



MediLog: A Pilot Study of Online Management System for Medical Device Status and Loan

Fadlin Amira Mohd Fairuz¹, Rania Hussein Al ashwal^{1,2*}, Maheza Irna Mohamad Salim^{1,2*}

¹Department of Biomedical Engineering & Health Sciences, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

²Diagnostics Research Group, Health and Wellness Research Alliance, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

*Corresponding Author maheza@utm.my; rania@utm.my



Cite: <https://doi.org/10.11113/humentech.v3n1.67>



Research Article

Abstract:

Malaysia's medical device industry is experiencing significant growth, with 309,829 devices procured at a cost of RM 7.78 billion and actively utilized in public hospitals nationwide. This surge highlights the need for an advanced medical device management system to efficiently handle the life cycle of these devices to ensure optimal utilization and streamline operations. Other proposed technological solutions like RFID, RTLS, and infrared tags aim to address these challenges, but their high installation costs pose barriers, especially for government hospitals. To overcome these obstacles, this pilot study advocates for a mobile application as a cost-effective alternative for comprehensive medical data management. The proposed application, developed using MIT Apps, capitalizes on portability, ease of management, and the multifunctionality of mobile platforms. A key feature of the application is the barcode scanner, widely employed across industries for enhanced data capture efficiency. The Real-time Database is integrated into the project, facilitating the swift and accurate storage of medical device information. In essence, the mobile application prototype provides a practical solution to the limitations of manual data management in the biomedical department. Leveraging MIT Apps and incorporating features like the barcode scanner and Real-time Database, the application streamlines the updating of machine details, ensuring users access precise and current information. This approach promotes efficiency, accuracy, and effectiveness in medical device management within the healthcare system.

Keywords: Medical device; Management; Software applications

1. INTRODUCTION

In the evolving landscape of the medical industry, technological advancements have led to significant growth and development in medical devices within our country. According to a March 2020 report by KPMG, based on Fitch Solutions data, Malaysia's medical device market is anticipated to reach RM 8.97 billion (USD 2.0 billion) in 2022, exhibiting a compound annual growth rate (CAGR) of 7.5% between 2018 and 2022 (1). The medical devices industry in Malaysia is recognized as a key growth sector, housing over 190 companies, ranging from small and medium-sized local manufacturers to multinational corporations (MNCs). The majority of these companies are concentrated in Penang, Klang Valley, and Johor, collectively capable of producing a diverse range of medical devices and equipment for the global market (2).

This robust industry has become a potent force, providing an extensive array of products and a solid foundation for disease prevention, diagnosis, treatment, and rehabilitation. The integration of medical device management has become essential in healthcare technology systems, given the continuous development and expansion of the industry. In the effective operation of a hospital, managing medical devices is as pivotal as overseeing human resources. Successful medical device management necessitates the availability of accurate and comprehensive data (3). An optimized medical device inventory system is designed to oversee the entire life cycle of medical devices, from initial planning and procurement to deployment, performance tracking, maintenance, and eventual disposal (4). Given the critical role medical devices play in determining patient outcomes, the status of these devices is of utmost importance. Hospital management must accord significant attention to medical device management to ensure the provision of safe, secure, and high-quality patient care services for all stakeholders, including patients, staff, and visitors (5).

Professionals engaged in medical device management bear the responsibility of ensuring that medical devices used for patient care are not only functional and secure but also configured correctly to meet intended goals. This ensures the safety of patients during device use and guarantees the continued efficiency and proper functioning of medical devices. Although medical devices significantly contribute to accurate diagnoses, optimal treatments, and improved patient

outcomes, managing their status and usage in healthcare facilities poses a complex and challenging task. Manual tracking systems, paper-based documentation, and decentralized processes often lead to inefficiencies, delays, and potential device loss or misplacement. Asset management systems such as medical device online application systems can help hospitals better manage their medical devices (6).

Numerous studies have highlighted the prevalent challenges faced by hospitals, particularly in the context of missing medical devices within specific departments and uncertainties regarding the status of machines, including whether they should be disposed of or remain in use (7). The financial impact is significant, with hospitals annually spending millions of dollars to replace or recover misplaced or stolen medical devices. A survey conducted by NursingTimes.net, involving 1000 nurses, revealed that at least one in three nurses spent an hour or more per shift searching for necessary medical devices. This implies that nurses might extend up to 40 hours monthly on equipment retrieval, with 16% admitting to abandoning their search after being unable to locate a specific device. Given the critical nature of time in healthcare settings, the misplacement of medical devices can potentially lead to dangerous situations (8, 9).

