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Article

Development of SIKAP LAB: A Web-Based Laboratory Equipment Categorization and Monitoring System at the Integrated Mini-Hospital Laboratory of Poltekkes Kemenkes Banjarmasin

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Abstract: Effective management of laboratory equipment is essential to support practical education and maintain reliable equipment information. This study aimed to develop SIKAP LAB, a web-based laboratory equipment categorization and monitoring system, as a functional prototype for the Integrated Mini-Hospital Laboratory of Poltekkes Kemenkes Banjarmasin. The study employed a Research and Development approach using the Analysis, Design, and Development phases of the ADDIE model. System requirements were identified through direct observation, interviews with four laboratory personnel, and documentation review. The prototype was developed using Google Apps Script and Google Sheets, with HTML, CSS, JavaScript, and Tailwind CSS for the interface. The system integrated equipment inventory, automatic categorization, condition monitoring, calibration monitoring, dashboard visualization, data filtering, data synchronization, and Microsoft Excel report export. Functional testing used nine predefined scenarios derived from the specified functional requirements. A scenario was considered passed when the intended function was successfully executed according to the corresponding requirement. All nine scenarios passed, with a functional success rate of 100% (9/9). The findings demonstrate that the SIKAP LAB prototype successfully implemented the specified functions within the scope of functional testing. Usability, user satisfaction, system acceptance, operational efficiency, effectiveness, and long-term impact were not evaluated.

Keywords: digitalization; educational laboratory; laboratory equipment; laboratory management; laboratory information system; SIKAP LAB.

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1. Introduction

Educational laboratories are strategic academic facilities that support the implementation of the Tri Dharma of Higher Education, namely education, research, and community service. In higher education institutions, laboratories provide students with opportunities to develop practical competencies through hands-on learning activities, particularly in health education programs where clinical and laboratory skills are essential. Therefore, effective laboratory management is indispensable for ensuring the quality of practical education and supporting the achievement of learning outcomes [1],[2].

Laboratory equipment constitutes one of the most important resources in educational laboratories because it directly supports teaching, research, and community service activities. The functional position and responsibilities of Educational Laboratory Personnel in Indonesia have been regulated through the Regulation of the Minister of Administrative and Bureaucratic Reform of the Republic of Indonesia Number 7 of 2019 [3], with an earlier regulatory framework established through Regulation Number 03 of 2010 [4]. Laboratory equipment management includes inventory management, operation, maintenance, calibration, evaluation, and reporting activities. Proper management of

laboratory equipment is essential to ensure equipment availability, operational safety, reliability, and sustainability and to support effective laboratory operations [2,5,6].

The Integrated Mini-Hospital Laboratory of Poltekkes Kemenkes Banjarmasin is an educational laboratory designed to simulate a hospital environment for healthcare students. The laboratory supports practical learning, research, and community service activities using various types of laboratory equipment with different operational characteristics, maintenance requirements, and risk levels. Consequently, an effective laboratory equipment management system is required to provide accurate, integrated, and up-to-date information that supports laboratory administration and decision-making.

Preliminary observations and interviews conducted during the needs analysis stage revealed that laboratory equipment management at the Integrated Mini-Hospital Laboratory is still performed manually using logbooks and conventional recording methods. Equipment inventory, condition monitoring, and calibration schedules are documented separately, resulting in difficulties in retrieving equipment information, delays in reporting, limited monitoring of calibration schedules, and an increased risk of recording errors. Furthermore, laboratory equipment data have not been integrated into a centralized information system, making systematic equipment monitoring and evaluation more difficult. These findings indicate that the existing laboratory management practices are insufficient to support efficient laboratory administration, highlighting the need for an integrated digital laboratory management system.

Several previous studies have demonstrated the potential of digital technologies to support laboratory equipment management. Wardani et al. [7] described laboratory inventory information systems for supporting laboratory administration, Ashari and Burhan [8] developed a QR Code-based system for equipment identification and monitoring, and Hanifah et al. [9] developed a web-based application for laboratory equipment and material inventory. Suwindra et al. [10] developed a web-based laboratory equipment inventory information system to facilitate the management and retrieval of information regarding laboratory equipment, including its location and condition. Other studies have also developed laboratory information systems for equipment recording and inventory management [11–13]. However, these systems generally address specific administrative or monitoring functions rather than integrating equipment inventory, equipment categorization, condition monitoring, calibration monitoring, dashboard visualization, data synchronization, and reporting within a single platform.

A previous study conducted by Jannah and Apriansyah [5] at the Department of Nursing, Poltekkes Kemenkes Banjarmasin, found that equipment procurement was relatively well organized, whereas inventory administration, equipment evaluation, and reporting were still conducted manually. The study identified limitations in administrative efficiency, data accuracy, and information retrieval and recommended the development of an integrated laboratory information system [5]. However, the study did not address the development of an integrated system that combines equipment categorization, condition monitoring, calibration monitoring, dashboard visualization, and reporting within a single platform.

