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Design and Implementation of Siprakfis (Physics Laboratory Practical Management Information System) to Optimize Practical Services in Higher Education

Widyastuti*[1], Muhammad Rofiudin[1], Ahmad Minanur Rohim[2]

[1]*Physics Education Department, Universitas Islam Negeri Walisongo Semarang, Indonesia*
[2]*Physics Education Department, Universitas Negeri Semarang, Indonesia*

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ABSTRACT

Physics laboratories often face difficulties managing practicums, especially in scheduling, equipment tracking, assessment, and evaluation of practicum results. The mismatch between practicum needs and resource availability usually results in delays, administrative errors, and increased workload of laboratory staff. This study proposes the development of a Physics Laboratory Practicum Management Information System (SIPRAKFIS) to optimize practicum management in physics laboratories. The research method used is R&D with a waterfall development model, which includes communication, planning, modeling, construction, and deployment stages. SIPRAKFIS was developed using the PHP MySQL programming language. System testing was done through unit testing, functionality, usability, and implementation. The study results indicate that SIPRAKFIS is feasible to use in practicum management and can be accessed online via www.labfisikauin.com. Unit testing on the login system was declared victorious. Functional testing obtained good results, namely a functional value of 1. Usability testing obtained a value of 82.59%. Deployment testing showed that the system can be run on various browsers, namely Mozilla Firefox, Google Chrome, and Internet Explorer. SIPRAKFIS can help facilitate the management of practicum services, reduce administrative errors, speed up the practicum scheduling process, and facilitate equipment monitoring and reporting of practicum values. The results of this study can also be further developed for research and testing services.

Introduction

The laboratory is one of the educational facilities and infrastructure that is most crucial in advancing education, research, and community service (Fabrianne et al., 2022). This aligns with the vision of UIN Walisongo Semarang, namely, to become a leading Islamic research university based on the unity of science, striving to improve the quality of education, research, and community service. The existence of a university can be seen from its laboratory (Cahyo & Prima, 2022). The laboratory is a place to conduct research experiments and discover and explore knowledge with the latest findings (Widyastuti, 2019). The role of the laboratory in improving the quality of education, among others, can enrich the field of science with the presence of various research/research in the laboratory (Aprillia D. P. Tanjung, 2022).

In today's digital era, the demand for efficient laboratory management is increasing, especially in universities with a strong focus on research and innovation. Laboratory management, which includes scheduling of labs, tracking of equipment, and evaluation of lab results, often encounters various operational constraints. Problems such as administrative errors, delays, and lack of resource availability result in low efficiency and a higher

*Correspondence email: widya.fisika@walisongo.ac.id
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workload for laboratory personnel. Many laboratories still use manual or semi-digital systems, which can cause delays, errors, and inefficiencies in managing lab scheduling, inventory, and assessment of lab results. Ineffective resource management results in laboratories experiencing constraints in managing the availability and condition of equipment (Najemah, 2020). Effective lab management, data collection, and analysis are essential to assessing experimental performance and results (Fabrianne et al., 2022). The limitations of conventional management systems further emphasize the need for technology-based solutions to overcome these challenges (Junaidi Fery Lusianto, 2022).

Practical services are routine laboratory management work every semester. The Physics Laboratory at the Faculty of Science and Technology Universitas Islam Negeri (UIN) Walisongo Semarang serves student practicums from 3 study programs: the physics study program, the physics education study program, and the chemistry study program. No less than 600 students use the practical services in the Physics Laboratory every semester. To serve student practicums, laboratory management involves the role of lecturers in charge of practicums and practicum assistants. Lecturers in charge of practicums are lecturers who are responsible for the practicum courses they teach (Widyastuti & Susanto, 2021). Practical assistants are students who are tasked with assisting lecturers in charge of practicums in managing the implementation of practicum activities from preparation to implementation of practicums. To support the smooth running of practicum activities, managers, lecturers in charge of practicums, and practicum assistants must work together and communicate well, supported by adequate practicum supporting equipment and practicum management systems.

