Design Of A Web-Based Information System Application For Laboratory Usage In The Air Navigation Engineering Department At Surabaya Aviation Polytechnic

Amelia Putri K[1] , Bambang Bagus H[1] , Bambang Driyono[1], Erdin Kamarudin[2]

[1] *Politeknik Penerbangan Surabaya*
[2] *AirNav Maintenance Facility*
Email: ameliapk29@gmail.com

ABSTRACT
This research resulted in a web-based laboratory management information system specifically designed for the Air Navigation Engineering Study Program at Politeknik Penerbangan Surabaya. The system was developed using the Laravel Filament framework, implementing the waterfall model approach, to address various issues found in the previous manual system. The manual system used before often caused schedule conflicts and delays in conveying information regarding the availability of laboratories. Through the design of this website, the author successfully created a platform that displays the laboratory status in real-time, allowing users to easily access up-to-date information. The laboratory booking feature developed is also equipped with a role-based access control system, enabling a more structured access distribution according to the roles of users, such as super admin, admin, monitor, and user. Furthermore, this system supports the tracking of laboratory usage history, helping in managing facility usage more efficiently. Usability testing indicates that users, including students, lecturers, and admins, found the website interface easy to use and highly informative. The website was also deemed secure based on security testing results, ensuring user data protection. These findings affirm that the developed information system not only provides a technical solution for managing the laboratory but also improves the effectiveness and efficiency of practical sessions in the Air Navigation Engineering Study Program at Politeknik Penerbangan Surabaya.

Keywords: Information System, Web-Based Laboratory, Real-Time, Role-Based Access Control.

1. INTRODUCTION

The management of laboratories in higher education institutions plays a crucial role in supporting practical learning processes, especially in engineering programs that require intensive use of laboratory facilities. However, many educational institutions still use manual laboratory management systems, which can hinder the efficiency and effectiveness of laboratory use. The main issues often arising from these manual systems include overlapping laboratory booking schedules, uncertainty regarding laboratory availability, and difficulty in tracking the history of laboratory equipment rentals. With the advancement of information technology, web-based solutions for laboratory management have become a more efficient option [1]. A web-based system allows laboratory management to be done in real-time, minimizing human errors, and improving transparency in the borrowing and returning of laboratory facilities. Previous research has also shown that web-based systems can improve administrative workflows in laboratories by providing role-based access control that aligns with the duties of users, such as lecturers, students, and laboratory staff. Furthermore, the implementation of web technology enables better integration between equipment borrowing data and laboratory schedules, providing faster and easier access to information for all laboratory users [2]. However, despite the numerous studies on web-based laboratory management, many laboratories in educational institutions still face difficulties in implementing such systems. Some of the challenges include insufficient technological infrastructure and resistance to change from established systems. Therefore, this study aims to design and develop a web-based information system to manage laboratory bookings efficiently, emphasizing the use of the latest technology to improve the performance and effectiveness of laboratory management at the Surabaya Aviation Polytechnic.

Laboratory management in education faces various challenges that affect its effectiveness and efficiency, especially in terms of scheduling the borrowing and use of laboratory facilities [3]. One of the main issues encountered is the lack of a system capable of managing laboratory schedules in real-time. This often leads to schedule overlaps, insufficient information about laboratory availability, and low efficiency in the use of laboratory resources. This problem becomes even more complex as the number of users increases and the availability of laboratory resources becomes more limited, necessitating the implementation of a more advanced and automated scheduling. Traditional scheduling systems, still widely used, are often inflexible and prone to human errors, such as schedule input mistakes or inaccuracies in planning the use of laboratory spaces. Inefficient scheduling can result in an imbalance in laboratory use and a reduction in the quality of the expected learning experience [4]. Therefore, this study aims to address these issues by designing and developing a web-based laboratory scheduling system that allows for more efficient laboratory management, with real-time features that can minimize schedule overlaps. Additionally, the integration of theory and practice in laboratory management remains a key challenge, where a good scheduling system can improve the use of laboratory spaces and support the smooth flow of the learning process. The use of appropriate scheduling algorithms based on information technology can provide a solution to optimize laboratory usage in the educational environment.

