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Design and Development of Web-Based E-Learning System Using Waterfall for Evaluation

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ABSTRACT

The learning evaluation process at SMK Assyafi'iyah 02 still encounters fundamental challenges, including the absence of an integrated digital system, reliance on manual distribution of questions and answers, frequent delays in score recapitulation, and limited transparency between teachers and students. These conditions often result in inefficiency, data inaccuracy, and difficulties in monitoring students' academic progress in real time. The research problem addressed in this study is how to design and implement a web-based e-learning application that is able to overcome these obstacles and support more effective evaluation. Therefore, the purpose of this study is to build an information system that integrates exam management, online submission, automated scoring, manual correction, a nd role-based access, with the goal of improving the speed, accuracy, and transparency of learning evaluations. This study applies the Waterfall development method consisting of requirement analysis, system design, implementation, and testing to ensure a structured and systematic process. The contribution of this research lies in providing a practical digital platform for schools that have not yet fully adopted e-learning systems, while the novelty is reflected in the integration of evaluation, communication, and monitoring features specifically adapted to the learning context of vocational schools. The testing results show that the system developed is able to reduce evaluation time, improve data accuracy, and provide better accessibility for both teachers and students.

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1. INTRODUCTION

The rapid development of information technology in the digital era has significantly influenced the education sector. One of its major implementations is e-learning, a digital-based learning system that allows teaching and learning activities to be conducted more flexibly, efficiently, and interactively. Several studies have proven that e-learning improves the effectiveness of learning, particularly in content delivery, student engagement, and evaluation processes [8] [2].

Despite these benefits, SMK Assyafi'iyah 02 still relies on manual learning evaluation methods. Teachers distribute exam questions using printed sheets or instant messaging applications, while students submit answers in photo or file formats. The grading process is carried out individually and recorded using spreadsheets. This approach is time-consuming, prone to human error, and often causes delays in score recapitulation, making it difficult to monitor students' academic progress comprehensively and in real time [10].

Previous research has highlighted the importance of adopting structured digital systems in the learning process. [4] and [11] found that the success of e-learning strongly depends on interface simplicity and system accessibility. Meanwhile, [3][1] emphasized that system usability contributes directly to student comfort and learning outcomes. These findings indicate the urgent need for a user-friendly e-learning platform that not only digitizes but also optimizes the evaluation process.

Based on these conditions, the research problem addressed in this study is how to design and implement a web-based e-learning system that can overcome inefficiencies in the current evaluation process, minimize scoring errors, and ensure transparency between teachers and students. Therefore, the objective of this research is to develop an integrated web-based evaluation system that includes exam management, online submission, automated and manual grading, score recapitulation, and role-based access control [7].

The contribution of this study is to provide a practical digital platform for vocational schools to transition from manual to digital evaluation systems. The system is expected to accelerate the evaluation process, enhance accuracy, and simplify the distribution of learning materials and exam questions. In addition, it can serve as a reference model for other educational institutions seeking to adopt similar digital learning solutions [12] [14]

The novelty of this research lies in the integration of evaluation, communication, and monitoring features into a single e-learning system specifically tailored to the needs of vocational schools. This comprehensive approach provides added value compared to previous studies, which often focused only on certain aspects such as usability or evaluation mechanisms [15] [16]. By combining these functions, the proposed system better supports effective learning and evaluation in vocational education settings.

To achieve this, the study adopts the Waterfall development methodology, which provides a structured workflow through requirements analysis, system design, implementation, testing, and maintenance. This model is considered suitable for projects with stable requirements and well-documented processes [17]. Its relevance is reinforced by studies such as, which confirmed the effectiveness of Waterfall in developing digital education systems at both school and higher education levels. Consequently, this research not only addresses practical challenges at SMK Assyafi'iyah 02 but also enriches the academic literature on web-based e-learning systems for vocational education.