The types of practicum courses are diverse, the number of experiments is large, and the quality demands must be met in practicum management services. Based on the results of observations and interviews conducted by researchers in May 2022 at the UIN Walisongo Semarang physics laboratory, several obstacles were found in the management of practicums in the physics laboratory, including (1) manual methods in scheduling practicums and recording experimental results which cause overlapping schedules, poor time management, and errors in recording grades. (2) laboratory staff have difficulty obtaining information on the status of equipment availability or the amount of stock of practicum materials; this causes delays or sudden changes to practicums, which can disrupt the flow of practicum learning. (3) In the assessment system, practicums are usually only assessed based on the final experimental result report; this causes lecturers to be unable to provide direct feedback when practicums conduct experiments. (4) Lecturers in charge of practicums have difficulty monitoring all students during physics practicums, which often involve many participants so that students who have difficulty conducting experiments do not immediately get attention and assistance, while students who complete assignments faster may not get further challenges. (5) The management of practicums previously used was a manual system, which created various obstacles, one of which was that the work of assistants and lecturers was less practical and time-efficient. In the digital era, the demand for time efficiency is undeniable. Ease and smoothness of practicums are the main things in service.

To overcome these problems, a system is needed to facilitate the management of practicums online using the web. In 2019, researchers created a web-based system design, namely the Physics Laboratory Information System (SILABFIS), which contains laboratory management features, one of which is laboratory equipment inventory management (Widyastuti, 2019). From this system, researchers intend to develop more specifically to support the practicum management services in the UIN Walisongo Semarang physics laboratory, where this practicum management system is still connected to the previously created inventory system. This system was designed to facilitate the management of practicum activities online using the SIPRAKFIS web. SIPRAKFIS can reduce the administrative burden by automating registration, scheduling, and reporting grades. This system allows lecturers and laboratory staff to arrange practicum schedules easily and ensures no time conflicts. All practicum data, result reports, and attendance records can be managed digitally, saving time and preventing errors often occurring in manual processes.

Laboratory equipment inventory management can be significantly improved. This system allows digital equipment stock recording, monitoring equipment conditions, and providing notifications when equipment needs to be repaired or replaced. This helps reduce waiting time and ensures smooth implementation of the practicum with the availability of adequate equipment. SIPRAKFIS integrates all parties involved through a single platform that can be accessed online. This practicum management system helps and facilitates human resources, especially lecturers in charge of the practicum, technicians, practicum assistants, and students in the practicum implementation process.

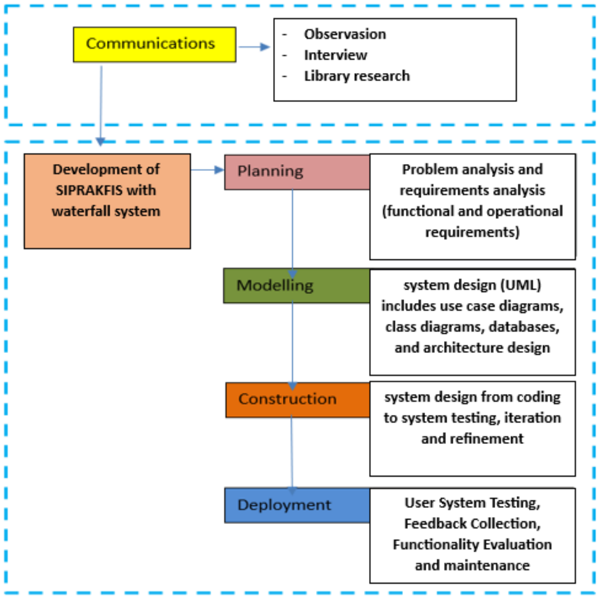
SIPRAKFIS is developed as a web-based system with several different characteristics from conventional software, requiring a particular engineering approach to create it. Three crucial points in developing a web-based system are incremental system releases, ongoing application changes, and a short timeline (Junaidi Fery Lusianto, 2022). Web-based information systems are developed incrementally, wherein, in each increment, the user determines the needs that will be added to the next increment (Febrianto et al., 2023). The process flow will continue to be repeated in each increment. This change is a user evaluation of the previous increment or is a consequence of system changes. The development of a web-based information system must also be carried out quickly to accommodate continuous system changes. This information system uses the PHP programming language with a MySQL database. PHP can make a web page more interactive and work dynamically (Murtaqi et al., 2022). MySQL is a popular database management system developed with an open source concept and is available for various operating systems (Kristiyanto et al., 2021).

