

## Development of a Web-Based Library Information System Using the Waterfall Method to Improve the Efficiency of Book Lending Services

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### Abstract

Libraries play a vital role as information centers, but manual management often leads to challenges such as recording errors, delays in the borrowing process, and low service efficiency. This study aims to develop a web-based library information system in an educational library environment to improve the speed and accuracy of services. The waterfall method was used as the development approach, comprising the stages of requirements analysis, design, implementation, and testing. Implementation was carried out using PHP with the CodeIgniter framework and a MySQL database. The results of the study show that the system is capable of providing key features such as book search, online borrowing and returns, book and member data management, and transaction verification by the administrator. Black-box testing showed that all system functions operate in accordance with user needs. Thus, the developed system has been proven to improve operational efficiency, speed up transaction processes, and minimize recording errors in library services.

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## INTRODUCTION

Libraries play a vital role as technical units that support the implementation of learning activities. Their existence serves not only to provide and manage information resources but also to preserve knowledge for the entire academic community. Libraries are expected to provide optimal, integrated services focused on user needs. Efforts to improve the quality of these services require adequate facilities and infrastructure so that all library activities can run effectively and efficiently (Putra et al., 2020). The rapid development of information technology has now been applied to various fields, including the management of school library systems. However, in practice, data management is still often carried out manually. Manual library management can dampen students' interest in visiting the library. The process of retrieving book borrowing data after a transaction becomes inefficient, resulting in slow service. Additionally, recording data in ledgers carries the risk of damage or unintentional errors, which can hinder the smooth operation of library services (Prastika & Feoh, 2023). The use of digital technology, particularly web-based and mobile applications, has become a strategic component in supporting improvements in the quality and effectiveness of educational delivery. The implementation of information technology in the form of web-based systems enables increased operational efficiency, optimized data management, and easier access to information for all parties involved in the education system (Dwi Puspita Anggraeni, 2023).

Digital transformation in library management also faces various challenges in the

future. The rapid pace of technological development demands that libraries not only rely on conventional systems but also be capable of continuous adaptation(Yunita & Rosmawati, 2021). Key challenges include maintaining the relevance of information systems amid rapid technological change. In addition, potential risks such as data breaches, unauthorized access, and limitations in system maintenance strategies are crucial aspects that must be anticipated from the design stage(Raya, 2021). The sustainability of library information systems requires optimal institutional governance and continuous software updates to avoid falling behind technologically and to reduce cybersecurity risks(Nabila Putri Utami Mustan et al., 2025).

## METHOD

This study employs the waterfall method because its structured phases are well-suited for projects with clearly defined requirements. The waterfall method used in this study is considered relevant for library information system development, as it features structured and sequential phases, as has been applied and validated in previous research (Nugraha et al., 2024). Requirements analysis was conducted through a literature review and observation of digital library systems. Functional requirements include book search, collection detail display, online borrowing and returns, book and member data management, and the provision of borrowing reports, while non-functional requirements include login security and access rights management, ease of use, interface responsiveness, and system access speed(Giofandi et al., 2023).

The system design phase focused on developing a library information system design that could improve the efficiency of book borrowing and return management by librarians and make it easier for students to access and search the book collection. System planning was carried out as a foundation to ensure that the developed system met user needs (Maulana et al., 2025). System design was conducted to transform the analyzed requirements into a model ready for implementation. The design uses the Unified Modeling Language (UML) through several diagrams that illustrate process flows, user interactions, and the overall data structure of the system(Luthfi Asari et al., 2025).

A use case diagram is used to illustrate the interactions between users and the developed library information system. This system has three main actors: visitors, members, and administrators(Putri et al., 2022). Visitors can view the catalog and search for books; members have additional access to borrow and return books and administrators are responsible for managing book and member data, as well as verifying transactions. The complete use case diagram is shown in Figure 1.

