responsiveness, and adding functions considered important by users based on field test results. After the revision is complete, the process can proceed in two possible ways: (1) return to the application testing phase to ensure the fixes are working as expected and don't introduce new problems, or (2) proceed directly to the application maintenance phase if the application has met all eligibility criteria. Thus, this validation and revision cycle forms a continuous feedback mechanism, ensuring that the resulting application not only meets the initial specifications but is also adaptable to real-world needs in the field.

9. TPQ Application Maintenance

The application maintenance phase is an ongoing activity aimed at maintaining system performance, fixing errors that may arise after the application is fully used, and updating features to keep pace with the evolving needs of TPQ. Maintenance includes routine monitoring of application performance, fixing bugs detected post-implementation, adjusting features to follow policy changes or operational procedures, and optimizing data security. In addition to technical aspects, maintenance also involves supporting the application's supporting infrastructure, such as updating the programming language, framework, and database versions used. One form of administrative maintenance is periodically renewing the hosting service validity every year to ensure the application remains accessible online to all TPQs in Sidoarjo Regency. With a structured maintenance process, the TPQ application can continue to function optimally, securely, and remain relevant to user needs in the long term.

RESULTS AND DISCUSSION

Based on the research method for optimizing data from the Muhammadiyah TPQ in Sidoarjo Regency that has been developed, the application design and testing process for the TPQ application requires further explanation. This explanation is presented to provide a detailed overview of the application design and the results of the testing that has been conducted. Additionally, this section also explains the implementation process of the Muhammadiyah TPQ data optimization application in Sidoarjo Regency.

Application Design Phase

The application design phase includes flowcharts, use case diagrams, activity diagrams, database tables, and user interface designs that serve as a guide for developers in implementing the application.

1. Flowchart

The flowchart of the data optimization application process flow for TPQ is shown in Figure 2. This flow explains the processes carried out by both general users and users with admin access rights (TPQ coordinators or chairpersons). The TPQ coordinator is the

central Muhammadiyah TPQ coordinator who oversees all TPQ institutions in Sidoarjo Regency, while the TPQ head is the leader of each TPQ institution. Therefore, only the TPQ coordinator or chairman can enter TPQ institution data. General users can directly access TPQ institution information, teacher data, and student data without going thru a login process. Meanwhile, the admin first logs in by entering a username and password that are verified against the user database. If the login is successful, the admin can access the form to add or update TPQ institution data, as well as manage other user data who have roles as TPQ coordinators or chairpersons. All data entered or updated will be stored in the database connected to the application, ensuring that the information available is always up-to-date and can be accessed according to each user's access rights.

