

WEB-BASED LABORATORY MANAGEMENT INFORMATION SYSTEM DESIGN

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Abstract - The application of information systems is very important in an effort to optimize the laboratory management process at the Electronics Department. At this time the Department of Electronics, Padang State University still uses conventional media and uses applications that are commonly used in the laboratory management process which results in information not being classified appropriately and accordingly. Laboratory management activities carried out in the form of recording goods and all activities that occur in the laboratory, this study aims to design an information system to optimize and collect information from data collection activities, borrowing, returning, maintaining inventory items and using laboratories in the Electronics Department. The method used to develop information systems is waterfall which represents a structured and sequential approach starting from requirements, design, implementation, verification and maintenance. The information system implementation process uses the Laravel framework. Verification or testing of system functionality using the black box testing method where the test results show that all functions contained in the system have successfully displayed the page as expected and can be used for laboratory management information systems in the Electronics Department.

Keywords— Information system, Laboratory Management, Website, Waterfall Method, Laravel Framework.

I. INTRODUCTION

The development of information and communication technology is currently progressing rapidly, along with the transition from the conventional era to the digital era. Almost all companies and agencies do data processing and storage both conventionally and digitally[1]. Data processing and storage becomes an organizational routine so that the information produced is organized and accurate. One form of digital data processing and storage is the management information system[2].

Previous research on management information systems has been carried out in various institutions including Bakrie University which developed a system to improve the effectiveness of laboratory management[3]. Other studies also show that the application of information systems in laboratory management can reduce recording errors, speed up administrative processes, and increase user satisfaction. For example, research conducted at several universities shows that web-based systems allow real-time access to data, thus facilitating coordination between users and laboratory managers. At the global level, institutions such as Massachusetts Institute of Technology (MIT) and Stanford University have adopted integrated information systems for laboratory management, resulting in significant improvements in operational efficiency and data accuracy. This reinforces the urgency to develop a similar system in the Department of Electronics at Padang State University.

The application of management information systems aims to facilitate data processing and storage activities both in aspects of planning, control, decision making and aspects of resource processing[4]. In the world of education, ranging from elementary to tertiary levels, laboratory facilities are very important to support the teaching and learning process[5]. Laboratories are facilities used to carry out experiments or research in various fields of science such as computers, electricity, physics, chemistry, and others[6]. The laboratory is also a learning process that integrates practice with theory. As a means of supporting practicum-based learning, the lab is equipped with various tools and devices that are in accordance with the related fields of study[7].

To ensure that laboratory facilities are optimally used in academic and research activities, effective laboratory management is needed. Laboratory management is a series of

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laboratory management processes that include planning, organizing, leading, and controlling to achieve the objectives of the laboratory. Laboratory management activities carried out in the form of schedule preparation, laboratory use, laboratory maintenance and repair, loan and return system for practicum / thesis / dissertation / final assignment / research and community service, provision and reporting of laboratory administration.

At this time, the Department of Electronics at Padang State University still uses conventional media and uses applications that are commonly used in the laboratory management process. So that laboratory management experiences obstacles in processing laboratory activities which cause the input of laboratory equipment and materials to be relatively long, vulnerable to loss or damage to data on the use of laboratory equipment and materials, lack of accessibility of laboratory-related information, prone to schedule errors, the business process of borrowing laboratories is not flexible and the process of monitoring laboratory activities is less efficient.

Based on these problems, it is necessary to design and build an integrated management information system to improve the effectiveness of the laboratory management process so that the process of inputting laboratory equipment and materials is fast, information about the laboratory is easy to obtain, determining the appropriate labor use schedule, the loan process can be done anywhere and monitoring laboratory activities is efficient.

To build an information system according to the needs mentioned, a framework is needed that can support the development process. Framework is a term often used by software developers to refer to a framework. This framework consists of various settings or components that have been designed with their respective functions, so that they can help facilitate developers in the process of making applications[8]. In this research, the development of the Department of Electronics laboratory management information system will use the Laravel framework. Laravel is a modern open source web framework that is widely used for developing web applications quickly and efficiently. This framework is equipped with advanced features that support developers in building applications, and offers advantages in writing code that is more concise, easy to understand, and expressive[9].

The development flow uses the waterfall method. This model represents a structured and sequential approach to the software development process[10].