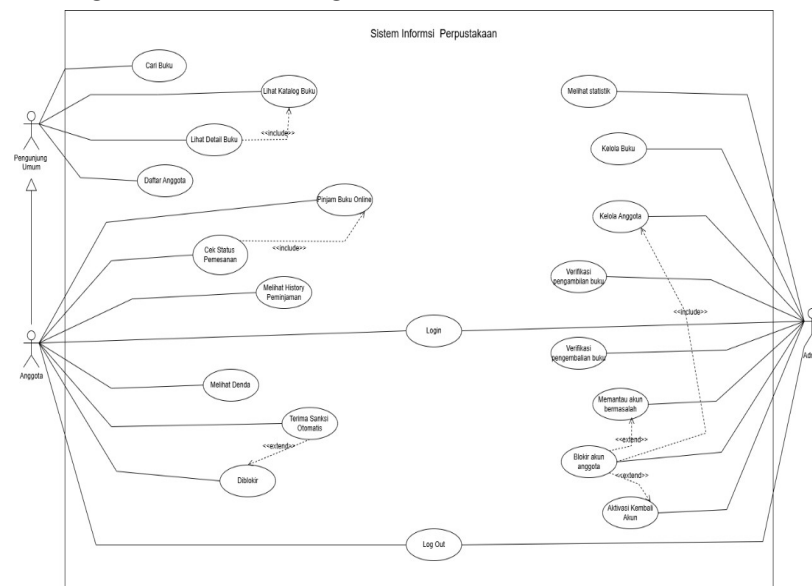


Figure 1. Use case diagram of the library information system

An activity diagram is used to depict the flow of activities occurring within the library information system (Hermanto & Firmansyah, 2020). This diagram illustrates the sequence of processes, starting from when a user accesses the system, searches for books, views details, through borrowing and returning books, as well as the management of book and member data. The activity diagram helps ensure that each workflow aligns with the system's functional requirements.

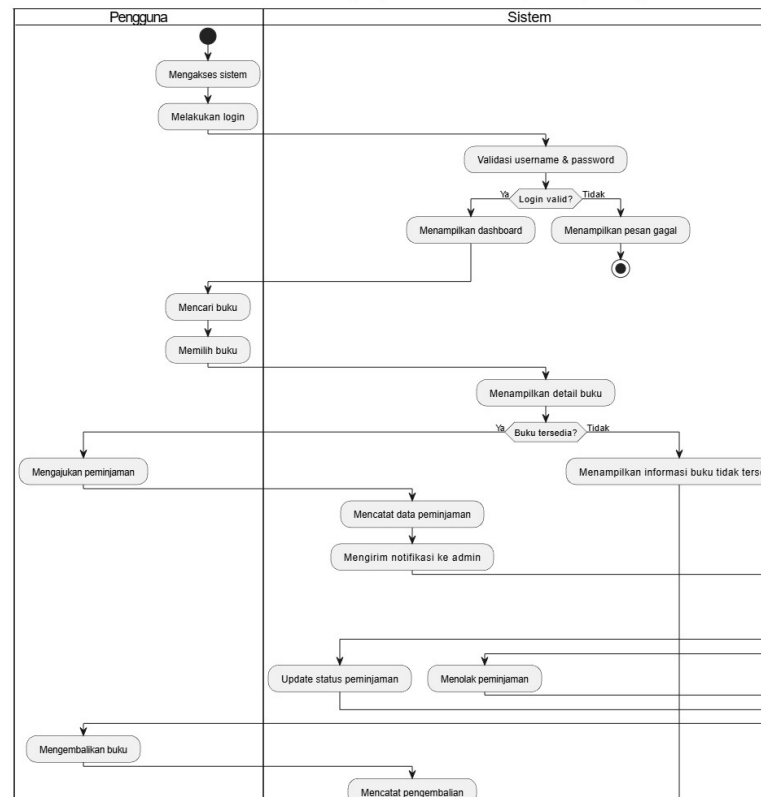


Figure 2. Activity diagram of the library information system

A sequence diagram is used to illustrate the sequence of interactions between users and the system during the book borrowing and return processes. This diagram shows the flow starting from the user logging in, selecting a book, submitting a borrowing request, through to the system saving the transaction and the administrator verifying it. For the return process, the diagram shows the steps where a member returns a book, the system records the return date, calculates any fines (if applicable), and the administrator confirms the completion of the transaction. This sequence diagram ensures that every step of the process proceeds logically according to the system's logic.