Adding to the complexity, the status of machines emerges as a significant issue in healthcare management (10). The utilization of aging medical assets raises concerns, as they are more prone to breakdowns compared to newer equipment. Hence, the disposal phase, as stipulated in the biomedical engineering life cycle, becomes crucial, marking the point when medical devices are no longer safe, beyond economical repair, have unattainable parts, significant damage, or are otherwise in poor condition (11). Regular maintenance of medical devices is paramount, particularly considering the complexity of certain machines found exclusively in intensive care units (ICUs) with crucial electrical connections linked to patient care. The failure of life-supporting medical equipment, used on patients incapable of responding to dangerous situations, can lead to fatal consequences. However, many hospitals still rely on manual management systems without backup storage. The use of paper documents further exacerbates the problem, as they are prone to misplacement. Implementing an effective medical device tracking system is imperative for hospitals to deliver high-quality care, reduce costs, and meet stringent medical device quality standards (2).

In this pilot study, application-based system for managing medical device loans and life cycle status offers several advantages over other technology such as RFID. An application provides a centralized platform for efficient loan application processing, allowing users to submit requests, track progress, and receive real-time updates. The system can be tailored to specific device workflows and integrated with existing hospital management systems for seamless operations. While RFID is useful for tracking, an application-based approach offers a more comprehensive and adaptable solution for efficient medical device management throughout their life cycle.

Applications developed using MIT App Inventor stands out as an accessible platform, particularly beneficial for pilot study where a quick and straightforward development process can be crucial for testing initial ideas, gathering feedback, and assessing the feasibility of an application concept. Its key advantages lie in its user-friendly, drag-and-drop interface, making app development accessible even to beginners. The platform facilitates rapid prototyping, enabling the creation of functional applications without extensive coding requirements. Furthermore, MIT App Inventor employs a visual programming approach, eliminating the need for manual coding and promoting a graphical understanding of application logic. However, for more intricate and performance-critical projects, traditional programming languages and platforms with greater control over system resources may be preferable. The suitability of MIT App Inventor versus other platforms ultimately depends on the specific needs and expertise of the developers involved.

2. APPLICATION DEVELOPMENT

Mobile applications represent a contemporary approach to application development, prioritizing portability and streamlined management. Their versatility, allowing for multiple functions with a single click and process automation, has made them invaluable tools. Beyond their traditional roles in entertainment or education, mobile applications have found extensive utility in healthcare solutions, particularly in medical centers and hospitals.

2.1 User Interface and User Experience (UI UX)

The User Interface (UI) serves as the design framework for the application, while User Experience (UX) is important for ensuring a high-quality outcome by aligning with user expectations and ensuring the application is accessible and user-friendly. MIT Apps Inventor is employed in the development of both the UI and UX components in this project. The UI and UX aspects of the project are carefully crafted to cater to user needs. This includes the creation of essential pages such as Login pages for secure access, a Mainpage for intuitive navigation, a Barcode Scanner feature facilitating quick retrieval of medical device details, and a dedicated form for managing medical device loans. This user-centric approach aims to enhance the overall usability and satisfaction of the application, aligning with the end-users' requirements and expectations. In this pilot study, a few considerations were made while designing the user experience (UX) with MIT App Inventor. The UX emphasizes simplicity to aid user with different proficiency levels, from beginners to more experienced users. Additionally, a clear and accessible interface supported by instructional resources are used to provide intuitiveness and learnability. Visual clarity of the medical devices, with well-labeled is also vital to facilitate easy navigation of the interface.

2.2 Login Page

A login page, also referred to as a sign-in page, serves as the initial interface for users to input their credentials, thereby gaining access to the application. It functions as the primary point of authentication, verifying the user's identity before

allowing entry to protected resources within the application. Upon submission of login credentials, the system or application cross checks them against a database of user accounts. Successful authentication results in the user being granted access and directed to the main page of the system. In cases where the submitted credentials are incorrect or invalid, an error message is promptly displayed, prompting the user to either retry the login or initiate the password reset process for account recovery. To visually represent the user login process, a User Login flowchart is depicted in Figure 1, outlining the sequential steps involved in the authentication and access-granting procedures. This comprehensive depiction aids in understanding the systematic flow of actions from user input to system response during the login process.

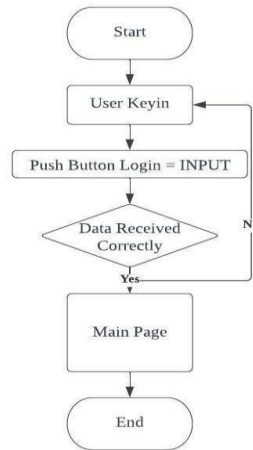


Figure 1. User Login flowchart.

2.3 Main Page

The main page, depicted in Figure 2, serves as the hub enabling users to seamlessly navigate to various sections or pages within the website or application. The main page is crafted to deliver a user-friendly and intuitive experience, facilitating swift access to pertinent information and actions. Users engage in practical application by scanning machine barcodes using the integrated scanner feature. Upon selecting the department option, an output list of departments is presented, offering users the flexibility to explore machines categorized by department or to initiate a targeted search by machine name. This dual functionality enhances user convenience, allowing for an efficient and tailored exploration of the available resources.