Based on the description above, the application of information systems is very important in an effort to optimize the laboratory management process at the Electronics Department. This research aims to design and implement a web-based information system using Laravel to improve the efficiency of laboratory management. The main contribution of this research is to provide an integrated solution that can overcome laboratory management problems as a whole, starting from data recording, tool lending, to monitoring laboratory activities. Thus, this research is expected to be a model for the development of similar systems in other educational institutions.

II. LITERATUR REVIEW

A. Information System

An information system is a series of coordinated and integrated activities that have a function to manage information. This system operates by receiving information as input, processing it using information technology, procedures, and involving the role of people, and producing useful information as output for its users.

B. Laboratory Management

Laboratory management refers to the process of planning, organizing, supervising, and controlling the resources and activities associated with laboratory operations. It covers various aspects, including management of personnel, equipment, budget, safety, quality, and research development. Laboratory management is critical in ensuring that laboratories operate efficiently, safely and productively. Effective laboratory management helps ensure that the laboratory operates properly, minimizes risks, and supports the achievement of research and testing objectives. It is also important to comply with applicable regulations and industry standards.

From the explanation of laboratory management above, Padang State University has also issued SOPs regarding workshop or laboratory management for each faculty including the Faculty of Engineering. Based on SOP.08.013.00 2018, the scope of laboratory management consists of schedule preparation, laboratory use, and laboratory administration systems. This shows that the university has clear and structured guidelines to ensure laboratory management runs effectively and efficiently.

This SOP can be used as a reference in research that will be carried out in the Department of Electronics laboratory. By following the procedures that have been set, research can be carried out in an organized manner starting from the preparation of laboratory use schedules, utilization of available facilities, to administrative management that supports the smooth running of research activities. Thus, the implementation of this SOP is expected to increase the effectiveness and quality of research in the Department of Electronics laboratory.

C. Website

Web-based information systems offer various significant advantages over manual systems, such as better accessibility because it can be accessed from anywhere and anytime, and faster and more accurate data processing speed by minimizing human error. Digital data storage on a website system saves physical space and facilitates backup, while manual systems are vulnerable to data damage or loss. The website system also facilitates automatic data search and report generation, is more flexible and scalable to expand, and ensures data security through encryption and authentication. Collaboration between users is easier to do in real-time, operational costs are reduced, and monitoring of activities is more efficient. In addition, the website system is more environmentally friendly because it reduces the use of paper[11]. With all these advantages, a website-based information system is a modern, efficient, and effective solution for information management in in the Department of Electronics laboratory.

D. Waterfall

The waterfall model is suitable for projects with clear and well-defined requirements. This model provides a structured approach to software development, where each phase must be completed first before proceeding to the next phase[12].

E. Framework Laravel

Framework laravel is an MVC web development framework designed to improve software quality by reducing development and repair costs and increasing productivity with clean and functional syntax that can reduce a lot of time to implement.[13].

F. PHP

PHP is a scripting language designed for building web applications. When called from a web browser, a program written with PHP will be parsed inside the web server by the PHP interpreter and translated into an HTML document, which will then be displayed back on the web server[14].

G. Laragon

Laragon is an application that can turn a computer into a server or local or can be called a web stack system for web development. Laragon can work well to develop a web and has amazing speed. Laragon has several excellent features such as supporting SSL, allowing developers to easily change the version of the supporting program, manage databases, create application projects quickly, and a user friendly display[15].

H. MYSQL

MYSQL is the most popular database among website programmers, for the reason that this program is a database that is very powerful and stable enough to be used as a data storage medium. As a database server that is able to manage databases well, MySQL is considered the most popular and most widely used database compared to other databases[16].

III. METHOD

This waterfall method uses a sequential software lifeflow approach starting from the stages of requirement, design, implementation, verification and maintenance[17]. The system development process in this study is like the following diagram.

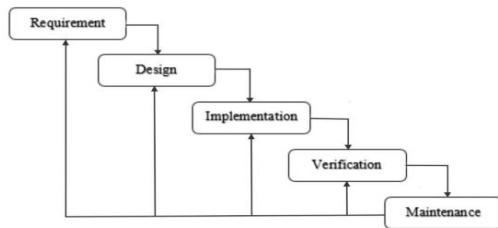


Fig 1. Waterfall Method

Requirement

The requirements gathering and analysis phase involves a comprehensive collection and evaluation of all application requirements. Based on these requirements, the design phase develops application components, workflows, and operational processes. In this research, figma and draw.io were used for the design process.[18]. This research will analyze the business processes currently running in the Electronics Department and evaluate the system functionality needed to overcome the problems that arise. This analysis is based on

information and data obtained through interviews and observations with the head of the Electronics Department laboratory.