The aim of this research is to design and develop a web-based information system that can efficiently manage laboratory scheduling and borrowing at the Air Navigation Engineering Program, Surabaya Aviation Polytechnic. The primary focus of this study is to create a platform capable of providing real-time laboratory availability information, which will help improve the efficiency of laboratory space utilization and minimize schedule overlaps that often disrupt the smooth execution of practical courses [5]. The developed system is intended to replace the manual system currently in use, which has proven to have several weaknesses, such as inaccurate information delivery, scheduling conflicts, and difficulty in monitoring the status of laboratory usage. In the design of this website, the system will be equipped with features that allow users to check laboratory availability, make reservations, and manage laboratory resources using role-based access control (RBAC), providing structured access for users based on their roles, such as administrators, lecturers, and students. This system will be built using the Laravel Filament framework, which enables the development of an interactive and user-friendly interface [6]. Furthermore, the choice of Laravel as the backend framework is aimed at simplifying database management and supporting integration with existing systems, such as the laboratory borrowing system and equipment usage tracking. The goal of this website design is to ensure that the system is not only easy to use for the users but also secure, reliable, and performs optimally. The website will include features for displaying laboratory schedules, borrowing statuses, and the history of equipment usage, which will facilitate the management of laboratory facilities. The system will undergo testing to evaluate the website's performance, including functionality testing, ease of use, and reliability in displaying real-time information [7]. With this system in place, it is expected to enhance transparency in laboratory management, improve resource allocation, and support the smooth and effective execution of practical courses in the Air Navigation Engineering Program.

This research makes a significant contribution to the field of educational laboratory management, particularly in designing a web-based information system for laboratory booking in the Air Navigation Engineering Program. Practically, this research develops a website capable of providing real-time laboratory status information, thus facilitating the management of laboratory schedules and reducing the risk of schedule overlaps that frequently occurred in the previous manual system [8]. The system also introduces role-based access control (RBAC) for laboratory management, ensuring that only authorized users can access data or make reservations. This contribution helps improve operational efficiency, transparency in laboratory management, and minimizes administrative errors, providing a more structured and accessible solution to support practical courses at the Surabaya Aviation Polytechnic.

This research adopts the Waterfall development method to design and develop a web-based information system focused on managing laboratory booking and scheduling in the Air Navigation Engineering Program at the Surabaya Aviation Polytechnic. The Waterfall method was chosen because it offers a structured and clear development process, where each phase is carried out sequentially without significant changes during each stage. The first phase is the requirement analysis, where the researcher identifies the issues in the manual laboratory booking system and determines the features needed in the new system, such as a laboratory schedule display, real-time booking status, and role-based access control (RBAC). Next, during the system design phase, the researcher designs the system architecture and user interface using the Laravel framework, which supports efficient and responsive data management. In the implementation phase, the researcher performs system coding and creates the database using MySQL to store booking and laboratory schedule data. After the system is built, the testing phase is conducted to ensure that all system functionalities work as expected and that the user interface is easy to use for all types of users, from administrators to students. In the final phase, system maintenance is performed to fix any bugs found during

testing and update the system based on user feedback. The Waterfall approach allows for systematic development and ensures that each phase is well-controlled to produce an efficient and easily accessible website [9].

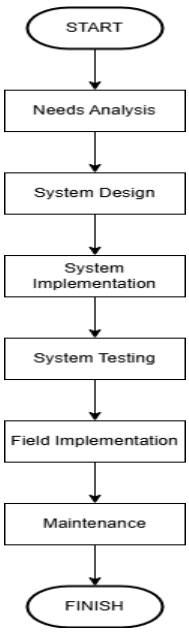

Figure 1 Waterfall Method Stages

This research employs the Waterfall software development method, which consists of six stages that are carried out sequentially. The first stage is requirements analysis, where the researcher identifies the issues occurring in laboratory management, such as schedule conflicts and inaccurate information. System requirements are gathered through interviews and observations with relevant stakeholders, such as lecturers, students, and laboratory managers. Based on this analysis, the next step is system design, as shown in Figure 2, which involves designing the application architecture and database. The system design is created with an emphasis on ease of use and efficient laboratory schedule management [10]. The next stage is implementation, where the design is translated into code using the Laravel Filament framework for web development and MySQL for database management. After the system is fully developed, system testing is conducted, including functionality, usability, and security tests to ensure the system operates according to the desired specifications. Subsequently, the system is tested in the real world during the field implementation phase, aimed at ensuring the system functions well in an operational environment and gathering feedback from users for further evaluation. Finally, the system enters the maintenance phase, which includes bug fixes, feature updates based on user needs, and continuous monitoring to ensure the system's performance remains optimal over the long term [11].