In 2015, A. Syaifudin et al. developed a practicum management system at the Faculty of Engineering, Majapahit Islamic University, Mojokerto. In developing his research, Syaifudin used the PHP Framework codeigniter, with database management using MySQL version 5.0.45. The practicum management system developed can present practicum management in terms of the registration system, scheduling system, and presentation of value reports (A. Syaifudin, 2015). SIPRAKFIS, developed by researchers, can present inventory management, tracking of equipment and materials, equipment lending, assessment, and presentation of reports easily so that practicum management becomes more efficient and facilitates laboratory personnel and human resources. Khadiman, in 2019, in the informatics engineering education laboratory, researched a web-based practicum reporting system that developed a feasible practicum reporting system. The assessment results from media experts got a score of 70% and a score from students of 70% (Khadiman, 2019). The scope of SIPRAKFIS is not only limited to the practicum reporting system. This system covers the entire cycle of physics practicum management, from scheduling, conducting experiments, borrowing equipment, and reporting damage to direct performance evaluation. SIPRAKFIS supports report management and provides integrated tools to monitor, assess, and provide feedback on student performance during the practicum process.

Methods

This study uses the research and development (R&D) method. The product produced in this study is SIPRAKFIS, a physics laboratory practicum management information system developed based on the web that can be accessed online. The development model uses the waterfall software development model, which includes communications, planning, modeling, construction, and deployment (Arsul et al., 2021). The research development stages can be seen in Figure 1.

Figure 1
Research Development Stage



The population in this study consisted of lecturers and students at UIN Walisongo Semarang. The sample in this study were users involved in practicum management services in the physics laboratory of the Faculty of Science and Technology, UIN Walisongo Semarang, lecturers in charge of practicums, laboratory assistants/laboratory technicians, practicum assistants, and students. The selected sample was 36, consisting of 4 lecturers, two laboratory technicians, eight practicum assistants, and 22 students.

The sampling technique used in this study was purposive random sampling. The selected respondents were experienced and competent in physics laboratory management and had knowledge and experience in laboratory management (Sugiyono, 2022). The practicum lecturer was responsible for planning and evaluating the practicum. Laboratory technicians are accountable for equipment preparation, logistics management, and maintenance. The lab assistant is responsible for assisting in the implementation of the lab and supervising the practicum during the experiment. Students directly involved in the lab implementation must go through the lab registration process, follow the lab schedule, conduct the lab, and report the results. This SIPRAKFIS development research was conducted from May to October 2022. The location of the study and the place where the research data was collected is in the physics laboratory of the Integrated Laboratory Building, 3rd Floor, Campus 3, UIN Walisongo Semarang.

System testing is carried out in four stages: unit, functional, usability, and deployment.

1) Unit testing

Unit testing in this study uses black box testing. Black box testing is a system testing method that tests system functions without looking at the details of the implementation, code structure, or system contents (Irnawati & Darwati, 2020). Black box testing ensures that the system being developed is genuinely ready or suitable for use by users (Arsul et al., 2021). Black box testing is carried out by four expert lecturers in web development, who test the functions of the login system. Testing on the login system is checking the login success function using a username and password (Murtaqi et al., 2022). The steps for black box testing in unit testing are: (1) Creating test cases to test various functions in the application. (2). Develop test cases to evaluate the extent to which the workflow of a function is following user needs and requests. (3) Identifying bugs or errors based on the application interface. (Jailani & Ainul Yaqin, 2024).

2) Functional testing

Functional testing in this study uses test case testing. Test case testing checks whether the functions in the system succeed or fail in the process (Nishom & Wibowo, 2020). Functional testing is carried out by four expert lecturers in the field of web development. This functional testing uses a checklist questionnaire on the test case containing system function data described according to the requirements analysis. Functional testing is carried out using descriptive analysis techniques, namely, analyzing the percentage of test results for each function of the software developed. The measurement scale used in the functional testing instrument is the Guttman scale. Each answer to the instrument item consists of two choices, namely "Yes" or "No". The categories for each statement are "Yes = 1" and "No = 0". Each function's success percentage is then analyzed to determine how well the software meets functional requirements.