TABLE I
BUSINESS PROCESS ANALYSIS OF PROPOSED SYSTEM

No.	Business Process	Activities	Related actors
1	Login	1) User accesses the laboratory management information system website 2) Users input their username and password.	Head of laboratory, laboratory assistants, students, lecturers.
2	Laboratory schedule preparation process	1) Laboratory Head or Laboratory Attendant selects the laboratory scheduling menu 2) Laboratory Head or Laboratory Attendant selects the feature to add/update laboratory usage schedule 3) The Head of Laboratory or laboratory assistant inputs the schedule data on the laboratory scheduling form then presses the save button.	Head of Laboratory, Laboratory an.
3	Laboratory usage process	1) The head of the laboratory/laboratory looks at the list of laboratory equipment and materials on the website before the laboratory is used. 2) Laboratory users carry out activities in the laboratory 3) The head of the laboratory/laboratory sees the use of laboratory equipment on the website	Head of laboratory, laboratory assistant, student, lecturer
4	Laboratory maintenance process	1) The laboratory head or laboratory assistant selects the laboratory maintenance menu. 2) The laboratory head or laboratory assistant selects the add maintenance feature for laboratory instruments/tools. 3) The laboratory head or laboratory assistant inputs the instrument data that will be carried out by the nurse then presses the save button.	
5	Equipment lending system for	1) Laboratory members (students and lecturers) see the assets available	Students, lecturers, laboratory

	practicum, thesis, dissertation, final project and research	2) in the system Laboratory members (students and lecturers) make loan applications by filling out forms on the system 3) The laboratory assistant views the asset loan request 4) The laboratory assistant approves/rejects the request 5) If the request is approved by the Laboran, it will be forwarded to the Head of Labor. 6) Head of Labor views the asset loan request 7) Head of Labor approves/rejects the request 8) If the request is approved, laboratory members (students and lecturers) will receive a notification that the request has been approved.	assistants, laboratory heads.
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Design

After analysis, the research progresses into the design phase based on the findings from the requirement gathering and analysis stage. the research employs UML diagrams (Unified Modeling Language) such as context diagram, use case, activity diagram and ERD.