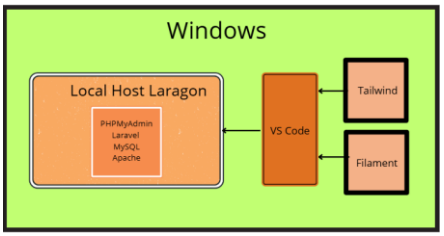

Figure 1 System Design

2. RESULTS

The website workflow begins with the account registration process for new users. Upon successful registration, users are required to log in to access the system. During the login stage, users are prompted to enter their username and password. If users forget their password, they can select the "forgot password" option, which enables them to recover their account access through a secure password reset process.

After successfully logging in, users are redirected to the homepage, where they can access various features based on their role admin or regular user. Admins have comprehensive access to manage the entire system's database. This includes full control over user data, such as the ability to view, edit, or delete user accounts, and manage laboratory loan requests. Admins also have the capability to generate reports and perform other administrative tasks essential for system maintenance and user management. On the other hand, regular users have more limited access. They can request lecturer schedules and view available time slots for classes. Additionally, they can fill out laboratory loan forms, which allow them to reserve laboratory space for experiments or coursework. Regular users do not have access to the management tools or database control that admins do, ensuring that only authorized personnel can modify critical system information. In this way, the website's workflow ensures a clear distinction between the functionalities available to different types of users, ensuring smooth operation and security within the system.

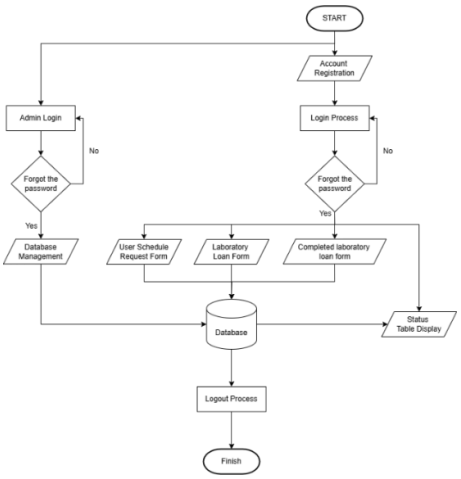

Figure 3 Website Workflow

After users select a schedule and complete the laboratory loan form, the system processes and stores the data in the database. This form allows users to finalize their laboratory loan request, marking the laboratory as used once the loan is completed. The system ensures that the laboratory's space availability is accurately updated and displayed in a status table. This status table is visible to users, providing real-time information on which laboratories are available or in use. For regular users, this process enables them to reserve laboratory space based on available time slots and track the status of their reservations. Admins, however, have broader control, being able to manage the database, including reviewing all laboratory loan forms and requests submitted by users. This ensures that admins can oversee the entire process and make necessary adjustments to schedules or space allocations as needed. Once users are finished with their tasks, they can log out of the system. This step ends the session, ensuring data security by closing access to sensitive information. The logout process ensures system integrity, facilitating efficient, secure laboratory management with role-based access and smooth reservations [12].

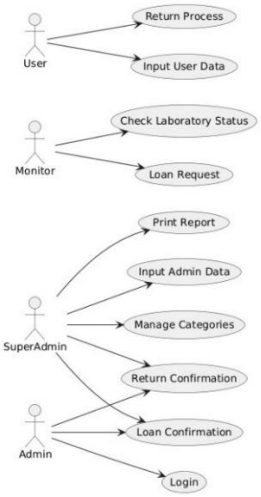

Figure 4 Use Case Diagram

The use case diagram provided illustrates the interactions between various actors and the laboratory management system. There are four main actors: Super Admin, Admin, Monitor, and User. The Super Admin has the highest level of access, responsible for managing categories within the system, entering admin data, and printing reports, ensuring that the system's structure and data management follow proper protocols. The Admin manages laboratory loans, confirms returns, and is responsible for logging into the system, which guarantees that only authorized users can access and modify crucial information. Admins also oversee the efficient operation of laboratory resources. The Monitor is tasked with checking the real-time status of the laboratories, providing accurate availability information necessary for managing loan requests. Finally, the User interacts with the system by requesting laboratory loans, inputting personal data, and processing returns. The interactions between these actors and the system are organized into use cases, highlighting essential functions such as data input, loan management, and the return process. This design ensures that all parties, from users to administrators, have a structured and clear way to interact with the laboratory management system, facilitating efficient resource use and smooth workflow in the laboratory environment [13].