The novelty of SIKAP LAB lies in the integration of complementary laboratory equipment management functions within a single web-based platform. Rather than focusing primarily on equipment inventory, identification, or calibration as separate functions, SIKAP LAB integrates equipment inventory management with equipment categorization based on Educational Laboratory Technologist standards, equipment condition monitoring, calibration monitoring, dashboard visualization, data filtering, data synchronization, and report generation. In particular, the categorization function enables laboratory equipment to be classified into Category I, Category II, and Category III based on criteria related to operational complexity, maintenance requirements, operational risk, and measurement accuracy [15]. The resulting equipment category is linked to equipment condition and calibration information, allowing these management components to be viewed together within the system. This integration is specifically designed for the

management needs of the Integrated Mini-Hospital Laboratory, where information on equipment identity, category, condition, location, and calibration status needs to be managed as interconnected components of laboratory equipment management.

Thus, the research gap addressed in this study is the limited integration of laboratory equipment management functions in existing digital systems, particularly the integration of inventory, equipment categorization, condition monitoring, calibration monitoring, visualization, and reporting within a single platform. SIKAP LAB was developed to address this gap by providing an integrated digital framework for laboratory equipment management in an educational mini-hospital laboratory.

Based on this gap, this study aimed to develop and functionally verify the Web-Based Laboratory Equipment Categorization and Monitoring System (SIKAP LAB) for the Integrated Mini-Hospital Laboratory of Poltekkes Kemenkes Banjarmasin. The system was developed using a Research and Development (R&D) approach with the Analysis, Design, and Development phases of the ADDIE model. The study focused on developing an integrated digital platform for equipment inventory, categorization, condition monitoring, calibration monitoring, dashboard visualization, data filtering, data synchronization, and reporting.

2. Materials and Methods

This study employed a Research and Development (R&D) approach using the ADDIE instructional design model, which consists of five sequential phases: Analysis, Design, Development, Implementation, and Evaluation [16]. The present study focused on the first three phases Analysis, Design, and Development because the primary objective was to develop a functional prototype of a web-based laboratory equipment management system. The Implementation and Evaluation phases are planned for future studies.

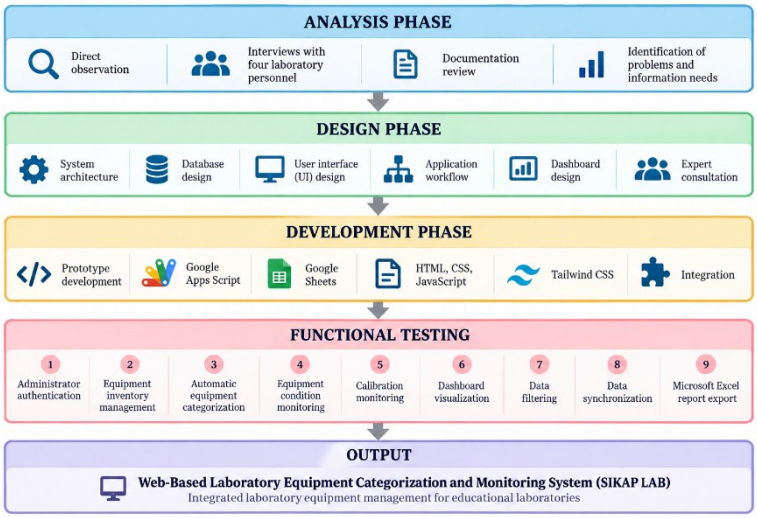


Figure 1. Research workflow of the SIKAP LAB development using the ADDIE model.

The study was conducted at the Integrated Mini-Hospital Laboratory, Poltekkes Kemenkes Banjarmasin, Indonesia. Data were collected through direct observation, interviews with four laboratory personnel involved in laboratory equipment management, and documentation review. The interview informants consisted of two Educational Laboratory Technologists (PLP) at the First Expert Level, one PLP at the Skilled Level, and one Operational Services Officer serving as the Laboratory Manager and person in charge of State-Owned Assets (BMN) at the Department of Nursing. The informants were involved in activities related to laboratory equipment inventory, equipment condition monitoring, calibration administration, and reporting.

The observation and interview findings were reviewed to identify existing laboratory equipment management practices, problems, workflows, and information needs. The

findings were then grouped according to the main laboratory management activities, including equipment inventory, categorization, equipment condition, calibration, data storage, and reporting. Each identified problem was subsequently translated into a corresponding system requirement. For example, the separate recording of equipment information was translated into an integrated inventory management requirement, while the separate recording of calibration schedules was translated into a calibration monitoring requirement. The resulting problem–requirement mapping was used as the basis for defining the functional requirements and system specifications of SIKAP LAB, as presented in Table 1.

During the Design phase, the system architecture, database structure, application workflow, and user interface were designed according to the identified requirements. The system design was further refined through consultation with information technology experts to evaluate navigation, application workflow, database organization, and dashboard visualization before the development process.