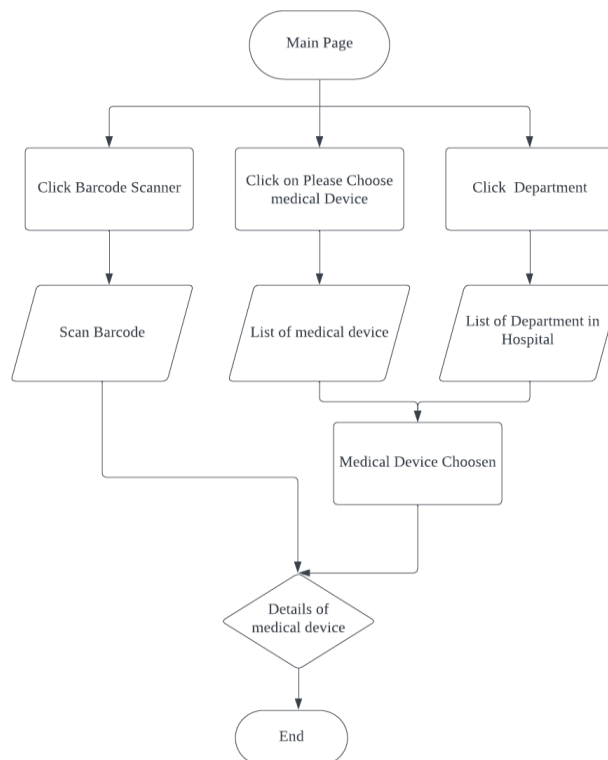


Figure 2. Main Page flowchart.

2.4 Features Page

The features page serves as a tool for users to explore and understand the application's capabilities, providing an overview of its functionalities. The general flow of the application is depicted through a comprehensive flowchart. Within this page, users can engage in various actions, including searching for machines by equipment name, scanning machine barcodes, or selecting a department and subsequently searching for specific equipment for enhanced user flexibility and convenience. Figure 3 illustrates the mobile application development process, specifically focusing on the features page and encompassing the entirety of the mobile app's functionalities. The visual representation aids users in understanding the step-by-step procedures involved in accessing and utilizing different features within the application. This comprehensive flowchart ensures a user-friendly experience, guiding individuals through the application.