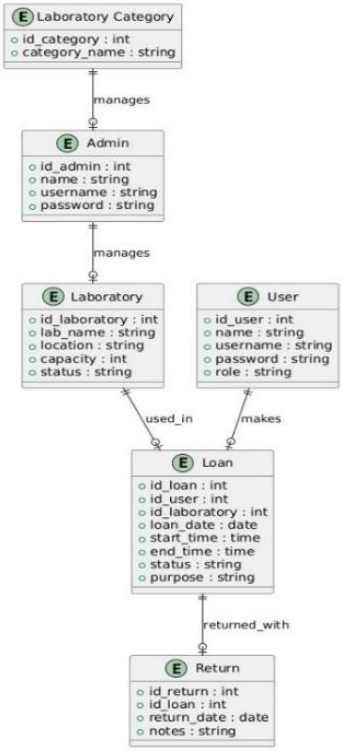

Figure 5 Entity Relationship Diagram

The Entity Relationship Diagram (ERD) outlines the data structure and relationships within the laboratory management system. It includes key entities such as Laboratory Category, Admin, User, Laboratory, Loan, and Return. The Laboratory Category groups laboratories, with a one-to-many relationship with the Laboratory entity, meaning one category can contain multiple laboratories. The Admin manages laboratory categories and individual laboratories. Admins handle tasks such as assigning laboratories and maintaining their data, including capacity, location, and status. The User entity represents individuals who can borrow laboratories. Users can submit borrowing requests recorded in the Loan entity, which stores details about the laboratory borrowed, the user's information, borrowing time, and the status of the loan. A Loan can transition to the Return entity, which records the laboratory return details, including the return date and any relevant notes about the condition of the laboratory or equipment. These entities manage laboratory space, borrowing, and returns, providing a structured system for tracking resources, user interactions, and ensuring smooth operations in the laboratory management system [13].

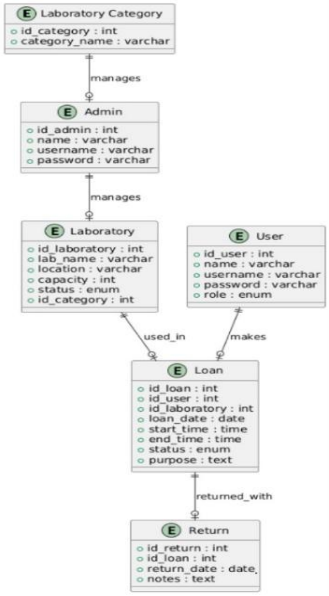

Figure 6 Logical Structure Records

The Logical Structure Records (LRS) diagram illustrates the data structure in a laboratory management system, focusing on the logical elements and relationships between entities within the database. The primary entities involved are LaboratoryCategory, Admin, User, Laboratory, Borrowing, and Returning. Each entity has attributes that define the data stored, such as category_id, category_name in LaboratoryCategory, and admin_id, name, username, and password in the Admin entity. Relationships between entities are described by relationships, such as Admin managing LaboratoryCategory and Laboratory, and User making a Borrowing to Laboratory. The Borrowing entity records borrowing-related data, such as borrowing date, start_time, and end_time, as well as borrowing status and requirements. The Returning entity stores return-related data, including return_date and related records. This diagram models the relationships between entities with dependencies, ensuring data integrity and a clear flow in laboratory system management [14].