The prototype was used to evaluate the application workflow and interface structure before further development. Following successful prototype testing, the system was further developed into a cloud-based web application using Google Apps Script and Google Sheets as the backend platform. The user interface was developed using HTML, CSS, JavaScript, and Tailwind CSS, enabling centralized data storage, online accessibility, and integrated laboratory equipment management.

The developed application consists of several functional modules, including administrator authentication, laboratory equipment inventory management, laboratory equipment categorization, equipment condition monitoring, calibration monitoring, dashboard visualization, data filtering, and Microsoft Excel report export. Laboratory equipment categorization was designed according to the Educational Laboratory Technologist standards established by the Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 145 of 2014, which classifies laboratory equipment based on operational complexity, maintenance requirements, operational risk, and measurement accuracy [15]. Based on these criteria, laboratory equipment was automatically classified into Category I, Category II, or Category III.

Functional testing was conducted after the system had been deployed using Google Apps Script Web App. The testing process evaluated administrator authentication, inventory management, automatic equipment categorization, equipment condition monitoring, calibration monitoring, dashboard functionality, data filtering, data synchronization, and report generation to ensure that all application functions operated according to the specified functional requirements. For calibration monitoring, the prototype estimated the calibration due date using a one-year interval from the last calibration date and assigned the corresponding status based on the remaining period.

3. Results and Discussion

3.1. Analysis Phase

The analysis phase was conducted to identify existing laboratory equipment management practices and determine the functional requirements of the SIKAP LAB system. Data were obtained through direct observation, interviews with four laboratory personnel, and documentation review at the Integrated Mini-Hospital Laboratory of Poltekkes Kemenkes Banjarmasin.

The analysis showed that laboratory equipment management was predominantly conducted using manual recording methods. Equipment inventory, equipment condition, maintenance history, and calibration schedules were documented separately using logbooks and spreadsheet files. This condition made equipment information retrieval more difficult and limited systematic monitoring of equipment conditions and calibration schedules. The absence of an integrated database also increased the possibility of data

inconsistencies and delayed administrative reporting. The identified problems and corresponding system requirements are presented in Table 1.

Table 1. Problems identified during the analysis phase and corresponding system requirements

Existing Condition	Identified Problem	System Requirement
Equipment data recorded manually	Equipment information was difficult to retrieve and update	Integrated equipment inventory
Equipment categories were not integrated into the inventory system	Equipment classification was less systematic	Automatic equipment categorization
Equipment conditions recorded separately	Monitoring equipment condition was inefficient	Equipment condition monitoring
Calibration schedules recorded separately	Calibration monitoring was limited	Calibration monitoring
Laboratory information was stored in separate records	Data were not centralized	Centralized database
Reports were prepared manually	Reporting required additional administrative work	Automated report generation
Laboratory information was not presented centrally	Management had limited overview of laboratory conditions	Dashboard visualization

Note: Data were obtained from observations, interviews, and documentation review at the Integrated Mini-Hospital Laboratory of Poltekkes Kemenkes Banjarmasin.

Based on these identified requirements, the researchers developed a web-based digital system for laboratory equipment management called the Laboratory Equipment Categorization and Monitoring System (SIKAP LAB). The system was designed as a digital solution to support laboratory administration and equipment management. The main functional requirements incorporated into the system included equipment inventory management, equipment categorization, condition monitoring, calibration monitoring, dashboard visualization, and report generation. The identified requirements were consistent with previous findings that laboratory inventory and administrative activities can benefit from integrated information systems [5,7,11].

The analysis findings therefore established the functional foundation for the subsequent design and development phases. In particular, the integration of inventory, categorization, condition monitoring, calibration monitoring, and reporting was considered necessary to overcome the fragmented nature of the existing manual management process.

3.2 Design Phase

The design phase translated the functional requirements identified during the analysis phase into the system architecture, database structure, application workflow, and user interface of SIKAP LAB. The design emphasized centralized data management and accessibility through a web-based platform.

The system architecture consisted of four major components: (1) administrator user interface, (2) Google Apps Script application layer, (3) Google Sheets database, and (4) report generation module. The user interface functions as the primary interaction layer for laboratory personnel, while Google Apps Script processes application functions and data transactions. Google Sheets was used as the centralized database for laboratory equipment information, while the reporting module supports data export for administrative purposes.

The database structure was designed to accommodate the information required for laboratory equipment management, including equipment identification, laboratory location, equipment category, equipment condition, calibration status, maintenance information, and supporting documentation. This centralized structure was intended to reduce fragmented data storage and facilitate information retrieval.

The user interface was designed based on the functional requirements identified during the analysis phase. The main interface components included the administrator login page, dashboard, equipment inventory page, equipment categorization page,

calibration monitoring page, and reporting page. The interface emphasized simple navigation and accessibility to support laboratory personnel in managing equipment information.