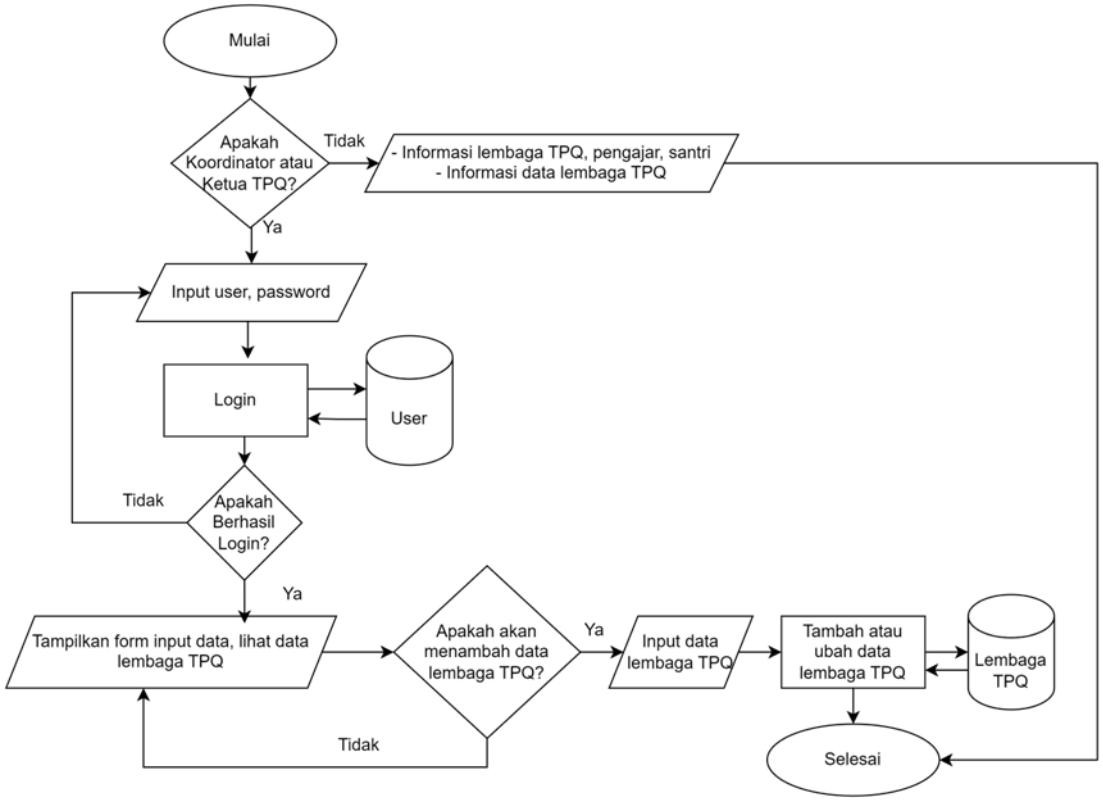


Figure 2. Flowchart for Optimizing Data from Muhammadiyah TPQ in Sidoarjo Regency.

Figure 2 shows the data optimization application process flow for TPQ Muhammadiyah in Sidoarjo Regency, illustrated in the form of a flowchart. The process begins with identifying the user's role, whether the user is a TPQ coordinator or chairman. If not, the system directly displays information about the TPQ institution, teacher data, student data, and TPQ institution data, and then the process ends. If the user is a TPQ coordinator or head, the next step is to enter the username and password to log in. The login data is verified against the user data stored in the database. If the login process fails, the system prompts the user to repeat the credential input process. If

successful, the system will display a form to enter new data and view existing TPQ institution data.

Next, users are given the option to add TPQ institution data. If they choose "Yes," the user (TPQ coordinator or chairman) can input the TPQ institution data, which will then be saved or updated in the TPQ institution database. If they do not add institution data, the system provides an option to add coordinator or chairman data. If the user chooses to add this data, the system displays a user data input form, which is then saved or updated in the user database. Thus, this flowchart visualizes the login flow, institution data management, and user data management within the application in a structured manner.

2. Use Case Diagram

The use case diagram for the TPQ data optimization application is shown in Figure 3.

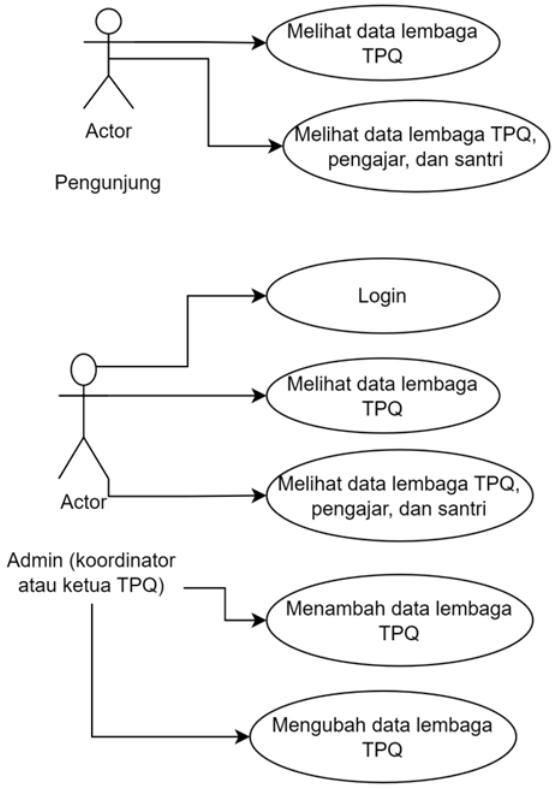


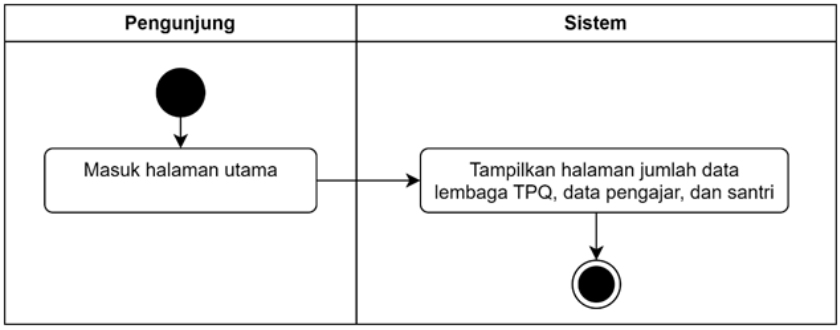
Figure 3. Use Case Diagram for Optimizing Data at Muhammadiyah Islamic Boarding Schools in Sidoarjo Regency.