A. Context Diagram

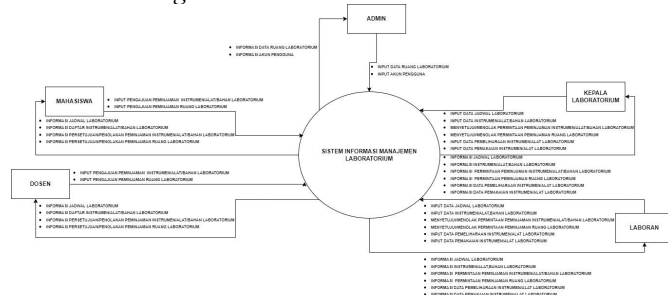


Fig 2. Context Diagram

B. Use case

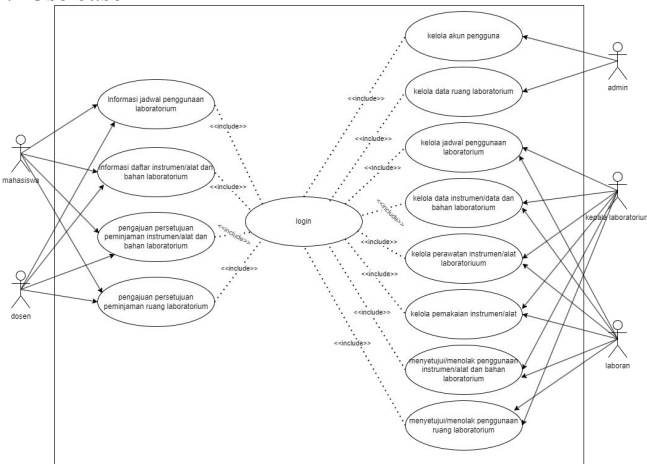


Fig 3. Use case

C. Activity Diagram

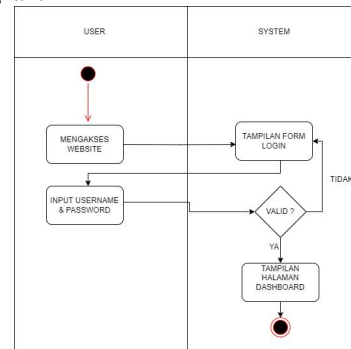


Fig 4. Activity Diagram

D. ERD

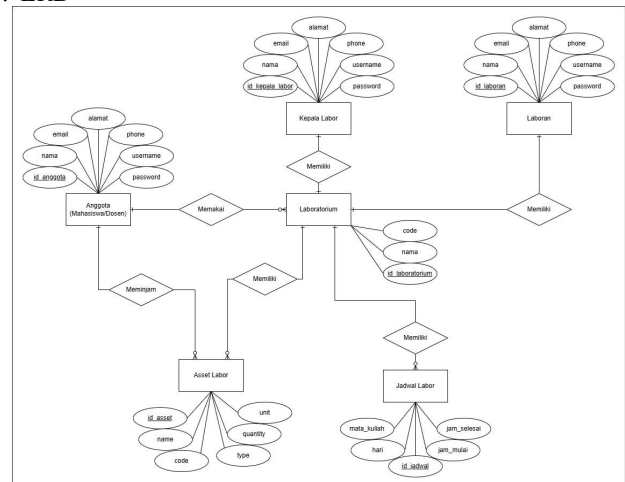


Fig 5. ERD

Implementation

After the design stage is complete, the next step is implementation. The database structure that has been designed is then implemented through migration using Laravel to store various types of data, such as information on tools, loans, users, and laboratory activities. Next, application logic was developed, including CRUD (Create, Read, Update, Delete) functions for data management, user authentication, and business processes. In addition, the user interface was integrated with the backend using Laravel's Blade templating.

A. Login Page All User

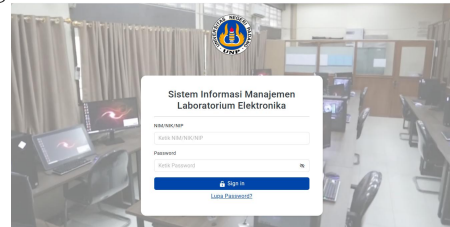


Fig 6. Login Page

The login page is the page that appears for the first time when the application is run. The login page is used as an intermediary to enter the application for users who have been granted access rights. On this login page there is the name of the application and a form for entering NIM/NIP/NIK and password then a button to log in and a forgot password button for users who forget the password that has been given.

B. System Design Result Superadmin

The *superadmin* page is a page provided for *superadmins* which includes user data and laboratory room data.

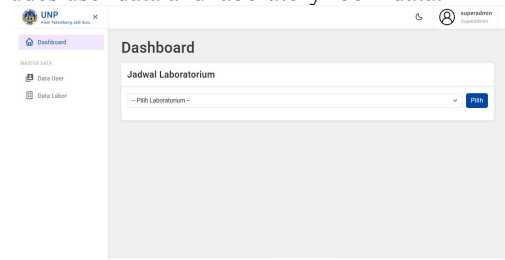


Fig 7. Dashboard Superadmin

Displays a page for superadmins to manage various data and functions in the system. On this display there are 2 activities that can be done by the super admin, namely managing user data and managing laboratory room data.

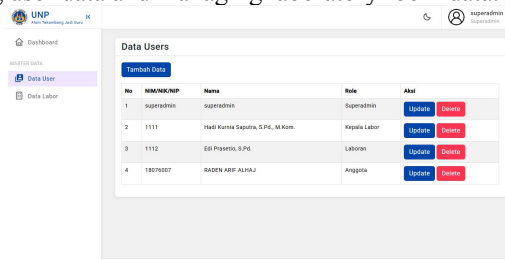


Fig 8. Data User

In this user data menu, *superadmins* can carry out activities to add user data, view user data, change user data and delete user data.