The design process also involved consultation with information technology experts to review the application workflow, navigation, database organization, and dashboard visualization. The feedback was used to refine the system design before development. This user-oriented design approach is consistent with previous laboratory information system development studies that emphasize alignment between system functionality and user requirements [12,13].

The design phase resulted in a system architecture that integrated laboratory inventory data with monitoring and reporting functions rather than treating inventory as an isolated administrative component. This approach provided the structural basis for developing SIKAP LAB as an integrated laboratory management platform.

3.3 Development Phase

Based on the approved design, SIKAP LAB was developed as a cloud-based web application using Google Apps Script as the application platform and Google Sheets as the backend data storage platform. The user interface was developed using HTML, CSS, JavaScript, and Tailwind CSS.

The development process initially involved the construction of a simple prototype using HTML and local storage. The prototype was used to evaluate the application workflow, interface structure, inventory process, equipment categorization, and calibration monitoring before integration with an online database. After the initial prototype was considered functional, the system was further developed using Google Apps Script and Google Sheets to support centralized and online data management.

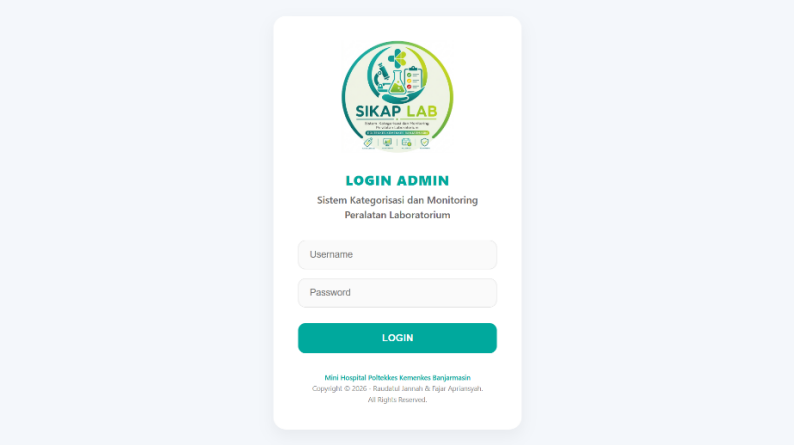
The use of Google Apps Script provided a relatively lightweight approach for developing a web-based laboratory information system without requiring dedicated server infrastructure. Previous studies have demonstrated the feasibility of Google Apps Script for developing laboratory information systems and supporting administrative efficiency [17,18]. Therefore, the technology selection was appropriate for the development context of an educational laboratory requiring accessible and relatively simple digital infrastructure.

The developed SIKAP LAB integrated eight major user-facing modules, supported by a data synchronization function between the web application and the Google Sheets database:

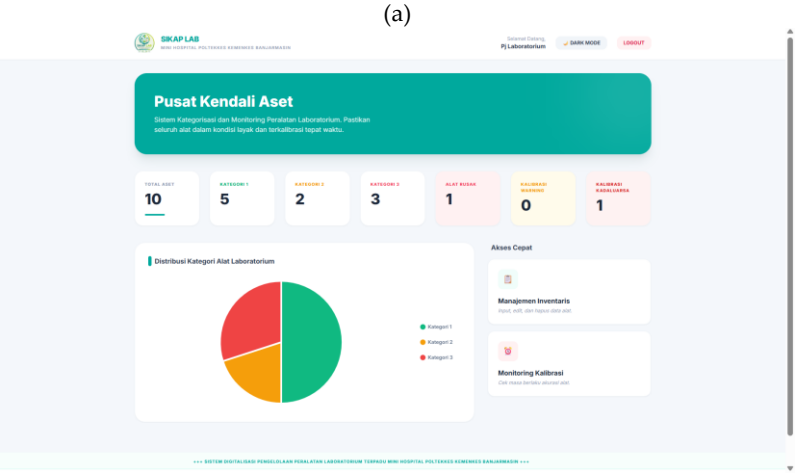
1. Administrator authentication;
2. Laboratory equipment inventory management;
3. Automatic equipment categorization;
4. Equipment condition monitoring;
5. Calibration monitoring;
6. Dashboard visualization;
7. Data filtering; and
8. Microsoft Excel report export.

The system also supports data synchronization between the web application and the Google Sheets database to maintain consistency between user input and stored laboratory equipment data. This synchronization enables equipment information entered or updated through the web interface to be stored in the centralized database and subsequently used for dashboard visualization, monitoring, and report generation.

The resulting interfaces and major system functions are presented in Figures 2–5.



(a)



(b)

Figure 2. Administrator authentication and dashboard interfaces of the SIKAP LAB system. (a) Administrator login page; (b) laboratory equipment management dashboard.