2. RESEARCH METHOD

2.1 Testing Methods

The Waterfall method is a sequential and structured software development model consisting of requirements analysis, design, implementation, testing, and maintenance, where each stage must be completed before the next begins. This model is considered highly suitable for projects with stable requirements and comprehensive documentation, particularly in the development of educational information systems. Previous studies have also confirmed its effectiveness: [6] applied the Waterfall method in designing a web-based e-learning system at MTs Al-Wusho and reported that it produced systematic documentation and supported efficient feature development; [13] successfully developed a web-based e-learning platform for MAN 1 Pesawaran using Waterfall and found that it increased student engagement and learning effectiveness; while [17][18] highlighted that Waterfall adoption in an online learning system improved evaluation management and usability for teachers and students. In this research, the Waterfall method was chosen to ensure a structured workflow that minimizes errors and guarantees that the final system meets both functional and usability standards.

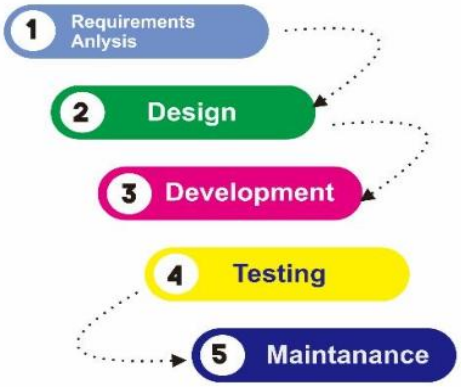

Figure 1. Waterfall Method

UML is a modeling language used to design, document, and visualize software systems. UML consists of four main types of diagrams. The *Use Case Diagram* illustrates the interactions between the system and its actors, such as administrators and users [11]. The *Activity Diagram* represents the workflow or sequence of processes within the system being developed [11]. The *Sequence Diagram* shows the order of interactions between objects in the system [19]. The *Class Diagram* presents the system's structure in detail, including the classes along with their attributes and methods [20].

2.2 Research Stages

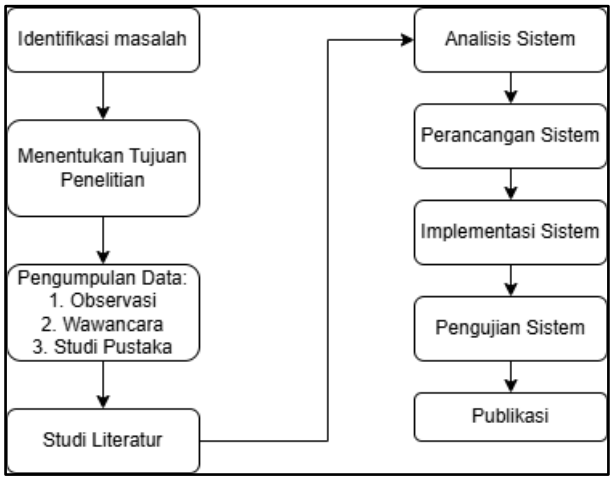

Figure 2. Research Stages

The figure above illustrates the research stages. Below is an explanation of each stage:

Problem identification stage is carried out to identify the main issues in the learning evaluation process at SMK Assyafi'iyah 02, particularly those that are still conducted manually. These issues serve as the basis for formulating solutions through the development of a web-based e-learning system.

Once the problems have been clearly identified, the next step is to formulate the research objectives, namely to design and develop an e-learning application system that can enhance the effectiveness of learning evaluations digitally.

At data collection stage, data is collected using three primary methods: observation, which involves directly observing the ongoing learning evaluation process at the school; interviews, aimed at obtaining in-depth information from relevant parties such as teachers or academic staff; and literature review, which focuses on examining relevant scholarly references to strengthen the theoretical foundation and research methodology.

A literature study is conducted to understand the concepts underlying the development of information systems, particularly e-learning systems, the Waterfall method, and the application of usability principles. References are taken from relevant and up-to-date scientific journals.

Based on the collected data, a needs analysis is carried out to determine the features required in the system. This analysis includes gathering information from the existing business processes and identifying the problems present.

At system design stage, the system design begins to take shape, including interface design, database structure, and UML diagrams such as use case diagrams, activity diagrams, sequence diagrams, and class diagrams, which visually represent the system's workflow.

The system design is then transformed into program code using predetermined programming languages and technologies, such as PHP and MySQL. The system is tested in stages to ensure compliance with user requirements.

Once the system is implemented, testing is conducted to determine whether all features function as expected. This testing includes validating functionality, reliability, and ease of use for teachers and students.