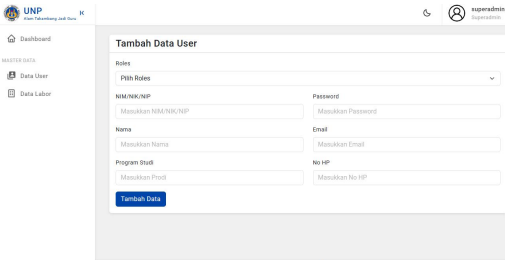


Fig 9. Add User Data

In this form, *superadmins* fill in user data and determine user *roles* according to their respective access rights.

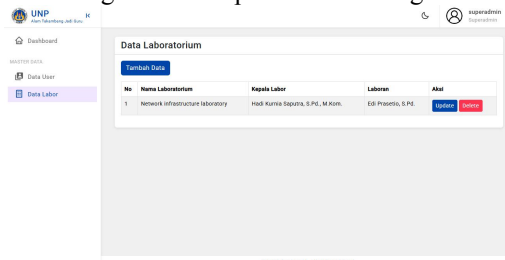


Fig 10. Laboratory Data

In this labor data menu, *superadmins* can carry out activities to add laboratory data, view laboratory data, change laboratory data and delete laboratory data.

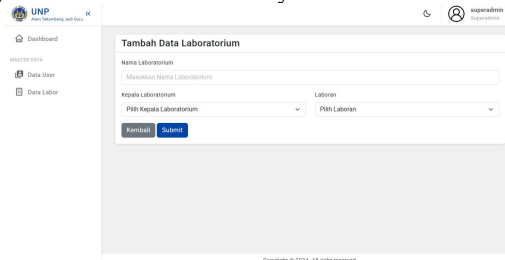


Fig 11. Add Laboratory Data

In this form, the *superadmin* performs the activity of filling in laboratory room data and also performs the activity of determining the laboratory head and laboratory assistant for each laboratory room.

C. System Design Result Head of Labor and Laboratory Assistant

The laboratory head and laboratory assistant page is a page provided for the head of the laboratory and laboratory assistant which includes labor asset data, labor schedule data, asset loan request data, asset return data, labor usage submission data and tool / machine usage control data.

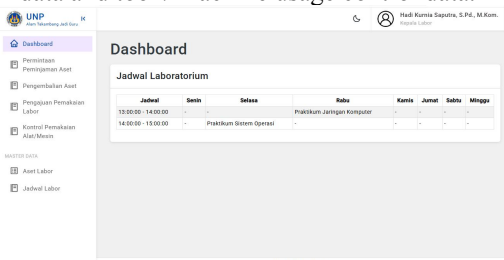


Fig 12. Dashboard Head of Labor and Laboratory Assistant

This is a page that functions to display information on various data and functions that can be performed by the head of the labor and laboratory assistants.

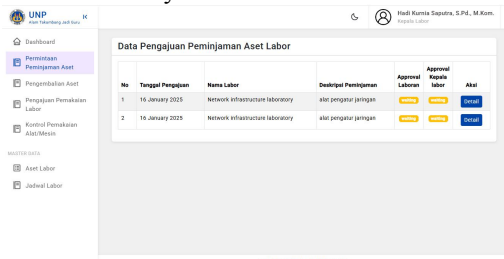


Fig 13. Laboratory Asset Loan Request List

This page is a list of laboratory asset loan requests made by labor members. On this page, the head of labor and laboratory assistants carry out activities to approve / reject requests for borrowing laboratory assets.

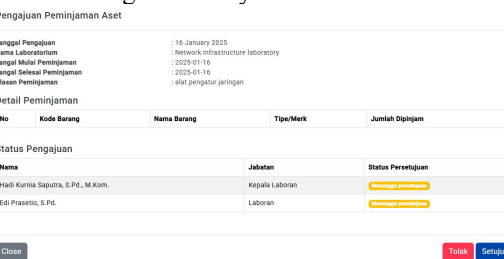


Fig 14. Laboratory Asset Loan Request Details

This pop-up contains information about the *detailed* data of laboratory asset loan requests. Heads of labor and laboratory assistants can approve or reject requests for borrowing laboratory assets.

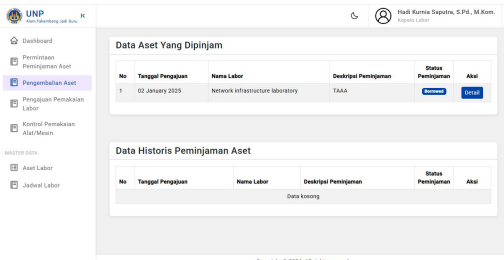


Fig 15. Borrowed Asset Data

On this page, the head of the laboratory and the laboratory assistant fill in the condition of the asset after it has been returned by the borrowing laboratory member.