This diagram is used to model the relationship between actors and the system, and to describe the functionality accessible to each actor within the application. The use case diagram in Figure 3 illustrates the interaction between actors and the data optimization application system for the Muhammadiyah TPQ in Sidoarjo Regency. There are two types of actors involved: visitors and administrators (TPQ coordinators or heads). Visitors can access the system without an authentication process and have two main functions: viewing TPQ institution data and viewing TPQ institution data including teacher and

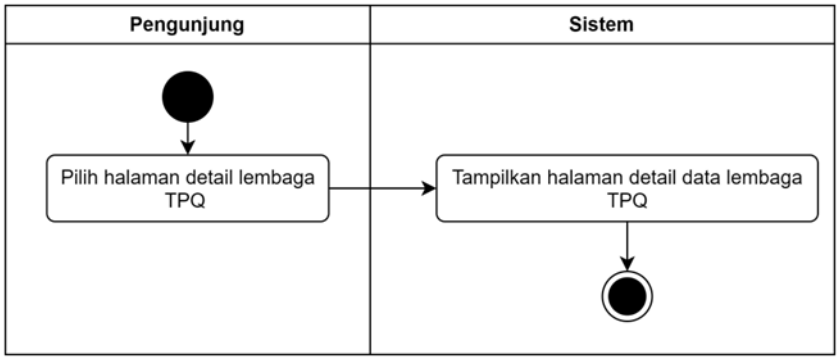
student information. Meanwhile, administrators have broader access rights after logging in. After successfully logging in, administrators can perform various functions, including viewing TPQ institution data, viewing TPQ institution data along with teacher and student data, adding TPQ institution data, and modifying TPQ institution data. This use case design ensures access restrictions are in line with user roles, allowing data to be openly accessible for public information needs, while data management and updates can only be performed by authorized parties to guarantee information security and accuracy.

3. Activity Diagram

The activity diagram for the TPQ data optimization application is shown in Figures 4 and 5. Figure 4 presents the activity diagram for the user, which is the visitor, while Figure 5 presents the activity diagram for the administrator (admin), which is the TPQ coordinator or chairman.



(a)

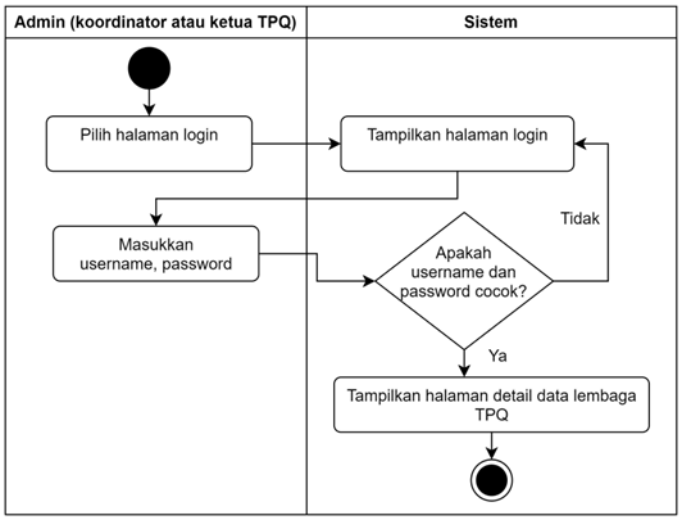


(b)

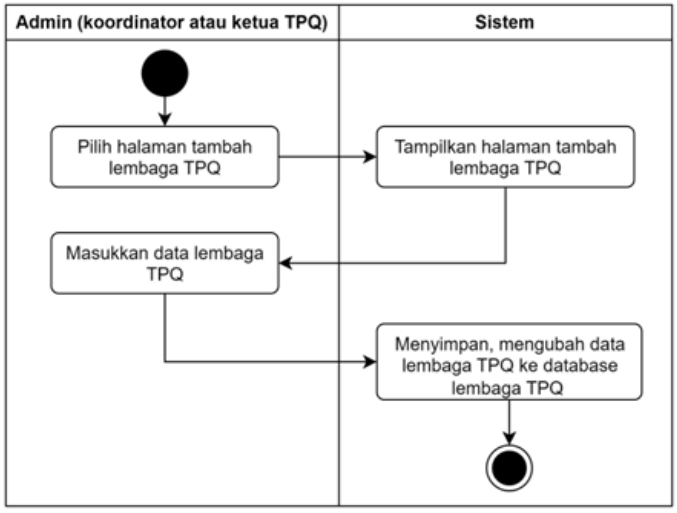
Figure 4. (a) User Activity Diagram for the Main Page. (b) User Activity Diagram for the TPQ Institution Data Detail Page.