To determine the level of software feasibility based on functional aspects, the standard interpretation set by ISO / IEC TR 9126-2: 2002 is used. The data analysis formula used is as follows Equation 1.

$$X = 1 - \frac{A}{B} \tag{1}$$

Description:
X : Functional
A : Total number of invalid functions
B : Total number of functions

Based on the functional testing formula, it can be seen that the developed system can be said to have met the standards or is said to have good functionality if the X value is close to 1, according to the measurement interpretation of ISO/IEC TR 9126-2:2002, namely $0 \leq X \leq 1$ (Aprillia D. P. Tanjung, 2022).

3) Usability testing

Usability testing determines whether users can use the system well, smoothly, effectively, and efficiently (Murtaqi et al., 2022). Usability testing aims to obtain information about user satisfaction or difficulty in using the system that has been created. Researchers get feedback from users and make it possible to fix it if there are still system errors (Murtaqi et al., 2022).

The stages in conducting usability testing include (1) determining the target achievement by developing the system, (2) preparing the product to be tested, (3) determining the sample in the test, (4) creating a usability testing instrument, (5) observing the system trial process, (6) making a summary and notes of the testing process to obtain a test analysis report. The usability testing instrument uses the SUS (Software Usability Scale) questionnaire (Ridho et al., 2021). Data analysis in usability testing uses a Likert scale to measure user perceptions or attitudes toward the system's usability. Likert scale answers can be categorized as follows:

- Disagree (TS) is given a score of 1
- Disagree (KS) is given a score of 2
- Agree (S) is given a score of 3
- Strongly Agree (SS) is given a score of 4

Usability test result data was analyzed using the average score of each respondent's answer. This Likert scale value is used to measure the ease of use of the system (usability), the level of efficiency, and the level of user satisfaction with their experience using the system. To obtain a total score interpreted with the results of the usability test using Equation 2.

$$P_{score} = \frac{total\ score}{i \times r \times 4} \times 100\% \quad (2)$$

Description:
P_{skor} = total score of the respondent's answer
i = number of questions
r = number of respondents

Furthermore, the results of the percentage calculation are compared with the score interpretation criteria table in Table 1.

Table 1
Score Interpretation

Percentage of Achievement (%)	Interpretation
$0 \leq P \leq 20$	Very poor/low
$20 < P \leq 40$	Less/low
$40 < P \leq 60$	Fair
$60 < P \leq 80$	Good/high
$80 < P \leq 100$	Very good/high

4) Deployment testing

Deployment testing is carried out by running the information system on various and commonly used browsers. If the system runs well, it can be declared to have passed the deployment test (Novy Christy, 2016).

SIPRAKFIS research complies with ethical standards to protect participants' rights, privacy, and security by obtaining ethical approval from the review board, using informed consent, and providing secure data storage and processing. This research was conducted by minimizing risks and maintaining the integrity and trust of participants.

Result and Discussions

SIPRAKFIS is designed to manage various aspects of physics laboratory practicum services, considering the different roles of each user group, namely lecturers, laboratory technicians, practicum assistants, and students. Each group has requirements, responsibilities, and functions that complement and support each other. At the requirement analysis stage, functional requirements were found in the system, namely functional requirements and operational requirements.

Table 2.
User Requirement List Admin

User	Requirements
Admin	- Login **Home** - Add news/article - Edit news/article - Delete news/article - Editing laboratory info - Delete laboratory info - Editing laboratory manager - Delete laboratory manager - Adding SOP - Edit SOP - Delete SOP - Downloading SOP - Adding module - Editing module - Delete module - Downloading module - Adding schedule - Editing schedule - Delete schedule - Downloading schedule - Practicum service - Adding practicum material tool request - Editing practicum material tool request - Delete practicum material tool request - View class - Add class - Editing class - Delete class - View practicum - Add practicum - Editing practicum - Delete practicum - Add practicum value - Editing practicum value - Delete practicum value - View practicum placement - View practicum placement student data details - Add student data to practicum placements - Delete student data on practicum placements

General functional requirements include managing news, laboratory information, tools and materials, laboratory room usage schedules, practicum modules, and laboratory standards/procedures. Specific functional requirements include managing practicum services, including class data, room data, student data, assistant data, lecturer data, registration, equipment borrowing, equipment returns, pre-test assessments, performance, initial and final reports, and equipment damage reports. Non-functional requirements include the system being accessed via a web browser; the system can handle many users with a fast response time; all users can access the system: lecturers, laboratory technicians, practicum assistants, and students. From the functional requirements analysis, a user requirement list table can be made as Table 2.