Fig 16. Add Asset Condition

This *pop-up* functions as a place for the head of labor and laboratory assistants to fill in data on asset returns that have been returned by laboratory.

Fig 17. Approval/Rejection of Requests from Labor Members to Use the Laboratory

On this page, the head of the laboratory or laboratory assistant can approve/reject requests for laboratory members to use the laboratory.

Fig 18. Added Control of Tool/Machine Usage

On this page, the head of labor and laboratory assistants can input users of tools/machines in the laboratory and see the history of their use.

Fig 19. Laboratory Asset Data

On this page, laboratory heads and laboratory assistants can view labor asset data, add labor asset data, update labor asset data, delete labor asset data and perform asset maintenance.

Fig 20. Add Laboratory Asset Data

In this form, the head of labor and laboratory assistants can add asset data contained in the laboratory.

Fig 21. Item Repair Data

On this page, the head of labor and laboratory assistants can fill in the maintenance data for each item that has been recorded on the laboratory asset data page.

Fig 22. Add Item Repair Data

In this form, the head of the laboratory and laboratory assistants fill in data on damage to goods and fill in data on repairs that have been carried out.

Fig 23. Laboratory Schedule Data

On the labor schedule page, laboratory heads and laboratory assistants can view labor schedule data, add labor schedule data, update labor schedule data and delete labor schedule data.

Fig 24. Add Laboratory Schedule Data

In this form, the head of labor and laboratory assistant can add laboratory schedules.

D. System Design Result Student and Lectures

On this page, students and lecturers can view the laboratory schedule, borrow assets and borrow laboratory space.

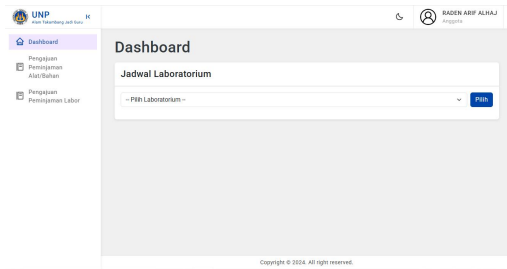


Fig 25. Dashboard Students and Lecturers

It is a page that functions to display information on various data and functions that can be performed by students and lecturers.

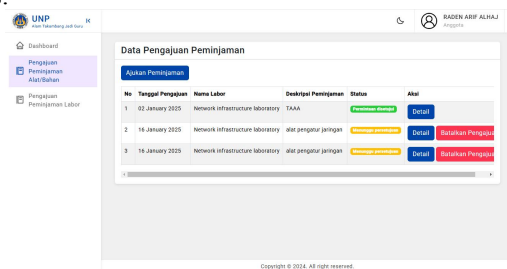


Fig 26. Asset loan request data

On this page, students and lecturers can apply for an asset loan and cancel the asset loan application. In addition, students and lecturers can also directly view the approval / rejection status of borrowing labor assets.

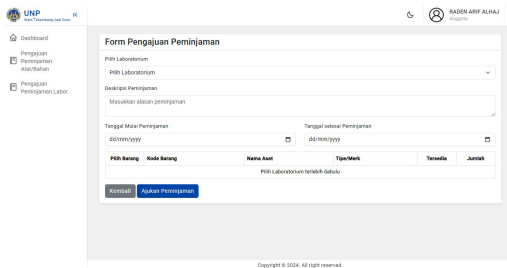


Fig 27. Add Asset loan request data

On this page, students and lecturers fill in requests for assets to be borrowed. The data filling process starts from selecting the laboratory where the required asset is available, filling in the reason for borrowing, filling in the borrowing start date, filling in the borrowing end date and selecting the asset and the number of assets needed.



Fig 28. Lab Usage Submission Data

On this page students and lecturers can apply for laboratory use.