Figure 4 presents two activity diagrams labeled (a) and (b) that model the visitor's access scenario (without authentication) to the TPQ data optimization application. Each diagram uses two swimlanes, namely Visitor and System, to emphasize the division of responsibilities: the Visitor triggers the action (navigation), while the System responds by displaying the requested output until the flow ends at the final node. Both scenarios are read-only without input processing or branching decisions, so the flow is linear with a request-response pattern.

Figure 4(a), the visitor starts the flow (starting point) and performs the "Enter main page" activity. This request is forwarded to the System, which executes the "Display TPQ institution data, teacher data, and student data" activity, which is an aggregate summary on the homepage; after the content is presented, the flow ends. In Figure 4(b), the visitor executes "Select TPQ institution detail page" to view information for a specific institution. The system responds with "Show TPQ institution data detail page" (institution profile and related attributes), and the return flow ends. Thus, both diagrams document simple yet important visitor interactions: navigation to the summary homepage and to the institution's detail page, while data processing and presentation are handled entirely by the system.



(a)



(b)

Figure 5. (a) Activity Diagram for Admin Login Page. (b) Activity Diagram for User TPQ Institution Data Detail Page.

Figure 5 shows two activity diagrams that model the usage scenarios for the admin (coordinator or head of the TPQ institution) with two swimlanes: Admin and System.

Diagram (a) represents the login process, while diagram (b) represents the process of adding/editing TPQ institution data. The start and end points are explicitly marked to indicate the boundaries of the flow in each scenario.

Figure 5(a), the flow begins when the admin selects the login page. The system responds by displaying the login page. The administrator then enters their username and password, which is subsequently validated by the system thru the decision node "Do username and password match?". If the validation result is not a match, the system returns to displaying the login page for the credentials to be reentered. If it matches, the system displays the details page for the TPQ institution data and the flow ends at the final node. This diagram confirms the existence of a feedback mechanism (loop) when authentication fails.

Figure 5(b), the process begins when the admin selects the TPQ institution add page. The system displays the TPQ institution add page/form, then the admin enters the TPQ institution data. The submitted data is processed by the system with the activity "Saving, changing TPQ institution data to the TPQ institution database," which marks the persistence of data to the database. After the storage/editing operation is complete, the flow ends at the final node. Unlike the login scenario, the flow in diagram (b) is linear without decision branches.

Overall, both activity diagrams clearly show the division of responsibilities, with the admin as the action trigger (navigation and data entry) and the system as the responding party (displaying pages, validating credentials, and saving/updating data to the database). This structure ensures the traceability of the application's core processes during the authentication and data management phases of the institution.

4. Class Diagram

The class diagram for the TPQ data optimization application is shown in Figure 6. This diagram illustrates the class structure involved in the application and their relationships. That class diagram is used to understand the relationships and roles of each class within the system.

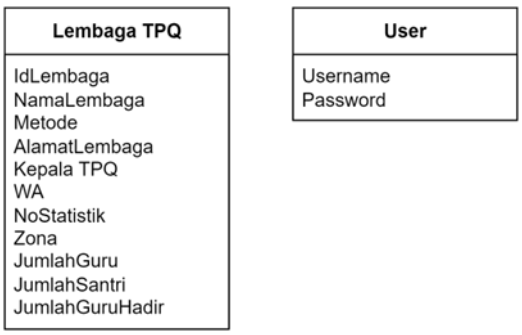


Figure 6. Class Diagram of the TPQ Muhammadiyah Data Optimization Application in Sidoarjo Regency.