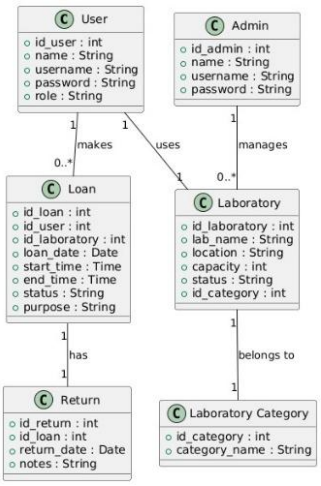

Figure 7 Class Diagram

The Class Diagram has several main classes, namely User, Borrower, Returner, Admin, Laboratory, and LaboratoryCategory. The User class is related to Borrower through a one-to-many relationship, where a user can make multiple borrowers. Each borrower has attributes such as borrower_date, start_time, end_time, status, and purpose. The relationship between Borrower and Returner is one-to-one, because each borrower has only one return recorded with the attributes return_date and note. The Admin class manages the Laboratory, where Admin can manage multiple laboratories. Each Laboratory has attributes such as laboratory_name, location, capacity, and status. In addition, the Laboratory is related to LaboratoryCategory, where each laboratory belongs to one category. This diagram shows how data and functions in the system are interconnected, providing a clear picture of the flow and structure of laboratory data management.

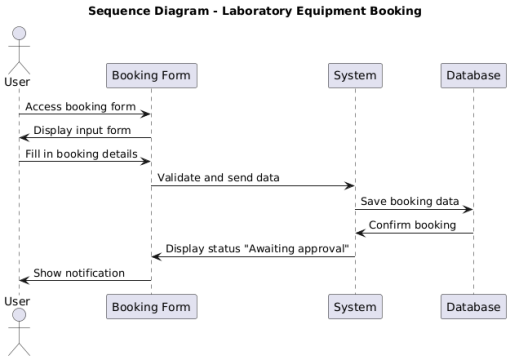

Figure 8 Sequence Diagram Laboratory Equipment Booking

The uploaded Sequence Diagram illustrates the flow of a user's laboratory loan request within the system. The process starts when the user accesses the Loan Form. Once the form is displayed, the user proceeds to fill in essential details such as the date, time, and duration of the laboratory loan. After completing the form, the user submits the data. Next, the System receives the loan data and initiates a validation process to ensure that the information complies with predefined requirements, such as availability, time constraints, and user eligibility. This validation step helps prevent errors or conflicts in the system. Upon successful validation, the System sends the data to the Database for storage and processing, ensuring that the loan request is securely recorded and tracked. Once the data is processed, the System updates the Loan Form with a "pending approval" status, indicating to the user that their loan request is awaiting further review or confirmation. This status serves as a notification to keep the user informed throughout the process. By following this structured flow, the system ensures an efficient, controlled process for handling laboratory loan requests. This process also ensures that proper checks and validations are in place, leading to organized management and timely approval of laboratory reservations [15].

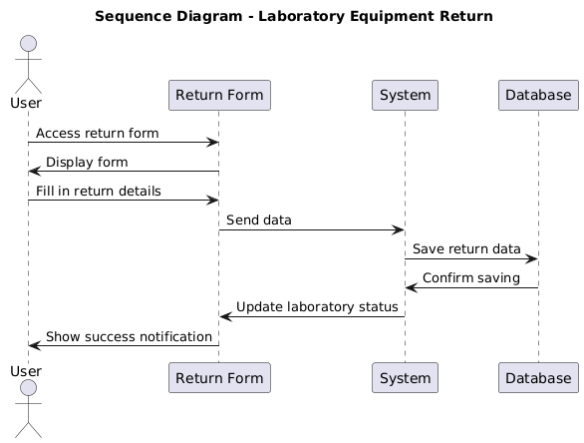

Figure 9 Sequence Diagram Laboratory Equipment Return

The uploaded Sequence Diagram illustrates the laboratory return process flow in the system. The process begins when the User accesses the Return Form and the return form is displayed on the screen. The User then fills in the return data, such as the laboratory return date. After that, the completed return data is sent to the System for processing. The System then updates the laboratory status in the Database, indicating that the laboratory has been returned. Next, the System saves the return data and sends a confirmation to the user that the return was successful. On the user side, the Return Form will display a notification informing them that the return process was successful. This flow ensures that the laboratory status is always updated accurately after the return is made, keeping laboratory management under control [16].