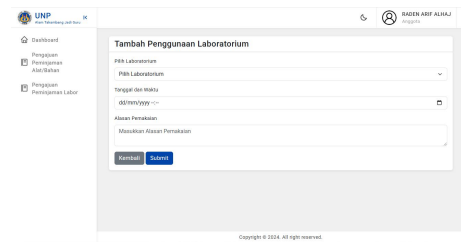


Fig 29. Add Lab Usage Submission Data

On this page, students and lecturers can apply for labor usage. The process of filling in the labor usage submission data starts from selecting the laboratory, determining the date and time of labor usage and the reason for labor usage.

Verification

After implementation, then enter the verification stage. The verification process on this system uses black box testing. the type of black box testing used focuses on the functionality of the system for users. System functionality testing is carried out on all superadmin pages, all pages for the head of labor and laboratory assistants and all pages for students and lecturers. The test results are as shown in tables II, III and IV.

TABLE II
SUPERADMIN ACCESS PAGE TESTING

No	Test Case	Expected Results	Testing Results	Status
1	Enter the login page	Login page displayed	Login page displayed	Success
2	Login to the system with username and password	Display the admin page	Display the admin page	Success
3	Error entering data during login	Display notification of incorrect username or password	Display notification of incorrect username or password	Success
4	Select the dashboard page	Display the admin dashboard page	Display the admin dashboard page	Success
5	Select the user data menu	Display the user data page	Display the user data page	Success
6	Select add data on the user data page	Display the user data filling page	Display the user data filling page	Success
7	Select user roles on the user data entry page	Display superadmin, labor head, laboratory assistant, member options	Display superadmin, labor head, laboratory assistant, member options	Success
8	select the update button on	Display the user data filling page	The user data filling page can be	Success

	the user data page	whose data can be edited	edited.	
9	select the delete button on the user data page	User data deleted	User data deleted	Success
10	Select the labor data menu	Display the labor room data page	Display the labor room data page	Success
11	select add data on the labor data page	Display the laboratory room data filling page	Display the laboratory room data filling page	Success
12	Select the laboratory head on the labor data page	Display a selection of laboratory heads who are already registered in the user data	Display a selection of laboratory heads who are already registered in the user data	Success
13	Select a laboratory assistant on the labor data page	Display a selection of laboratory assistants who are already registered in the user data	Display a selection of laboratory assistants who are already registered in the user data	Success
14	select the update button on the labor data page	Display the labor data filling page where the data can be changed	Display the labor data filling page where the data can be changed	Success
15	select the delete button on the labor data page	Labor data deleted	Labor data deleted	Success

TABLE III
HEAD OF LABOR AND LABORATORY ASSISTANT ACCESS PAGE TESTING

No	Test Case	Expected Results	Testing Results	Status
1	Enter the login page	Login page displayed	Login page displayed	Success
2	Login to the system with NIP and password	Display the Head of Labor / Laboratory page	Display the Head of labor / Laboratory page	Success
3	Error entering data during login	Display notification of wrong NIP or password	Display notification of wrong NIP or password	Success

4	Select the dashboard menu	Display the dashboard page of the head of labor / laboratory assistant	Display the dashboard page of the head of labor / laboratory assistant	Success
5	Select the labor asset loan request menu	Display the labor asset loan application data page	Display the labor asset loan application data page	Success
6	Select the detail button on the labor asset loan request page.	Display a pop-up to approve or reject an asset loan on the labor asset loan application page.	Display a pop-up to approve or reject an asset loan on the labor asset loan application page.	Success
7	Select the asset return menu	Display the borrowed asset data page	Display the borrowed asset data page	Success
8	Select the details button on the asset return page	Display a pop-up to fill in the returned asset and confirm the return on the asset return page.	Display a pop-up to fill in the returned asset and confirm the return on the asset return page.	Success
9	Select the labor request menu	Display the labor submission data page	Display the labor submission data page	Success
10	select the approve button on the labor usage submission page	Display approved status on laboratory usage data	Display approved status on laboratory usage data	Success
11	select the reject button on the labor usage submission page	Display notification of successful rejection of laboratory usage data	Displays a successfully rejected notification on the laboratory usage data	Success
12	Select the tool/machine usage control menu	Display the tool/machine usage control page	Display the tool/machine usage control page	Success
13	Select an asset on the tool/machine	Display the list of assets then display	Display the list of assets then display	Success