Figure 6 shows the class diagram of the TPQ Muhammadiyah data optimization application in Sidoarjo Regency, which consists of two main classes: TPQ Institution and

User. The TPQ Institution Class represents an institutional entity containing various important attributes for data collection and reporting, including Institution ID as the unique identifier or primary key of the institution, Institution Name to store the official name of the TPQ, the Method used in the learning process, and Institution Address containing the complete address of the TPQ location. Additionally, there are attributes for TPQ Head to store the name of the institution's leader, WA as the official contact number via WhatsApp, Statistics Number as the official registration number, and Zone indicating the TPQ's operational area. Data on the number of resources is also recorded thru the attributes Teacher Count, Student Count, and Present Teacher Count, which store information on teacher attendance. Meanwhile, the User class represents user accounts used for system access authentication and authorization, with the Username attribute storing the user's unique login identity and the Password attribute storing the encrypted password. This class diagram confirms the separation of functions between the TPQ Institution class, which focuses on storing institutional data, and the User class, which focuses on managing access to data management.

5. User Interface Design

The user interface design for the TPQ data optimization application consists of four pages: the main page (Figure 7), the login page (Figure 8), the page for adding TPQ institution data (Figure 9), and the page for TPQ institution data reports (Figure 10).

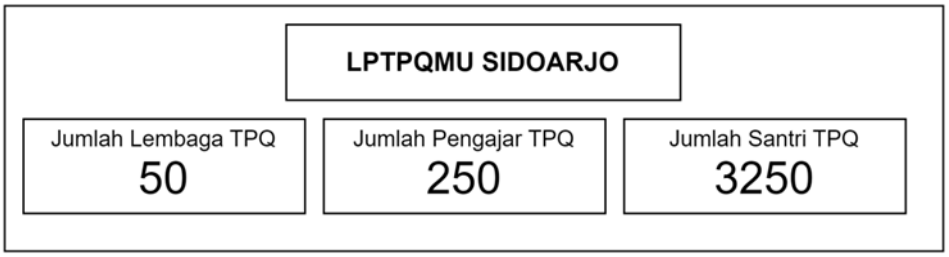


Figure 7. Design of the Main Page for the TPQ Muhammadiyah Data Optimization Application in Sidoarjo Regency.

Figure 7 shows the design of the main page for the TPQ data optimization application in Sidoarjo Regency, Muhammadiyah. At the top of the page, the application's identity is displayed as the text "LPTPQM U Sidoarjo". This page contains summary information regarding the number of TPQ institutions, the number of teachers, and the number of students registered in the system. The data displayed in this image is an example for interface design purposes, so the numbers shown are not actual data. This display is designed to allow users to quickly get an overview of TPQ statistics before accessing more detailed information on the next page.

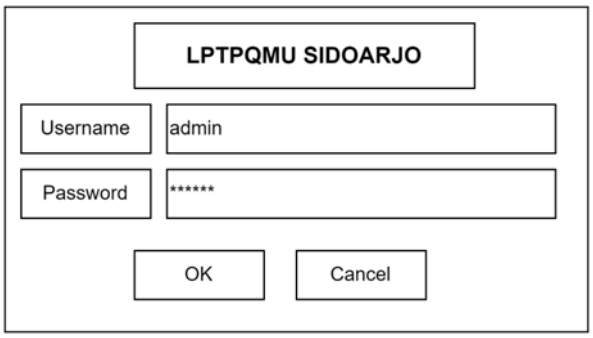


Figure 8. Design of the Login Page for the Muhammadiyah TPQ Data Optimization Application in Sidoarjo Regency.

Figure 8 shows the design of the login page for the TPQ Muhammadiyah data optimization application in Sidoarjo Regency. This page serves as an authentication gateway for users with specific access rights, particularly administrators or data managers. There are two input fields used to enter credentials, namely username and password, which must be filled in correctly for the system to verify the user's identity. Additionally, two interaction buttons are provided: the "OK" button to send login data to the system and initiate the authentication process, and the "Cancel" button to cancel the login process. This design is intended to ensure data access security by limiting the users who can log into the system based on predefined access rights.

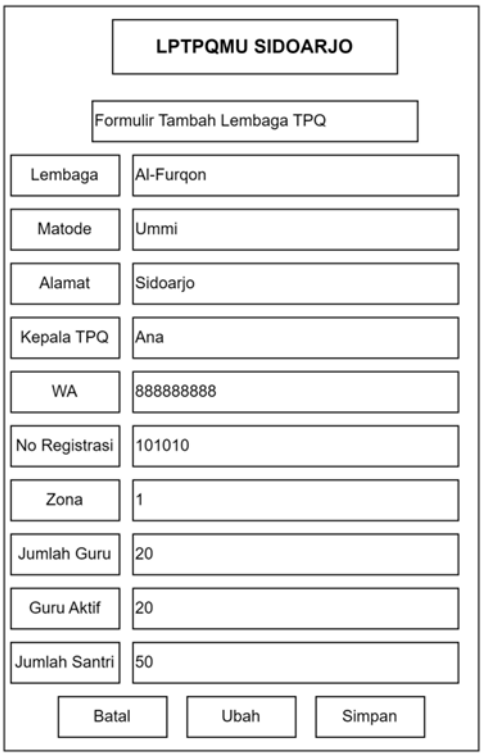


Figure 9. Design of the Add TPQ Institution Page in the TPQ Data Optimization Application for Muhammadiyah in Sidoarjo Regency.