Operational requirements are the hardware and software requirements needed during the research. In this case, the operational requirements include the necessary hardware and software as follows: Core i.5 computer, Windows 7 operating system, Notepad ++, PHPMyAdmin, Mysql, Xampp v3.1.03.1.0, Web Browser, and Barcode.

The next stage is the system design stage, which includes the UML design stage, database design, and user interface design.

1) UML design stage

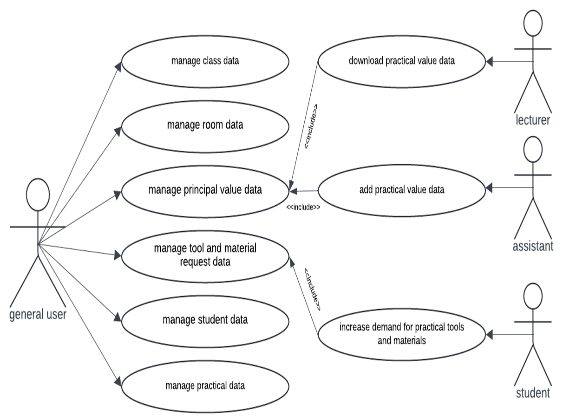
UML is used to describe the overall system design. UML helps define the system's structure, interactions, and functions systematically and visually (Nishom & Wibowo, 2020). Two types of UML diagrams used to describe the workflow of SIPRAKFIS are Use Case Diagrams and Class Diagrams.

- Use Case Diagram

A use case diagram describes users interacting with the system to complete tasks. The users include lecturers, laboratory technicians, laboratory assistants, and students (Ridho et al., 2021).

The following is a use case diagram that describes the requirements and functionality of the system from the user's perspective.

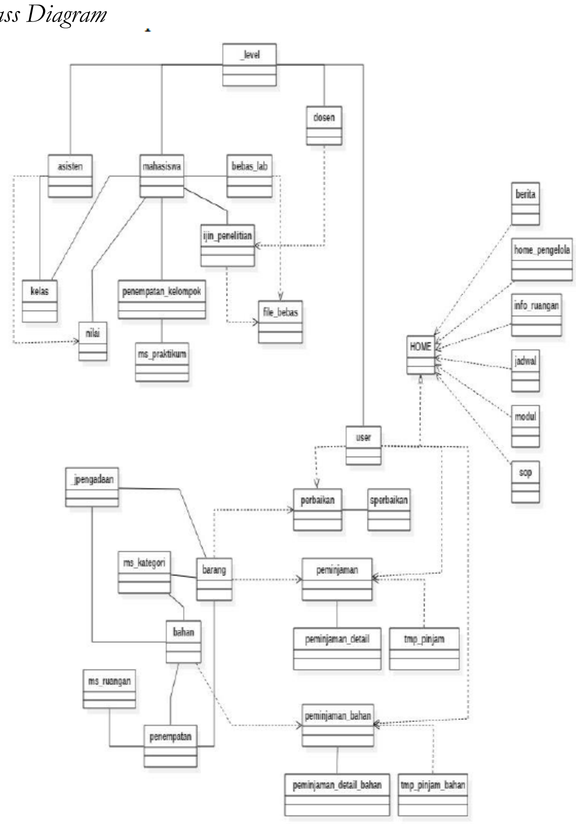
Figure 2
Use Case Diagram of Practicum Services



- Class Diagram

Class diagrams are used to help visualize the structure of the classes of a system and the relationship between classes, as well as a detailed description of each class (Ridho et al., 2021).