	e usage control page	the tool / machine control page	the tool / machine control page	
14	select the tool/machine control data entry on one of the asset lists in the tool/machine control page.	Display options for filling in the date, username, start time, end time and description.	Display options for filling in the date, username, start time, end time and description.	Success
15	select the labor asset menu	Display the laboratory asset data page	Display the laboratory asset data page	Success
16	select the add data button on the labor asset data page	Display the page for filling in labor asset data	Display the page for filling in labor asset data	Success
17	select the maintenance data button on the labor asset data page	Display the item repair data page	Display the item repair data page	Success
18	select the add data button on the item repair data page	Display the page for adding repair data	Display the page for adding repair data	Success
19	select the edit button on the item repair data page	Display the page for filling in repair data updates	Display the page for filling in repair data updates	Success
20	select the delete button on the item repair data page	Delete item repair data	Delete item repair data	Success
21	select the edit button on the labor asset data page	Display the page for filling in laboratory data updates	Display the page for filling in laboratory data updates	Success
22	select the delete button on the labor asset data page	Delete labor asset data	Delete labor asset data	Success
23	select the labor schedule	Display the laboratory schedule data	Display the laboratory schedule	Success

	menu	page	data page	
24	Select the add data button on the labor schedule data page	Display the laboratory schedule filling page	Display the laboratory schedule filling page	Success
25	Select the edit button on the labor schedule data page	Display the laboratory schedule update page	Display the laboratory schedule update page	Success
26	Select the delete button on the labor schedule data page	Delete laboratory schedule data	Delete laboratory schedule data	Success

TABLE IV
STUDENTS AND LECTURERS ACCESS PAGE TESTING

No	Test Case	Expected Results	Testing Results	Status
1	Enter the login page	Login page displayed	Login page displayed	Success
2	Login to the system with username and password	Student / Lecturer page displayed	Student / Lecturer page displayed	Success
3	Error entering data during login	Display notification of incorrect NIM/NIP or password	Display notification of incorrect NIM/NIP or password	Success
4	Select the dashboard page	Student/lecturer dashboard page displayed	Student/lecturer dashboard page displayed	Success
5	Select a tool/material loan request	Display the tool / material loan application data page	Display the tool / material loan application data page	Success
6	Select the loan request button on the tool/material loan request page.	Display the page for filling out the loan application for tools / materials	Display the page for filling out the loan application for tools / materials	Success
7	select a laboratory in the list of laboratories on the page of filling out the loan	Display a list of laboratories that have been inputted in the labor room data	Display a list of laboratories that have been inputted in the labor	Success

	application for equipment / materials		room data	
8	Select the detail button on the tool/material loan application page.	Display pop-up of loan details and application status	Display pop-up of loan details and application status	Success
9	Select the cancel request button on the tool/material loan request page.	A submission deletion warning pop-up appears if you press the yes button then the data is deleted otherwise the data is canceled.	A submission deletion warning pop-up appears if you press the yes button then the data is deleted otherwise the data is canceled.	Success
10	select the labor loan application menu	Display laboratory submission data	Display laboratory submission data	Success
11	select the apply for laboratory usage button on the labor loan application page.	Display the page for filling out the labor usage request	Display the page for filling out the labor usage request	Success

Based on the test results listed in Tables II, III, and IV, it can be concluded that the system functions perfectly (100%) for users.

Maintenance

The last phase in the waterfall method is the operation and maintenance of the completed software. At this stage, the software is run and maintenance activities are carried out, including fixing errors or bugs that were not detected in the previous stages.

IV. CONCLUSIONS

This final project produces a web-based laboratory management application that is used by laboratory heads, laboratory assistants, students, and lecturers. This application was developed with PHP and Laravel, using MySQL as a database and Laragon as a web server. The system built is divided into three main parts: for superadmin (managing user data and laboratory space), for laboratory heads and laboratory assistants (managing assets, schedules, borrowing, returning, and controlling the use of equipment), and for students and lecturers (viewing schedules and applying for borrowing assets and laboratory space).

The results show that this system improves accuracy and efficiency in laboratory management. This system also has the potential to be adopted by other institutions to improve

transparency, accountability, and efficiency of laboratory management.

Further development is recommended to integrate this system with the university's academic system, to facilitate data synchronization. In addition, the application of artificial intelligence (AI) can be done to predict asset maintenance needs and optimize laboratory schedules automatically, so that this system continues to grow and provide greater benefits in the future.

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