Figure 9 shows the design of the TPQ institution addition page in the TPQ data optimization application for Muhammadiyah Sidoarjo Regency. At the top, the application's identity "LPTPQMU SIDOARJO" is listed, followed by the title "TPQ Institution Addition Form". Available filling components include: Institution, Method, Address, TPQ Head, WA, Registration Number, Zone, Number of Teachers, Active Teachers, and Number of Students. The design shows examples of filling values, including Institution "Al-Furqon", Method "Ummi", Address "Sidoarjo", TPQ Head "Ana", WA "888888888", Registration Number "101010", Zone "1", Number of Teachers "20", Active Teachers "20", and Number of Students "50". At the bottom, three action controls are provided: Cancel to cancel filling, Change to modify existing data, and Save to save new data to the database. This design shows that the institution data collection process is structured, including information on the institution's profile, legality, contact details, zoning, and basic statistics.

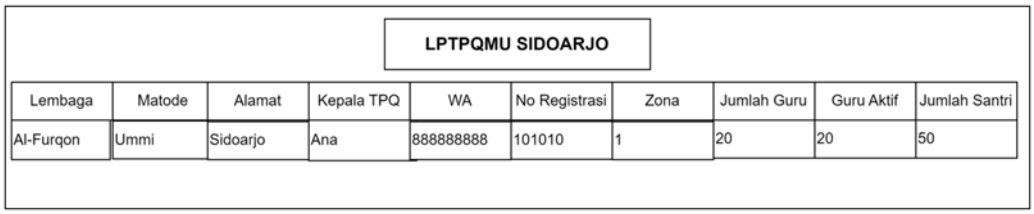


Figure 10. Design of the TPQ Institution Report Page in the Muhammadiyah Sidoarjo Regency TPQ Data Optimization Application.

Figure 10 shows the design of the TPQ institution report page in the TPQ Data Optimization application for Muhammadiyah Sidoarjo Regency. At the top, the application identity "LPTPQM U SIDOARJO" is listed. The report is presented in a structured summary format containing the columns: Institution, Method (as named in the design), Address, Head of TPQ, WA, Registration Number, Zone, Number of Teachers, Active Teachers, and Number of Students. Example values displayed for illustration in the design are: Institution "Al-Furqon", Method "Ummi", Address "Sidoarjo", Head of TPQ "Ana", WA "8888888888", Registration Number "101010", Zone "1", Number of Teachers "20", Active Teachers "20", and Number of Students "50". This design shows that the system is designed to present a neat and easy-to-read summary of profiles and basic statistics for each TPQ, thus supporting institutional monitoring and reporting needs.

Implementation of the TPQ Data Optimization Application for Muhammadiyah Institutions in Sidoarjo Regency

The implementation of the TPQ data optimization application consists of four pages: the main page (Figure 11), the login page (Figure 12), the page for adding TPQ institution data (Figure 13), and the page for reporting TPQ institution data (Figure 14).

Figure 11. Implementation of the Main Page of the TPQ Muhammadiyah Data Optimization Application in Sidoarjo Regency.

Figure 11 shows the implementation results of the main page of the TPQ data optimization application for Muhammadiyah institutions in Sidoarjo Regency. This display serves as a concise dashboard presenting three key indicators: the number of TPQ institutions (42), the number of teachers (ustaz or ustazah) (264), and the number of students (3018).

Each indicator is equipped with thematic icons to clarify the context of the information and is visually distinguished thru a contrasting color scheme, making it easily recognizable. The values displayed are an aggregation from the application database and are intended as a quick overview of the current condition before the user explores further details on the next page. This design supports quick monitoring by TPQ managers by emphasizing the readability of numbers and presenting information that is dense yet informative.