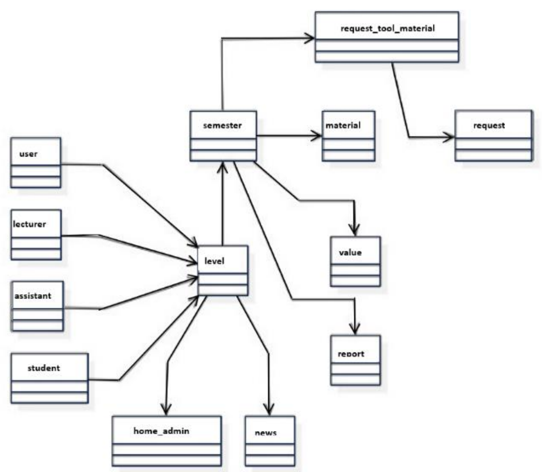
Figure 3
Class Diagram



2) Database Design

The database design stage includes identifying the database requirements needed in developing SIPRAKFIS.

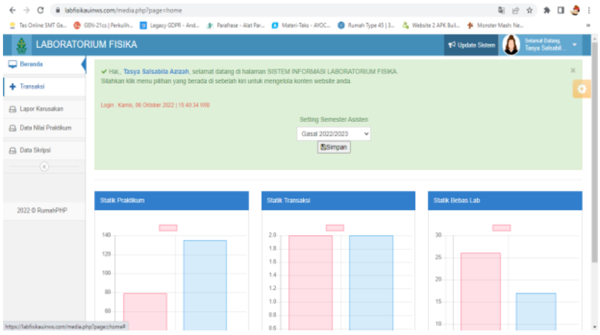
Figure 4
Database Design



3) User Interface Design

User interface design provides an overview of making the system (Nistrina & Sahidah, 2022). The user interface design comprises an admin page, lecturer user page, assistant user page, and student user page.

Figure 5
User Interface of the Assistant Page

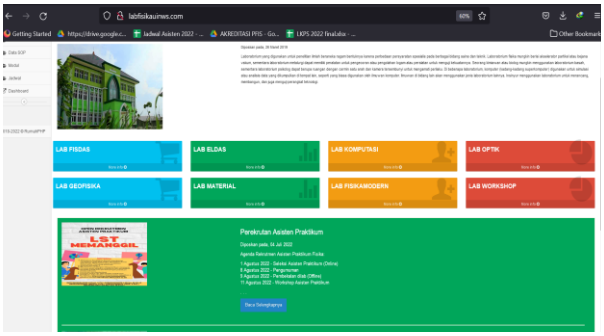


The implementation uses a web-based system with PHP coding and a MySQL database (Adiatama, 2012). The system design that has been made can be accessed online on the page http://www.labfisikauin.com/. Implementation of several forms, including the following:

1) Main Page

Users can use this main page without going through the login page. The main page contains the following Figure 6.

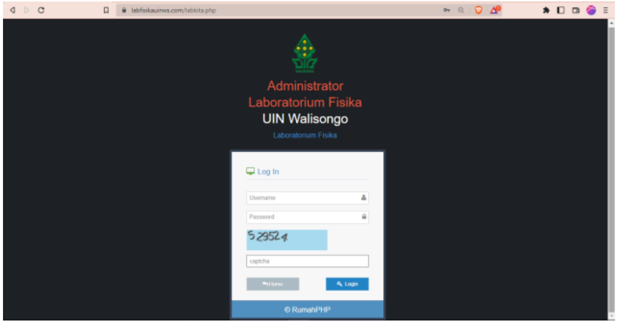
Figure 6
Display of Laboratory Information



2) Login Page

The login page is used to enter the system. To join the system, users must correctly enter their username and password, as shown in Figure 7.

Figure 7
Implementation of The Login Page



3) Lecturer Page

The lecturer page can be used after logging in as a lecturer, as shown in Figure 8, and the practicum equipment loan page implementation can be seen in Figure 9.