Table 1. Quality of Service Test Results

Parameter	Hasil Pengujian	Kategori Kestabila
Throughput	97 kbps	Baik (di atas 50 kbps)
Packet Loss	0.2%	Sangat Kecil (<1%)
Delay	38.71 ms	Responsif (<150 ms)
Jitter	0.228 ms	Sangat Kecil (<1 ms)

Based on Quality of Service (QoS) testing on the laboratory loan website server, the results obtained showed excellent performance. The throughput value was recorded at 97 kbps, which indicates a fairly good data transmission speed for web-based applications with a limited number of users. Packet loss was recorded at only 0.2%, which is very low and does not significantly impact data integrity during network transmission. The average delay was recorded at 38.71 ms, indicating low communication delay between the server and client, providing a responsive user experience. Furthermore, the recorded jitter was only 0.228 ms, indicating that the delay variation between packets is very small, maintaining a stable connection. Overall, the test results show that the server can support applications with stable performance and provide a smooth user experience [17].

3. DISCUSSION

With these results, the laboratory inventory website can display real-time laboratory status information with optimal service quality. This excellent performance ensures that users can access laboratory information without significant disruptions or delays. High throughput, low packet loss, minimal delay, and almost no jitter guarantee a smooth and efficient user experience. The system meets the technical standards required for use in academic environments, providing quick and reliable access to information for better laboratory management. The research also tested the system's functionality and usability. Functionality testing was performed to ensure that the system could handle expected tasks, such as managing laboratory room bookings, monitoring laboratory status in real-time, and properly handling user requests. Usability testing involved feedback from users to assess the ease of use of the interface, accessibility, and system navigation .

The results showed that the system is user-friendly, with an intuitive interface that allows users to access laboratory information without obstacles. Security testing, an equally important aspect of the research, was conducted to ensure that user data, such as schedules and laboratory bookings, as well as other sensitive information, is secure from potential threats or breaches. The security testing results indicated that the system has adequate protection, with role-based access control limiting user rights based on their roles (e.g., admin, lecturer, student). One significant outcome of this research is the system's ability to reduce laboratory booking schedule overlaps. With the use of a web-based system supporting real-time scheduling, it successfully minimizes scheduling conflicts often found in the previous manual system. Both lecturers and students can easily check laboratory room availability and make bookings without worrying about overlapping schedules. The system also proved effective in displaying real-time laboratory information [18]. The speed of access and reliability in providing status updates allow users to make decisions quickly, which is crucial in practical learning environments that require efficient and timely access to information. This advantage makes the system highly useful for managing dynamic laboratory spaces, where schedules and availability frequently change. In addition to technical testing results, user feedback obtained during testing highlighted that the system is not only efficient but also easy to use for all types of users, including students, lecturers, and laboratory administrators. This demonstrates that the system not only meets functional needs but also provides comfort and ease of use for its users [19].

4. CONCLUSION

This research successfully designed and developed a web-based laboratory management information system specifically for the Air Navigation Engineering Program at the Surabaya Aviation Polytechnic. Developed using the Laravel Filament framework and following the Waterfall development model, the system addresses issues faced by the previous manual system, such as scheduling overlaps and delays in providing laboratory availability information. The platform enables real-time laboratory status updates, allowing users to easily access the most current information. Additionally, the system incorporates role-based access control (RBAC), providing structured data access based on user roles like super admin, admin, monitor, and users, while also facilitating the tracking of laboratory usage history for efficient resource management. Functionality and usability testing confirmed that the system is intuitive, with an easy-to-navigate interface, ensuring that all user groups including students, lecturers, and administrators can use the platform effectively. Security testing demonstrated the system's ability to safeguard user data using RBAC. A key contribution of this research is the system's ability to reduce schedule conflicts in laboratory bookings by offering real-time scheduling, enabling both lecturers and students to view laboratory availability and make bookings without concerns about overlapping schedules. Overall, the system enhances laboratory resource management, addressing technical challenges and improving the efficiency and effectiveness of laboratory practicals at the Surabaya Aviation Polytechnic.

REFERENCES

[1] Syamsiah, N. (2022). The Use Of E-Reservation Open-Source Software (OSS) On Web-Based Laboratory Scheduling Information Systems In Order To Support Education Laboratory Management. Prosiding Simposium Nasional Multidisiplin (SinaMu). DOI: https://doi.org/10.31000/sinamu.v3i0.5794

[2] Zheng, B. (2017). Design and Implement of Laboratory Management System based Web. , 424-429. DOI: https://doi.org/10.2991/ICEAT-16.2017.87

[3] Santoso, P., Khoswanto, H., & Sandjaja, I. (2018). Web-Based Robotics Laboratory. , 164, 01034. DOI:https://doi.org/10.1051/MATECCONF/201816401034