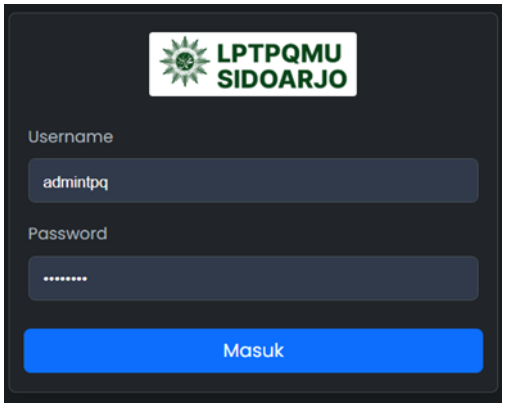


Figure 12. Implementation of the Login Page for the TPQ Muhammadiyah Data Optimization Application in Sidoarjo Regency.

Figure 12 shows the implementation view of the TPQ Muhammadiyah Sidoarjo Regency data optimization application login page. At the top, there is the institution's identity "LPTPQMU Sidoarjo" along with its logo, followed by two input fields for username and password—with the example entries "admintpq" and a masked password. The authentication action is triggered thru the Login button. The interface uses a dark theme with blue accents to highlight interactive elements, thereby improving readability and user focus. This page serves as a security gateway, restricting access only to authorized users (TPQ coordinators or chairpersons); the credentials entered will be verified by the system before granting access rights to data management features. This design supports role-based access control practices and is an important part of the application's data integrity protection mechanism.

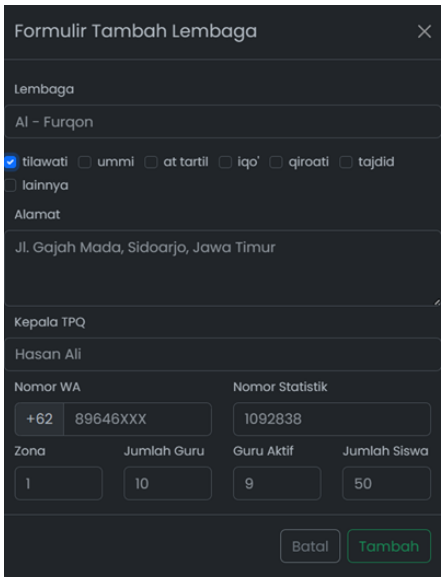


Figure 13. Implementation of the Add TPQ Institution Page in the TPQ Data Optimization Application for Muhammadiyah Institutions in Sidoarjo Regency.

Figure 13 shows the implementation of the add institution page in the TPQ Muhammadiyah data optimization application for Sidoarjo Regency. This page allows administrators to completely enter data for TPQ institutions, including the institution's name, teaching methods (more than one can be selected via checkboxes), full address, name of the TPQ head, WhatsApp number, and statistical number. Additionally, there are fields available to specify the zone, number of teachers, number of active teachers, and number of students. Each column has been designed to fit the required data format, such as separating country codes for WhatsApp numbers. At the bottom of the page, there are two action buttons: Cancel to cancel the filling process and Add to save the new institution data into the system. The interface uses a dark theme with color emphasis on action buttons, aiming to improve user focus while providing a comfortable user experience. This design supports a structured, efficient data input process and minimizes recording errors.

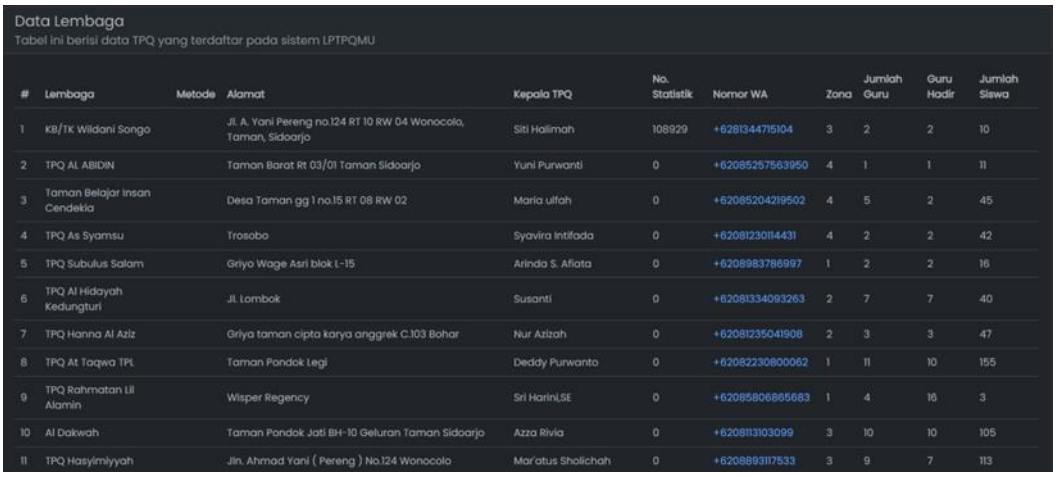


Figure 14. Implementation of the TPQ Institution Report Page in the Muhammadiyah TPQ Data Optimization Application in Sidoarjo Regency.