Figure 8
Implementation of the Lecturer Page

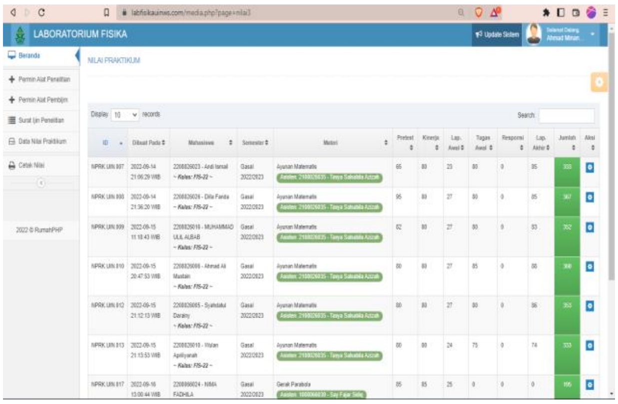
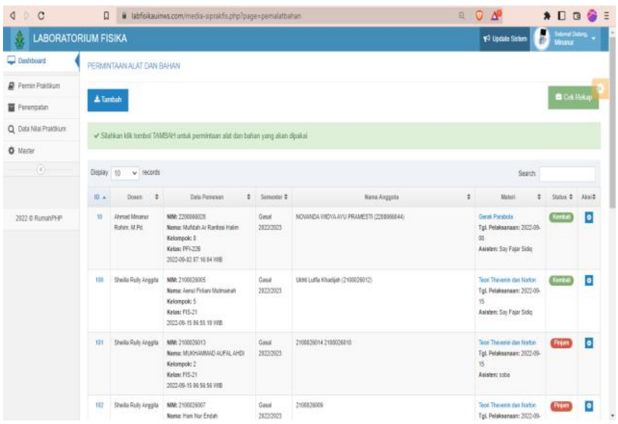


Figure 9
Implementation of The Practicum Equipment Loan Page



System Unit Testing Results

Unit testing is done using black box testing. Unit testing is done on the system login unit without looking into the source code. Testing on the login system in this study checks the login success function using the username and password of all users. The test results from 4 experts in web development and programming on the system login showed promising results, as evidenced by the successful test response according to the expected function. The results of system unit testing on the login unit can be seen in Table 3.

Table 3
Results of System Unit Testing on the Login Unit

No	Test Scenario	Test Case	Expected	Test Result	
				Success	Failed
1	Username and Password are not filled in, then click the login button	Username: (blank) Password: (blank)	The system will deny the user access and display the message "Please fill out this field."	√	
2	Fill in the username, leave the password blank, and click the login button.	Username: (fill in) Password: (blank)	The system will deny the user access and display the message "Please fill out this field."	√	
3	Username is not filled in and Password is filled in then click the login button.	Username: (blank) Password: (fill in)	The system will deny the user access and display the message "Please fill out this field."	√	
4	Username and Password are filled with the wrong username and correct password then click the login button.	Username: (wrong) Password: (correct)	The system will deny the user access and display the message "Sorry, your login failed. The username and password you entered do not match."	√	
5	Username and Password are filled with the correct username and incorrect password, then click the login button.	Username: (correct) Password: (wrong)	The system will deny the user access and display the message "Sorry, your login failed. The username and password you entered do not match."	√	
6	Username and Password are filled in with the correct username and password then click the login button	Username: (correct) Password: (correct)	The system displays the system's main page	√	
7	Username and Password are filled with the wrong username and password then click the login button.	Username: (wrong) Password: (wrong)	The system will deny the user access and display the message "Sorry, your login failed. The username and password you entered do not match."	√	

System Functional Testing Results

Functional testing was conducted by four experts in web development and programming. This functional testing used a checklist questionnaire on the test case containing 43 system function data described according to the requirements analysis. The functional testing result is shown in Table 4.

Table 4.
Functional Testing Results

Validator	Success	Failed	Total Functions
Validator 1	43	0	43
Validator 2	43	0	43
Validator 3	43	0	43
Validator 4	43	0	43
Average	43	0	43

The functional testing results obtained the system's functional level using the ISO/IEC TR 9126-2(2002) data analysis formula of 1. So it can be said that the functional value equals 1, meaning that the information created shows good functional value.