Figure 2 presents the main access and monitoring interfaces of SIKAP LAB. The administrator login interface provides controlled access to the system, while the dashboard provides a centralized overview of laboratory equipment information. The dashboard displays the total number of equipment items, equipment distribution by category, damaged equipment, and calibration-related information. This centralized presentation enables laboratory personnel to obtain an overview of laboratory asset conditions without reviewing separate records.

The equipment categorization module represents one of the main functional characteristics of SIKAP LAB. Equipment was categorized according to criteria related to operational complexity, maintenance requirements, operational risk, and measurement accuracy. The system classified equipment into Category I, Category II, and Category III. This categorization was based on the Educational Laboratory Technologist standards established in the relevant regulation [15].

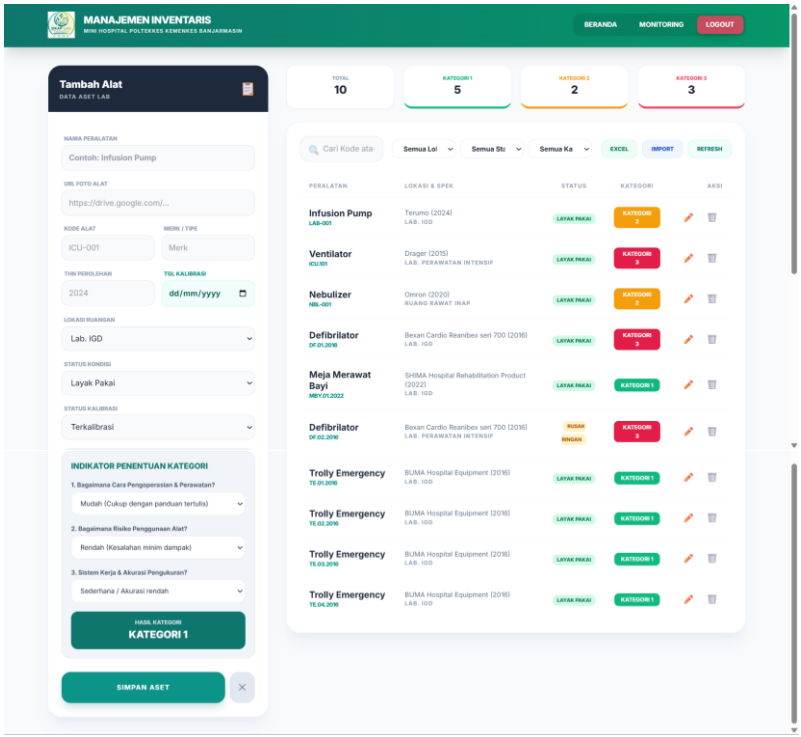


Figure 3. Laboratory equipment inventory management and categorization interfaces of the SIKAP LAB system.

Figure 3 illustrates the integration of equipment inventory management and categorization within SIKAP LAB. The inventory interface allows laboratory personnel to record and manage equipment information, including equipment name, equipment code, manufacturer, acquisition year, laboratory location, equipment condition, and calibration status. The categorization interface provides assessment indicators related to equipment operation and maintenance, usage risk, and system complexity and measurement accuracy. The selected indicators are processed to determine the corresponding equipment category, which is displayed directly within the system.

The integration of categorization with inventory management distinguishes SIKAP LAB from systems that primarily focus on equipment recording or identification. Previous studies have developed laboratory inventory and management information systems [9–13], while Wijaya et al. [14] explored the adoption of SNI ISO/IEC 17025:2017 principles in the development of a laboratory management information system. QR Code-based equipment monitoring has also been developed to support equipment identification and monitoring [8], while Kuswandari et al. [19] demonstrated the integration of inventory management with online calibration monitoring. SIKAP LAB extends these approaches by combining equipment inventory, categorization, condition monitoring, calibration monitoring, dashboard visualization, and reporting in a single platform.

The dashboard was developed to provide a centralized overview of laboratory equipment information. It displays the total number of equipment items, equipment distribution by category, damaged equipment, and calibration-related information. The dashboard also provides graphical visualization of equipment categories to facilitate rapid interpretation of laboratory conditions.

The calibration monitoring module displays the last calibration date, estimated calibration due date, and calibration status. The system uses three monitoring statuses, namely SAFE, WARNING, and CRITICAL, together with the remaining period before calibration expiry. This feature provides a more structured approach to calibration monitoring compared with separate manual records.