Figure 14 shows the implementation of the institution report page in the TPQ Muhammadiyah data optimization application for Sidoarjo Regency. This page presents data for all TPQ institutions registered in the LPTPQM system. The information displayed includes serial number, institution name, teaching method used, full address, name of the TPQ head, statistical number, WhatsApp number, regional zone, number of teachers, number of active teachers, and number of students. The data is presented in a table format with a structured layout, making it easier for administrators to search, group, and analyze information. Each row in the table represents a single TPQ institution entity with the details necessary for administrative and evaluation purposes. Using a dark theme for the interface provides clear contrast between text and background, thus improving readability and user comfort. This design not only facilitates the rapid and accurate monitoring of institutional conditions but also supports data-driven decision-making by management.

Testing Phase

The testing phase was conducted using the black-box testing method to verify the performance of each function. This testing aims to observe the output generated from testing the TPQ Muhammadiyah data optimization application in Sidoarjo Regency. The results of black-box testing for the TPQ Muhammadiyah data optimization application in Sidoarjo Regency are shown in Table 1.

Table 1. Application Testing with Black-Box Testing in the TPQ Muhammadiyah Data Optimization Application in Sidoarjo Regency.

Tested Page	Executed Action	Expected Result	Test Result
Login Page	Entering username and password, then pressing the login button.	Displays the TPQ institution data report with the presence of an Add Institution button, and the Edit and Delete buttons appear. In addition, there is also an Add Institution button.	Ok
Add Institution Page	Filling in all institution data, then pressing the Add button.	A message “Data successfully saved” appears.	Ok
	Filling in all institution data, then pressing the Edit button.	A message “Data successfully updated” appears.	Ok
Admin Institution Data Report Page	Clicking the Edit icon, then filling in the TPQ institution data that needs to be updated, and pressing the Edit button.	A message “Data successfully updated” appears.	Ok
	Clicking the Delete icon, clicking OK on the	A message “Data successfully deleted” appears.	Ok

	message that appears regarding the seriousness of deleting data.

Table 1 presents the results of testing the TPQ Muhammadiyah data optimization application in Sidoarjo Regency using the Black-Box Testing method on several main pages. On the login page, testing was conducted by entering the correct username and password combination, then pressing the login button. The expected result was for the system to display a report of TPQ institution data with add, edit, and delete buttons. This test showed the expected results with an Ok status. Next, on the add institution page, testing was performed by filling in all institution data and then pressing the add button, which was expected to display the message "Data successfully saved". Another test was conducted by filling in institution data and pressing the edit button, which was expected to produce the message "Data successfully changed", with the test result being Ok. Testing was also performed on the admin institution data report page. The first action is to select the edit icon, modify the necessary TPQ institution data, then press the edit button, with the expected result being the message "Data successfully updated". The next action is to test the delete feature by pressing the delete icon and confirming the data deletion. The expected result is the appearance of the message "Data successfully deleted", which is consistent with the test results and receives an Ok status. The overall test results show that each main function of the application works as expected according to the specifications.

CONCLUSION

Fundamental Finding : The development of a web-based information system for Muhammadiyah TPQ in Sidoarjo Regency was successfully completed using the R&D method and the Waterfall model. This system is capable of overcoming the problems of manual data management that have been a constraint, thus accelerating the monitoring process, improving data accuracy, and increasing reporting efficiency. **Implication :** The implementation of this system is expected to be the initial step toward the digital transformation of TPQ management, support more effective training, and serve as a development model for other Islamic educational institutions. This can significantly improve the administrative processes and enhance the quality of service provided by TPQ. **Limitation :** While the system has successfully addressed the issue of manual data management, its scalability and adaptability to other regions or institutions may need further evaluation, especially in areas with different technological capabilities or resource availability. **Future Research :** Future research could focus on refining and expanding this system's capabilities, exploring its potential for integration with other educational systems, and assessing its long-term impact on the digital transformation of Islamic education institutions across different regions.

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