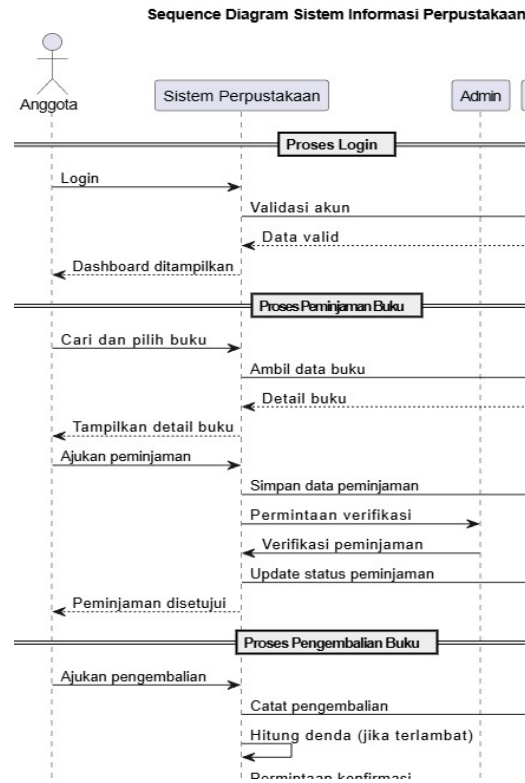


Figure 3. Sequence diagram of the library information system

A class diagram is used to depict the data structure and relationships between entities within the library information system. This diagram shows the main classes of the such as Book, Member, Admin, and Loan complete with their attributes and relationships. Each class is interconnected to form data management workflows, such as storing book details, member information, recording loan transactions, and the return process. This class diagram ensures that the database design and system logic are clearly and consistently organized.

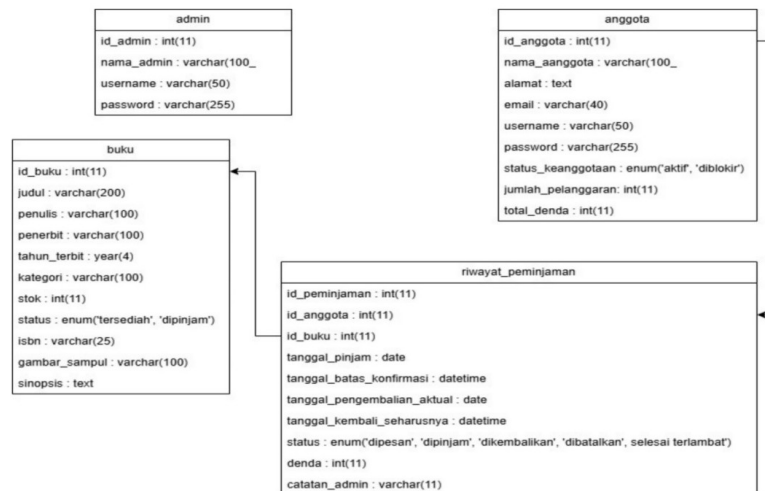


Figure 4. System class diagram

Implementation is the phase carried out after the system design has been agreed upon, involving the realization of the design into a system ready for use. The built system is then tested to ensure functional compliance before being deployed within the organizational environment. This phase is based on the design results compiled in the previous stages. The

library information system was developed using the PHP programming language with the CodeIgniter 4 framework and MySQL as the database. The Model-View-Controller (MVC) architecture was used to separate application logic, data processing, and the user interface. The system consists of visitor, member, and admin modules used for book searches, borrowing, returns, and the management of book and member data.

System testing was conducted using the black-box testing method. Black-box testing is a functional testing technique aimed at verifying that every process and feature operates properly according to user needs [8]. Security testing was performed manually with the assistance of the SQLMap tool. In addition to functional testing, web application security testing was also conducted to identify potential security vulnerabilities in the system, particularly regarding SQL injection attacks

## RESULTS AND ANALYSIS

The web-based library information system was successfully implemented in accordance with the design specifications. The system is capable of managing book data, member data, and borrowing and return transactions electronically. Additionally, the system provides a book search feature to help users access information about the library's collection quickly and accurately. Based on the results of the implementation and testing, the system is deemed to support the library management process more effectively and efficiently.