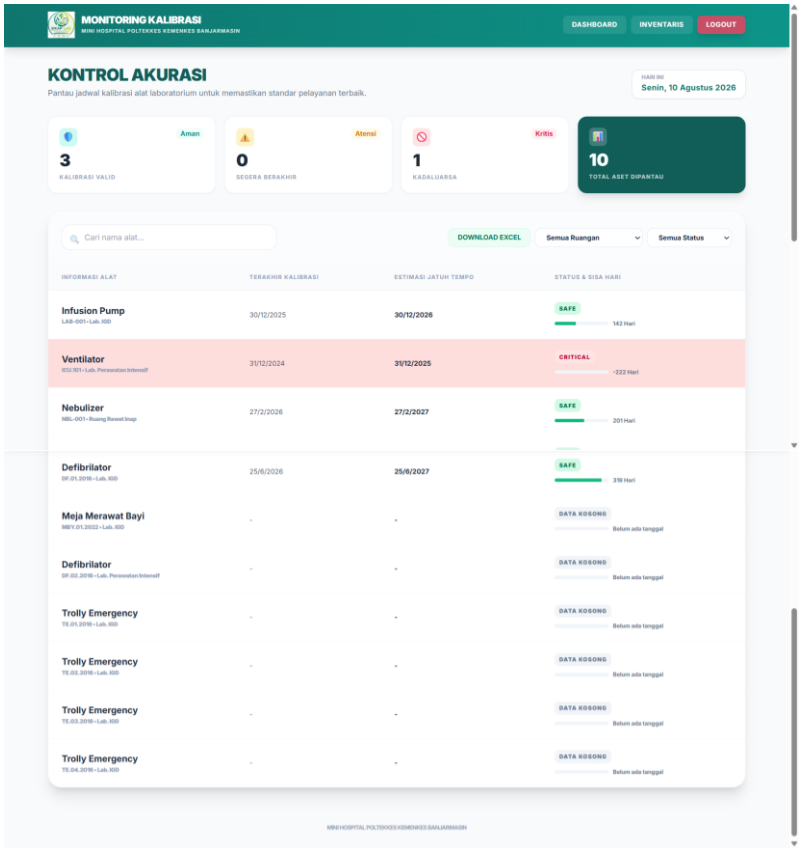
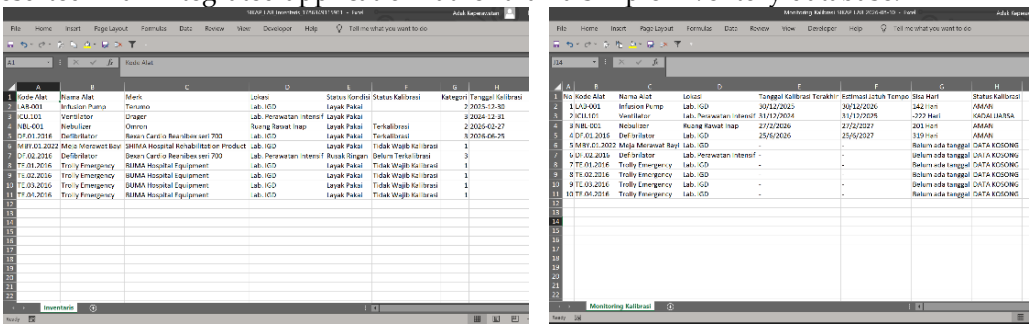


Figure 4. Calibration monitoring interfaces of the SIKAP LAB system.

Figure 4 shows the calibration monitoring function developed in SIKAP LAB. The system automatically presents the latest calibration date, estimated calibration due date, and the remaining period before calibration expiry. Equipment with valid calibration is displayed with a SAFE status, while equipment requiring attention can be identified through warning or critical status indicators. The system also identifies equipment for which calibration data have not yet been entered. This feature allows laboratory personnel to prioritize follow-up actions based on the current calibration status of each equipment item.

The inventory module supports equipment data entry, editing, deletion, automatic categorization, condition monitoring, calibration status monitoring, filtering by location/status/category, and export to Microsoft Excel. The development therefore resulted in an integrated application rather than a simple inventory database.



(a) (b)

Figure 5. Examples of Microsoft Excel reports generated by the SIKAP LAB system. (a) Laboratory equipment inventory report; (b) calibration monitoring report.

Figure 5 demonstrates the report export functionality of SIKAP LAB. The system generated structured Microsoft Excel reports containing laboratory equipment identification, equipment name, manufacturer, location, equipment condition, calibration status, and category information. A separate calibration monitoring report provides the

latest calibration date, estimated calibration due date, remaining calibration period, and calibration status. These outputs demonstrate that the reporting module can transform centralized laboratory equipment data into structured administrative reports for further documentation, data processing, and reporting.

3.4 Functional Testing

The final functional testing was conducted to verify whether the main functions of the SIKAP LAB prototype operated according to the specified functional requirements. The testing covered nine functional scenarios: administrator authentication, equipment inventory management, automatic equipment categorization, equipment condition monitoring, calibration monitoring, dashboard visualization, data filtering, data synchronization, and Microsoft Excel report export.