The final stage of this research is the publication of the thesis results in the form of a scientific journal, as part of the graduation requirements and as a contribution to the advancement of knowledge, particularly in the field of educational information systems.

3. RESULTS AND DISCUSSION

The testing results show that the developed e-learning system at SMK Assyafi'iyah 02 functions effectively, with all modules—login, dashboard, data management, activities, surveys, and logout—successfully operating as expected. This indicates that the system is reliable in supporting digital learning evaluation, particularly in ensuring accuracy and transparency. These findings are in line with [4], who demonstrated that structured Learning Management Systems (LMS) significantly improve efficiency and reduce errors in evaluation processes.

The outcomes also emphasize the importance of usability in increasing user satisfaction and engagement. (Pratama et al., 2023) found that system usability strongly influences student learning outcomes, which aligns with the present study where role-based interfaces and clear navigation improved accessibility for both teachers and students. Compared to the

study of [14], which mainly focused on subject data management, this research provides a more comprehensive integration by combining evaluation, communication, and monitoring into one platform.

Furthermore, the application of the Waterfall methodology contributed to systematic development and minimized errors. Similar to the findings of [6], who applied Waterfall in designing an e-learning system with well-structured documentation, and [17][18], who reported improvements in engagement and usability, this study confirms the effectiveness of the model in educational contexts. Therefore, the developed system not only addresses practical issues of evaluation at SMK Assyafi'iyah 02 but also enriches the literature by presenting an integrated solution tailored for vocational education.

3.1 Use Case Diagrams

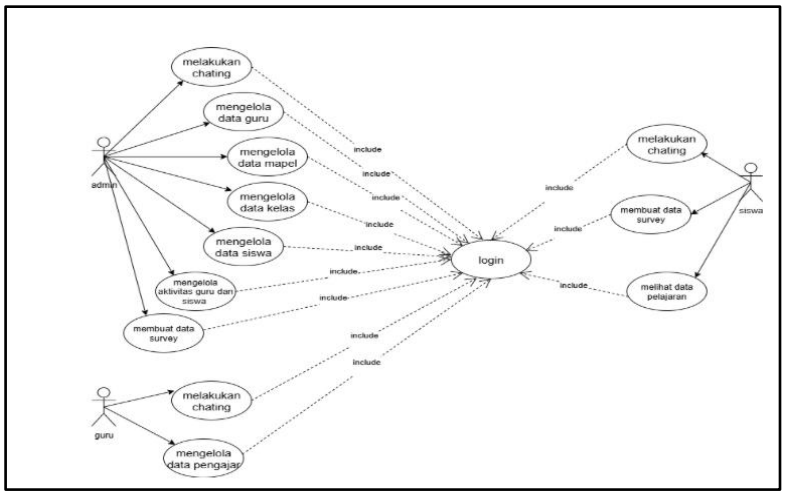

Figure 3. Use Case

The image above is a use case diagram of the proposed e-learning system for SMK Assyafi'iyah 02. Before entering the coding stage, the researcher designed the use case to illustrate the interactions between the users (actors) and the system. This diagram also helps in identifying the functional requirements of the application to ensure that all user needs are represented clearly. In addition, it serves as a communication tool between developers and stakeholders, minimizing misunderstandings during the system development process.