### System Implementation Results

The web-based library information system provides key features such as book search, online book borrowing, and management of book and member data by administrators. The implementation of this system simplifies library administrative processes and reduces recording errors that often occur in manual systems.

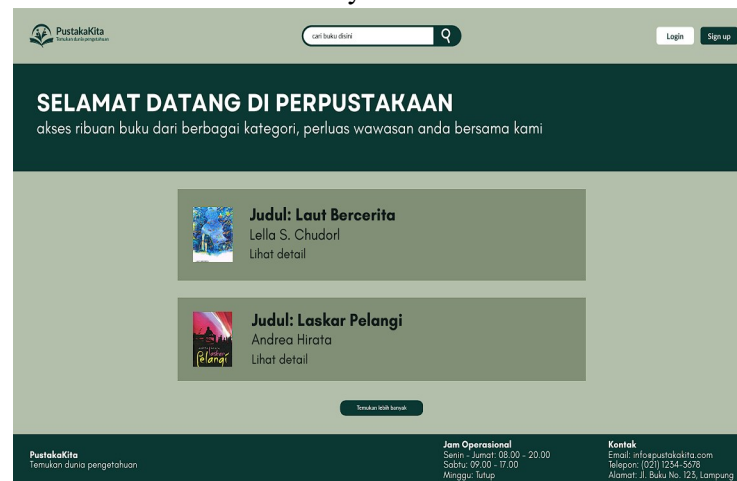


Figure 5. Library Information System Home Page

This figure shows the home page of the library information system, which is accessible to users. This page serves as the main page for displaying general information and making it easier for users to search for books. This figure displays the book detail page, which contains complete information about the library's collection. This feature makes it easier for users to check a book's availability before borrowing it. The display of the library information system admin dashboard.

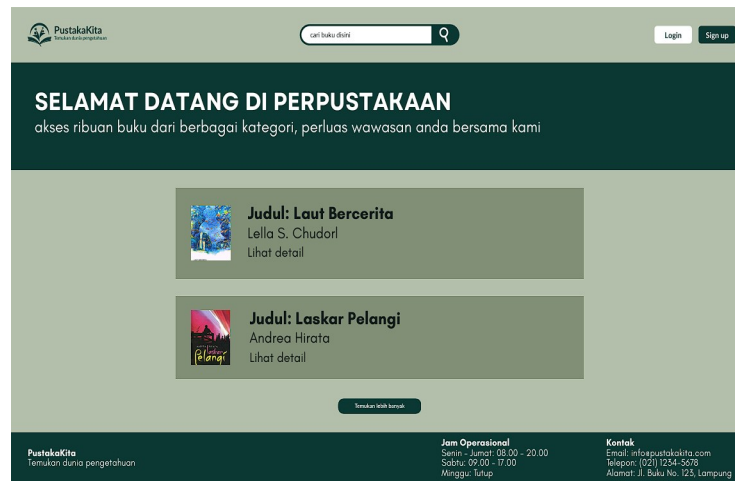


Figure 7. Admin Dashboard Page

This figure shows the admin dashboard used to manage book data, member data, and borrowing and return transactions. This dashboard helps administrators monitor and manage the system efficiently.

#### System Testing Results

The system test results are presented to demonstrate the level of functionality and security in the developed web-based library information system. Testing was conducted to ensure that the system is capable of executing all features in accordance with user needs and has adequate protection against potential security threats. The testing focused on system functional testing and security testing against common attacks on web-based applications.

## CONCLUSIONS

After conducting the research and discussing the results, it can be concluded that the development of a web-based library information system using the waterfall method is capable of improving the efficiency of book borrowing and return services. The system successfully provides an integrated and computerized process for managing book data, member data, and book borrowing and return transactions. The implementation of this system helps reduce recording errors, speed up transaction processes, and improve the quality of library services compared to the manual system previously used. Further research is recommended to develop the system by adding notification features via email or text message to remind users of book return due dates, integrating the system with QR codes or RFID to streamline the physical borrowing and return process, and adding features for printing membership cards and a more interactive statistics dashboard for administrators.

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