Table 2. Results of Final Functional Testing of SIKAP LAB

No.	Functional scenario	Test result / evidence	Status
1	Administrator authentication	Using the provided username and password, the administrator could access the system through the controlled login interface.	**Passed**
2	Equipment inventory management	Equipment data could be displayed and managed through the inventory module, including add, save, edit, delete, search, filter, import, refresh, and Excel functions.	**Passed**
3	Automatic equipment categorization	The system generated equipment categories based on predefined indicators and displayed Categories 1–3. The dashboard displayed Category 1 = 5, Category 2 = 2, and Category 3 = 3.	**Passed**
4	Equipment condition monitoring	Equipment condition status could be monitored through the inventory module and dashboard summary.	**Passed**
5	Calibration monitoring	The system displayed the last calibration date, estimated due date, remaining days, and calibration status. The monitoring module displayed 10 monitored assets, comprising 3 assets with SAFE status, 0 with WARNING status, 1 with CRITICAL status, and 6 assets without calibration data.	**Passed**
6	Dashboard visualization	The dashboard presented aggregate information on inventory, equipment categories, condition, and calibration status.	**Passed**
7	Data filtering	Equipment data could be searched and filtered based on available information, including location, status, and category.	**Passed**
8	Data synchronization	Data stored in Google Spreadsheet were displayed consistently in the inventory, monitoring, and dashboard modules.	**Passed**
9	Microsoft Excel report export	Inventory and calibration-monitoring data could be exported to Microsoft Excel.	**Passed**

Note: Overall, 9 scenarios were tested; 9 passed; 0 failed; functional success rate = 100% (9/9).

The final testing demonstrated that all nine functional scenarios were successfully executed. The results confirmed the operational availability of the main SIKAP LAB functions, including equipment inventory management, automatic categorization, condition monitoring, calibration monitoring, dashboard visualization, data filtering, data synchronization, and Microsoft Excel report export.

These findings indicate that the developed prototype fulfilled the functional requirements established during the analysis phase and provided an integrated digital environment for managing equipment inventory, categorization, condition, calibration, and reporting. The 100% success rate therefore reflects the successful execution of the tested functional scenarios within the scope of the prototype.

The functional testing should be interpreted as functional verification within the scope of the tested prototype functions, rather than as an evaluation of usability, user satisfaction, system acceptance, efficiency, or effectiveness. Therefore, the 100% functional success rate does not establish improvements in operational efficiency or effectiveness. Further assessment involving users, usability, acceptance, and longer-term implementation is required to evaluate these outcomes. The final expert review also identified further development needs, particularly regarding role-based access control,

data validation and duplication prevention, data backup, technical documentation, calibration-status rule maintenance, and system scalability.

3.5. Discussion

The development of SIKAP LAB demonstrates the feasibility of integrating several laboratory equipment management functions into a single web-based platform. The analysis phase identified fragmented management practices involving equipment inventory, equipment condition, calibration, and reporting. These findings were translated into system requirements and subsequently implemented through the SIKAP LAB prototype. The final functional testing confirmed that the main functions could be executed according to the specified requirements.

The findings are consistent with previous studies that have applied information systems to laboratory equipment management. Wardani et al. [7] described a laboratory inventory information system, Hanifah et al. [9] developed a web-based application for laboratory equipment and material inventory, and Mahdalena et al. [11] developed a laboratory equipment recording system. Ashari and Burhan [8] developed a QR Code-based system for equipment identification and monitoring, while Kuswandari et al. [19] incorporated online calibration monitoring into a laboratory equipment inventory system. Fauzi et al. [20] developed SIONLAP as a digital information system for educational laboratory management, including equipment inventory and the digitalization of laboratory management workflows. These studies demonstrate that digital systems can support various laboratory management activities.

Compared with these previous approaches, the contribution of SIKAP LAB lies primarily in the integration of complementary laboratory equipment management functions rather than in introducing a completely new individual function. While Fauzi et al. [20] developed a broader educational laboratory management information system that digitized laboratory procedures and equipment inventory, SIKAP LAB focuses specifically on integrating equipment inventory with equipment categorization, condition monitoring, calibration monitoring, dashboard visualization, data filtering, data synchronization, and reporting within a single platform. This integration connects equipment identity, category, condition, location, and calibration-related information within the same digital environment. Thus, the contribution of SIKAP LAB is its integrated equipment management structure, which extends beyond systems that primarily focus on general laboratory management, inventory recording, equipment identification, or individual monitoring functions.

The equipment categorization function provides an additional management dimension within the integrated system. Laboratory equipment is classified into Category I, Category II, and Category III according to predefined criteria related to operational complexity, maintenance requirements, operational risk, and measurement accuracy [15]. The categorization information is incorporated into the inventory interface and connected with other equipment information. The functional testing verified that the system generated and displayed the predefined equipment categories. However, this study did not conduct an independent statistical validation of the categorization model; therefore, the result should be interpreted as verification of the functional implementation of the predefined categorization rules rather than as evidence of classification accuracy beyond those rules.