3.2 Class Diagram

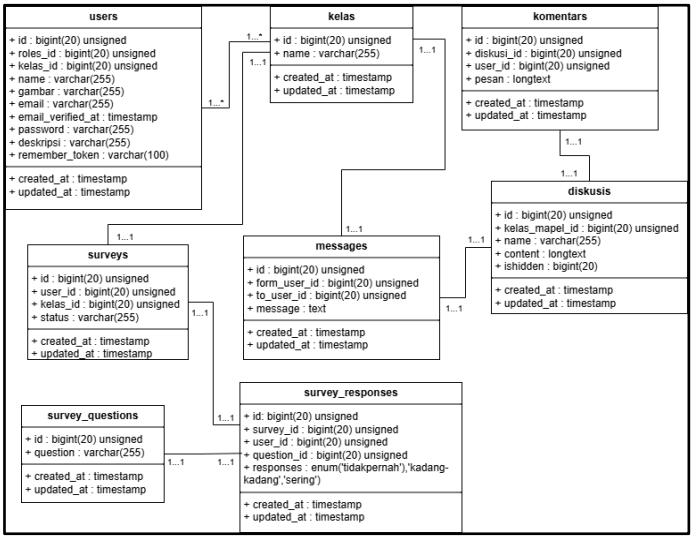

Figure 4. Class diagram

The image above is a class diagram of the web-based e-learning management system. This class diagram is used to model the database structure and the relationships between the tables used in the system. It provides a detailed representation of the system's entities, attributes, and methods to ensure data consistency. Furthermore, the diagram facilitates communication among developers and stakeholders by visualizing how different components interact within the system.

3.3 System Implementation and Output

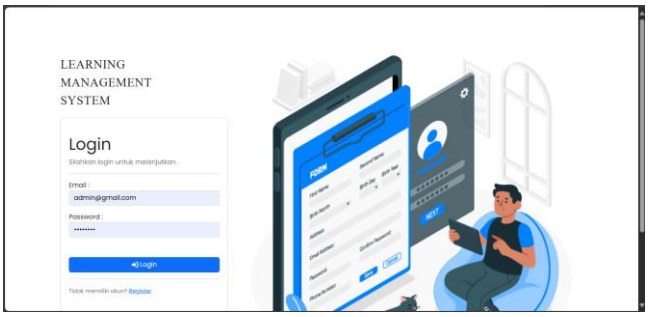

Figure 5. Login

Figure 5 shows the login interface of the Learning Management System (LMS), where users are required to enter their email and password to access the application. This figure illustrates the role-based authentication mechanism, ensuring that each user—admin, teacher, or student—can only access features according to their role. The purpose of this figure is to demonstrate the security and accessibility aspects of the system.

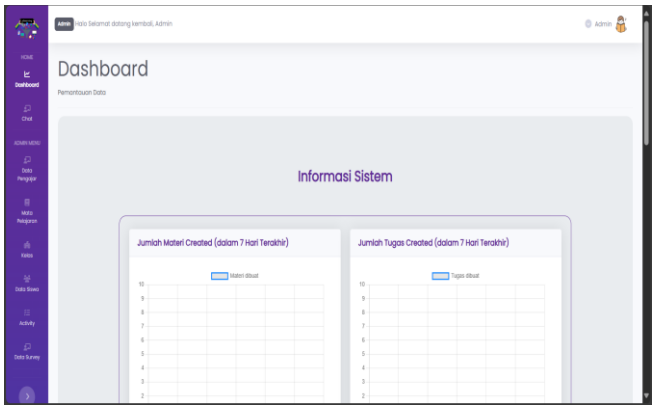

Figure 6. Dashboard page

Figure 6 displays the dashboard page, which provides a summary of learning activities over the past seven days. Two charts are presented side by side, showing the number of materials and assignments created. This figure aims to help administrators monitor productivity trends among teachers and students in real time. The dashboard also includes navigation menus, making it easier for users to access other system features.

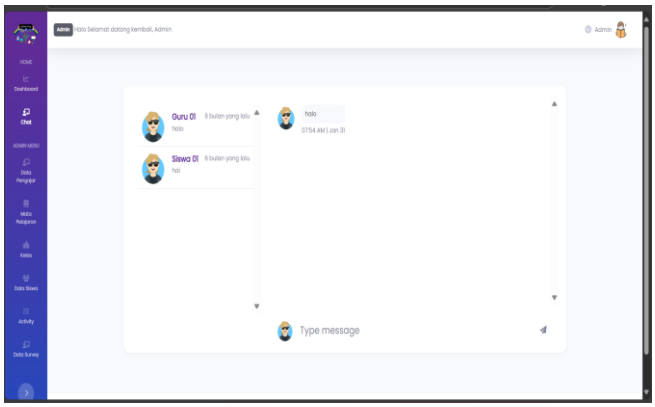

Figure 7. Chat Page.

Figure 7 illustrates the chat page, which facilitates communication between system users such as teachers and students. On the left side, a contact list is shown, while the right side displays the selected conversation. This figure demonstrates how the system integrates direct messaging to improve collaboration and interaction in a digital learning environment.