[4] Adekunle, A., Abolore, B., Mutiu, G., & Olalekan, A. (2024). Design and Implementation of a Web-Based Laboratory Management System for Efficient Resource Tracking. Asian Journal of Electrical Sciences. DOI: https://doi.org/10.70112/ajes-2024.13.2.4248

[5] Syamsiah, N. (2022). The Use Of E-Reservation Open-Source Software (OSS) On Web-Based Laboratory Scheduling Information Systems In Order To Support Education Laboratory Management. Prosiding Simposium Nasional Multidisiplin (SinaMu). DOI: https://doi.org/10.31000/sinamu.v3i0.5794

[6] Huang, J. (2020). Online Booking Laboratory Management System. , 799-804. DOI:https://doi.org/10.1007/978-3-030-62743-0_114

[7] Drury, L., Bliven, K., & Achterberg, A. (2018). Improving Laboratory Workflow Through Utilization of a Schedule Free System. American Journal of Clinical Pathology. DOI: https://doi.org/10.1016/j.jala.2004.10.001

[8] Hua, M. (2015). Laboratory course scheduling management system based on MVC. Laboratory Science.

[9] Spilakova, P., & Schauer, F. (2015). Remote laboratory management system remlabnet and its booking system. 2015 Forth International Conference on e-Technologies and Networks for Development (ICeND), 1-5. DOI:https://doi.org/10.1109/ICEND.2015.7328544

[10] Nafi'ah, R., & Dewanto, A. (2017). Development And Quality Analysis Of Web-Based Laboratory Management Information System At Pti Smkn 3 Yogyakarta. , 6, 1-7.

[11] Haritman, E., Somantri, Y., Wahyudin, D., & Mulyana, E. (2018). A Remote PLC Laboratory (RLab) for Distance Practical Work of Industrial Automation. IOP Conference Series: Materials Science and Engineering, 306. DOI:https://doi.org/10.1088/1757-899X/306/1/012034

[12] Jatnika, H., Rifai, M., & Napitupulu, L. (2023). Implementation of the Rational Unified Process (Rup) Method in Designing a Web-Based Certification Scheduling Application (Citation) on Itcc Itpln. Syntax Idea. DOI:https://doi.org/10.46799/syntax-idea.v5i4.2188

[13] Van Veen-Berkx, E., Van Dijk, M., Cornelisse, D., Kazemier, G., & Mokken, F. (2016). Scheduling Anesthesia Time Reduces Case Cancellations and Improves Operating Room Workflow in a University Hospital Setting.. Journal of the American College of Surgeons, 223 2, 343-51.

DOI:https://doi.org/10.1016/j.jamcollsurg.2016.03.038

[14] Itoh, T., Horinouchi, T., Uchida, H., Takahashi, K., & Ozaki, H. (2021). Optimal Scheduling for Laboratory Automation of Life Science Experiments with Time Constraints. Slas Technology, 26, 650 - 659. DOI: https://doi.org/10.1177/24726303211021790

[15] Maiti, A., Kist, A., & Maxwell, A. (2014). Time scheduling in a peer-to-peer remote access laboratory for STEM education. 2014 IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE), 179-185. DOI: https://doi.org/10.1109/TALE.2014.7062615

[16] Wu, C., & Wang, R. (2014). Evaluating Chinese Tourist's Service Quality Criteria under Uncertainty. International Review of Management and Business Research, 3, 858.

[17] Khazri, Y., Fahli, A., Moussetad, M., & Naddami, A. (2019). Design and Implementation of a Reservation System and a New Queuing for Remote Labs. *Int. J. Online Biomed. Eng.*, 15, 57-68. DOI: https://doi.org/10.3991/IJOE.V15I12.11098

[18] Syamsiah, N. (2022). The Use Of E-Reservation Open-Source Software (OSS) On Web-Based Laboratory Scheduling Information Systems In Order To Support Education Laboratory Management. *Prosiding Simposium Nasional.* DOI: https://doi.org/10.31000/sinamu.v3i0.5794

[19] Budiman, E., & Wicaksono, O. (2016). Measuring quality of service for mobile internet services. *2016 2nd International Conference on Science in Information Technology (ICSITech)*, 300-305. DOI:https://doi.org/10.1109/ICSITECH.2016.7852652