System Usability Test Results

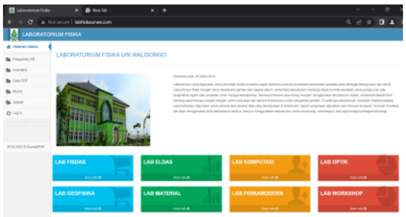
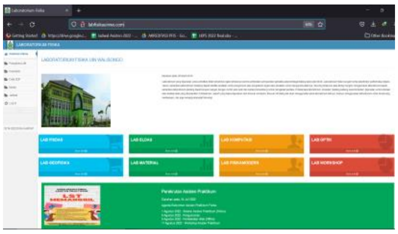
The usability testing using the SUS (Software Usability Scale) questionnaire was given to 36 respondents, including lecturers in charge of the practicum, practicum assistants, and practicum students. The results of the usability test obtained a percentage value of 82.59%, so it can be said that the usability test has a good/high value.

System Deployment Test Results

Deployment testing was carried out by running the system on various different and commonly used browsers. The test results showed no errors in the program's display or functionality, with a page load response time of no more than 2.4 seconds and a server response time of no more than 0.7 seconds. The deployment test results can be seen in Table 5.

Table 5

Deployment Test Results

Browser	Appearance	Error	Page Load Time	Server Response
Google Chrome		No errors were found in the system's appearance or functionality.	2.1 second	0.6 second
Internet Explorer		No errors were found in the system's appearance or functionality.	2.4 second	0.7 second
Mozilla Firefox		No errors were found in the system's appearance or functionality.	2.4 second	0.6 second

For SIPRAKFIS to continue to develop and adapt in the future, several steps have been taken in designing the system, including the system is built with a modular architecture so that the addition of new features or updates to certain parts can be done without disrupting the entire system, the system is equipped with caching technology and database query optimization to deal with the growth in the number of users, the system will continue to be tested on the latest versions of popular browsers and devices. Regular updates are made to address cross-browser compatibility issues, and the system currently runs on scalable cloud-based hosting.

This study has several limitations in the application of the results of SIPRAKFIS, including: (1) The development of SIPRAKFIS is focused on meeting the needs of the physics laboratory at UIN Walisongo Semarang, so there may be features that are specific to this environment. This system requires further adjustment for use in laboratories with different characteristics. (2) Functional and usability testing was carried out primarily in a local environment with limited users. This may limit the external validity of the research results, especially in a larger-scale context or at different institutions. (3) Compatibility testing was done on several commonly used devices and browsers. Still, it did not cover the various variations of devices or operating systems that users might use outside the context of this study. This may affect system performance when implemented on more varied devices. (4) SIPRAKFIS has been designed to handle up to 200 users simultaneously. Still, this study has not fully explored how the system will perform in scenarios of much larger usage or heavier loads over the long term. (5) System testing was conducted over a relatively short period, so the potential impacts of long-term use, such as performance degradation or problems with large data storage, have not been thoroughly studied. (6) This study did not specifically consider accessibility aspects for users with special needs, such as those with disabilities. These limitations indicate that although SIPRAKFIS has proven effective in the context of the physics laboratory at UIN Walisongo, more studies and adjustments are needed to ensure that its implementation can run well in other environments or on a larger scale. Further research is recommended to expand the scope of testing in terms of the number of users, duration, and variety of devices used, as well as to pay attention to accessibility aspects so that the system can be used more inclusively.

Conclusions

Based on the results of the research and discussion that has been conducted regarding the development of SIPRAKFIS, the following conclusions can be drawn: (1) The development of SIPRAKFIS (physics laboratory practicum management system) uses a waterfall development model consisting of communication, planning, modeling, construction and deployment stages. The programming language used is PHP, MySQL's central database, and the Xampp web server can be accessed online via www.labfisikauin.com. (2) Analysis of the quality of SIPRAKFIS development shows good results in unit, functional, usability, and system testing. In unit testing, which is represented by login testing, all test cases in the login system are declared successful. Functional testing obtained good results, namely a functional value of 1. Usability testing obtained a value of 82.59%. Deployment testing shows that the system can be run on various browsers, namely Mozilla Firefox, Google Chrome, and Internet Explorer, without finding errors in either the display or functionality. Future system development is the development of more detailed research services up to the publication of sample test results, using more diverse system testing techniques and developing methods so that system quality is more emphasized; the system can be accessed via an Android cellphone without desktop mode, the system is equipped with laboratory practicum videos so that students can use it.

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