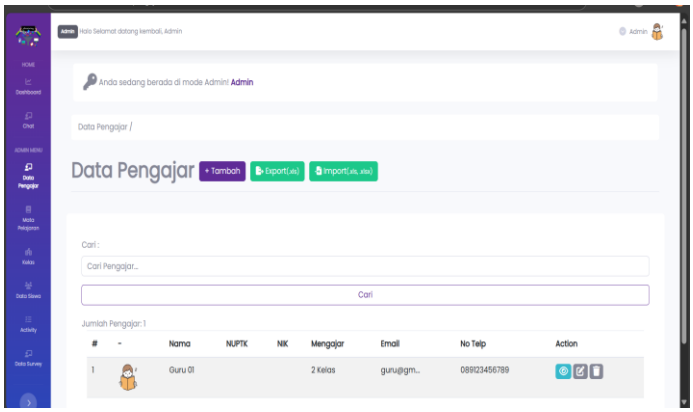

Figure 8. Teacher data.

Figure 8 presents the teacher data page, where administrators can view a list of registered teachers along with their details such as name and email. Action buttons like “Add Data,” “Edit,” and “Delete” are provided for easy management. The objective of this figure is to show how the system structures and simplifies teacher data management.

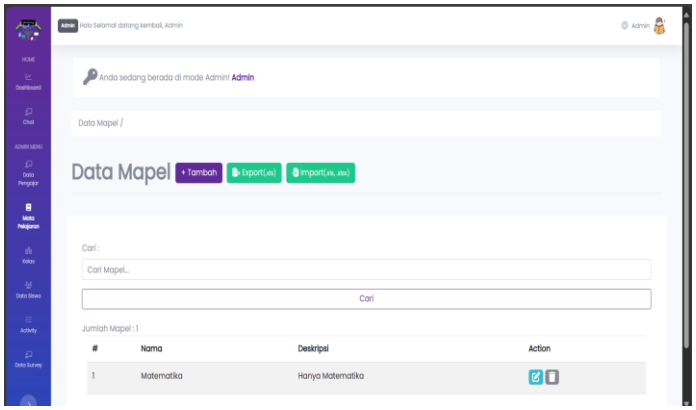

Figure 9. Subject data.

Figure 9 shows the subject data page, which allows the admin to add, edit, or delete subject information. This figure emphasizes the flexibility of the system in maintaining updated curriculum data. A search feature is also available to ensure that users can quickly locate specific subjects.

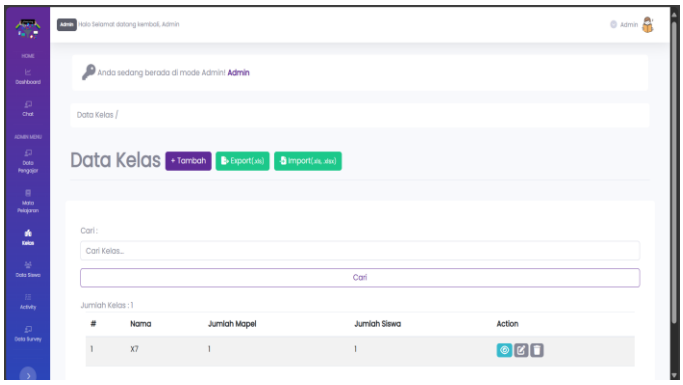

Figure 10. Class data.

The Class Data page is used to manage class information within the school. On this page, the admin can add new class data, assign homeroom teachers, as well as edit or delete existing class records. The layout is consistent with other data pages, featuring a search field and action buttons. This page helps the admin organize class structures neatly and make them easily accessible.

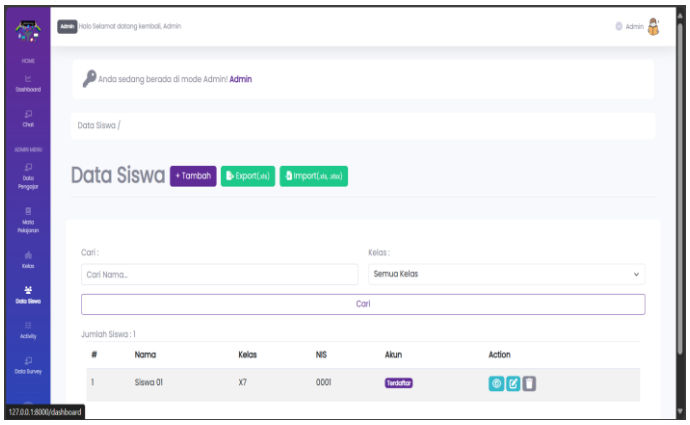

Figure 11. Student Data

Figure 10 illustrates the class data page, where class information such as name, homeroom teacher, and records can be added, updated, or deleted. The figure highlights how the system supports efficient class organization and structure management within the school.