Calibration monitoring represents another component of the integrated management approach. Previous research has demonstrated the incorporation of calibration monitoring into laboratory equipment inventory management [19]. SIKAP LAB extends this approach by connecting calibration information with equipment inventory, categorization, condition monitoring, dashboard visualization, filtering, synchronization, and reporting. The system applies a one-year calibration interval in the prototype and automatically assigns SAFE, WARNING, or CRITICAL status according to the remaining days before the estimated due date. The final functional testing verified that these

calibration-monitoring functions operated according to the predefined rules. However, these results demonstrate functional operation only and do not establish improved calibration compliance or maintenance performance.

The technical architecture using Google Apps Script and Google Sheets provided the infrastructure for centralized data storage and web-based access in the developed prototype. The final testing verified consistency between the Google Spreadsheet data source and the information displayed in the inventory, monitoring, and dashboard modules. The expert review, however, identified further technical development needs, particularly regarding role-based access control, data validation and duplication prevention, data backup, technical documentation, calibration-status rule maintenance, and system scalability. Therefore, the current architecture should be considered appropriate within the scope of the developed prototype, while further technical evaluation is required for broader and longer-term implementation.

From a laboratory management perspective, the integration of inventory, categorization, condition, calibration, dashboard, and reporting functions may facilitate the retrieval and review of equipment information within a single platform. The dashboard may also support rapid review of equipment status, while the reporting function may support structured administrative documentation. These statements represent potential operational benefits of the system and should not be interpreted as empirically demonstrated improvements. The present study did not measure information retrieval time, reporting time, data accuracy before and after implementation, user satisfaction, usability, or administrative efficiency.

The findings also respond to the previous study by Jannah and Apriansyah [5], which identified manual administration, equipment evaluation, and reporting as limitations in laboratory equipment management at the Department of Nursing, Poltekkes Kemenkes Banjarmasin. The present study addresses this identified need by developing an integrated digital platform for laboratory equipment management in the Integrated Mini-Hospital Laboratory. Thus, the contribution of SIKAP LAB is demonstrated primarily through system development, functional integration, and successful execution of the tested functions, rather than through measured improvements in laboratory management performance.

Overall, the final functional testing demonstrated that all nine tested scenarios were successfully executed, producing a functional success rate of 100% (9/9). This result establishes that the main SIKAP LAB functions were operational within the scope of the tested prototype. It does not, however, establish improvements in efficiency, effectiveness, usability, user satisfaction, system acceptance, or long-term laboratory management outcomes. Further studies involving actual users and longer-term implementation are required to evaluate these outcomes.

4. Conclusions

This study successfully developed the Web-Based Laboratory Equipment Categorization and Monitoring System (SIKAP LAB) using a Research and Development (R&D) approach with the Analysis, Design, and Development phases of the ADDIE model. The developed prototype integrates laboratory equipment inventory management, equipment categorization based on Educational Laboratory Technologist standards, equipment condition monitoring, calibration monitoring, dashboard visualization, data synchronization, and report generation within a single web-based platform.

Functional testing demonstrated that all nine tested functional scenarios were successfully executed, with nine scenarios passed and no failed scenarios, resulting in a functional success rate of 100% (9/9). The testing verified the operation of administrator authentication, equipment inventory management, automatic equipment categorization, equipment condition monitoring, calibration monitoring, dashboard visualization, data filtering, data synchronization, and Microsoft Excel report export. These findings

demonstrate that the developed prototype fulfilled the specified functional requirements within the scope of the tested functions.

The study demonstrates the feasibility of integrating multiple laboratory equipment management functions into a single digital platform for the Integrated Mini-Hospital Laboratory. However, the study did not evaluate usability, user satisfaction, system acceptance, operational efficiency, effectiveness, or long-term impact. Therefore, the 100% functional success rate should not be interpreted as evidence of improved laboratory management performance. Further studies are required to evaluate these outcomes through implementation with actual users and comparative assessment before and after system implementation.

5. Patents

Not applicable.

Supplementary Materials: Not applicable.

Author Contributions: Conceptualization, F.A. and R.J.; methodology, F.A.; software, F.A.; validation, F.A. and R.J.; formal analysis, F.A.; investigation, F.A.; data curation, F.A.; writing—original draft preparation, F.A.; writing—review and editing, F.A. and R.J.; visualization, F.A.; supervision, R.J. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The study was reviewed and granted Ethical Exemption by the Health Research Ethics Committee of Poltekkes Kemenkes Banjarmasin, Indonesia (Protocol No. 196/KEPK-PKB/2026), approved on 27 April 2026. The ethical exemption is valid from 27 April 2026 to 27 April 2027.

Informed Consent Statement: Participant consent was waived by the Health Research Ethics Committee because this study was granted Ethical Exemption and did not involve clinical interventions or the collection of sensitive personal data.

Data Availability Statement: The research data supporting the findings of this study are available from the corresponding author upon reasonable request. These data are not publicly available because they contain institutional laboratory management records and interview data. The developed application (SIKAP LAB) can be demonstrated or accessed for academic purposes upon reasonable request and with permission from Poltekkes Kemenkes Banjarmasin.

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