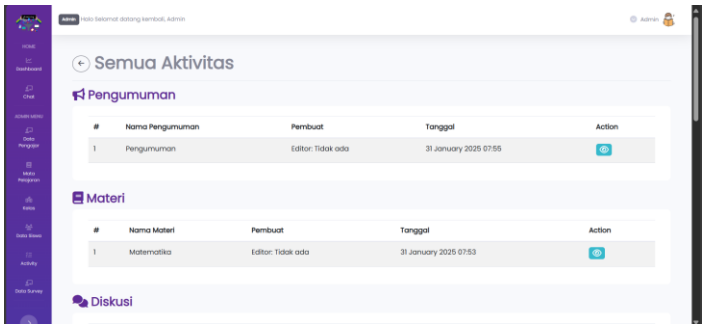

Figure 12. Activities

Figure 11 presents the student data page, which provides administrators with the ability to manage student information including name, email, gender, and class. With a search field and action buttons available, this figure demonstrates how the system ensures student data is well-organized and easily accessible.

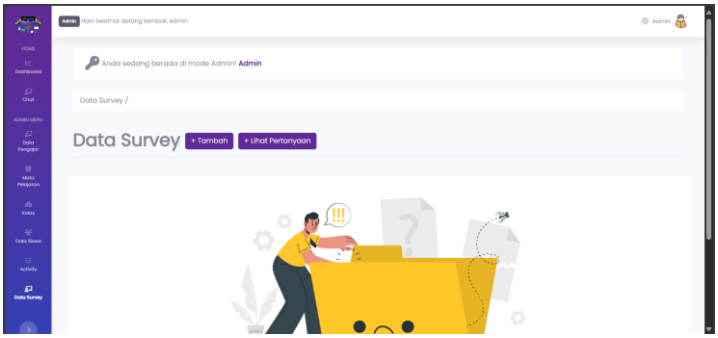

Figure 12. Survey Data

Figure 12 shows the survey data page, which displays results from user surveys stored in the system. If no data is available, an illustration of an empty folder is shown to inform users of the absence of records. The purpose of this figure is to illustrate how the system collects and presents feedback for evaluation and quality improvement.

3.4 System Testing

Table 1: Black Box Testing for Admin Section

No	Menu	Process	Status
1	Login	Enter valid email and password	Succeed
2	Main Page	Successfully log in, then system redirects to the admin dashboard	Succeed
3	Teacher Data	Add, edit, delete, and search teacher records	Succeed
4	Subject Data	Add, edit, delete, and search subject records	Succeed
5	Class Data	Add, edit, delete, and search class records	Succeed
6	Student Data	Add, edit, delete, and search student records	Succeed
7	Activities	View the list of activities with details such as name, description, and date	Succeed
8	Survey Data	View and manage survey data; display empty folder icon if no data available	Succeed
9	Logout	Exit the page and return to the login page	Succeed

Table 1 presents the results of black-box testing conducted on the Admin module. The table lists each menu, its related process, and the outcome status. From this table, it can be seen that all tested functions such as login, teacher data management, subject data management, and logout worked successfully. This confirms that the system is functionally valid and reliable for use.

4. CONCLUSION

This study successfully designed and developed a web-based e-learning system at SMK Assyafi'iyah 02 using the Waterfall method. The system streamlines the learning evaluation process through features such as exam management, online answer submission, automated grading, manual correction, score recapitulation, and role-based access. Its implementation has proven to accelerate evaluations, improve accuracy, facilitate material distribution, and provide real-time access to results, thereby enhancing the effectiveness, efficiency, and transparency of the learning process while supporting the school's digitalization efforts.

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