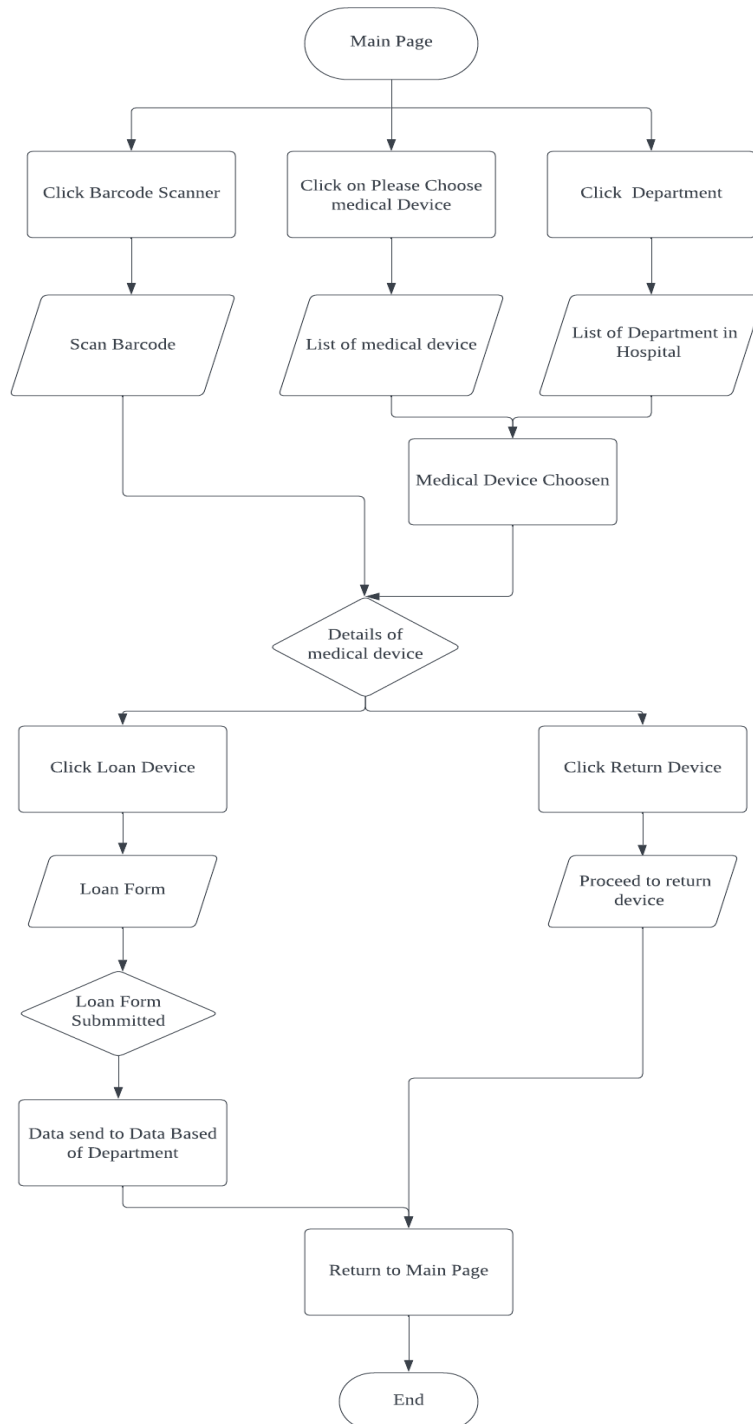


Figure 3. Mobile Application development process.

2.5 Software/Tools

Software is a comprehensive assembly of computer programs, data, and instructions designed to enable a computer system to execute specific tasks or functions (12). It's used to automate tasks, process data, facilitate communication, entertain, and proficiently handle a diverse array of activities for both individuals and businesses. The dynamism of software is evident in its continuous evolution, with regular updates introducing new features, enhancing performance, and addressing security vulnerabilities or bugs.

In the context of this project, the development of the user interface and the mobile application itself is facilitated through the utilization of MIT Apps Inventor. This platform streamlines the process of creating a user-friendly interface and ensures efficient mobile application development, aligning with the project's objectives.

2.6 MIT App Inventor

MIT App Inventor is a web-based development platform that allows users to create mobile applications for Android devices without any prior programming experience. It is a simple, visual programming environment that enables anyone, including children, to create fully functional apps for smartphones and tablets. It uses a block-based coding program.

2.7 Lucidchart

Users can create expert flowchart diagrams using Lucidchart, which also offers project management designs. Since it is a top choice for diagramming software, Lucidchart is fluid and simple to learn. It is a useful tool for non-designers due to its extensive libraries of templates and objects. Real-time co-editing and excellent collaboration support are also provided.

2.8 Heuristic Evaluation Form

In this study, a heuristic evaluation serves as a method to pinpoint design issues within a user interface (13). It involves a checklist or questionnaire that evaluators use to identify usability problems and offer feedback. In the context of mobile application development, the heuristic evaluation form focuses on the visibility of the system to provide users with clear and immediate feedback regarding the current state of the system or any ongoing processes. This ensures that users stay informed about the system's status, fostering an understanding of its behavior and response to their actions.

Additionally, the evaluation addresses the importance of user control and freedom. This entails providing users with the autonomy to navigate and interact with the system freely, avoiding a sense of entrapment or an inability to undo actions.

3. RESULTS & DISCUSSION

3.1 Wireframing Mobile Application

The hospital's database credentials, including usernames and passwords, are securely stored in cloud storage managed by the IT department. Upon user login, the system initiates a verification process, confirming the accuracy of the provided credentials. Once successfully authenticated, users are granted access to the system and directed to the home page. On the home page, users can explore available medical devices by clicking the "Choose Medical Device" button, revealing a comprehensive list of devices within the hospital. Selecting a specific device displays detailed information about that particular device. The application incorporates a barcode scanner feature, activated by capturing the barcode image through the device's camera or scanning component. The scanner processes the captured barcode, decoding the encoded data and presenting the device's specifications in a readable format.

Clicking on a department reveals a list of departments within the hospital. For instance, selecting the "General Ward" department displays a list of devices in that department along with their respective details. Users can also access a loan form by clicking on the "Loan Device" option. Here, they provide necessary information, and upon submission, the details are saved until the device is returned. When returning a loaned device, users can click on "Return Device," follow the necessary steps, and upon completion, they are redirected to the main page. The wireframe of the mobile app, depicted in Figure 4, visually represents the application's layout and design. This wireframe serves as a guide for the app's structure, showcasing the arrangement of elements and navigation pathways, contributing to an intuitive user experience.

3.2 Login Page and Main Page

The login page (Figure 5(a)) functions as a critical user interface where individuals input their credentials to securely access the system or application. The username and password input fields will undergo validation by being sent to the server or authentication system. The system authenticates the user's identity by comparing the provided username and password against stored user data. In the event of non-existence in the system, an error message for incorrect password or username is displayed. The "About Us" section further elucidates the purpose and essence of MediLog.

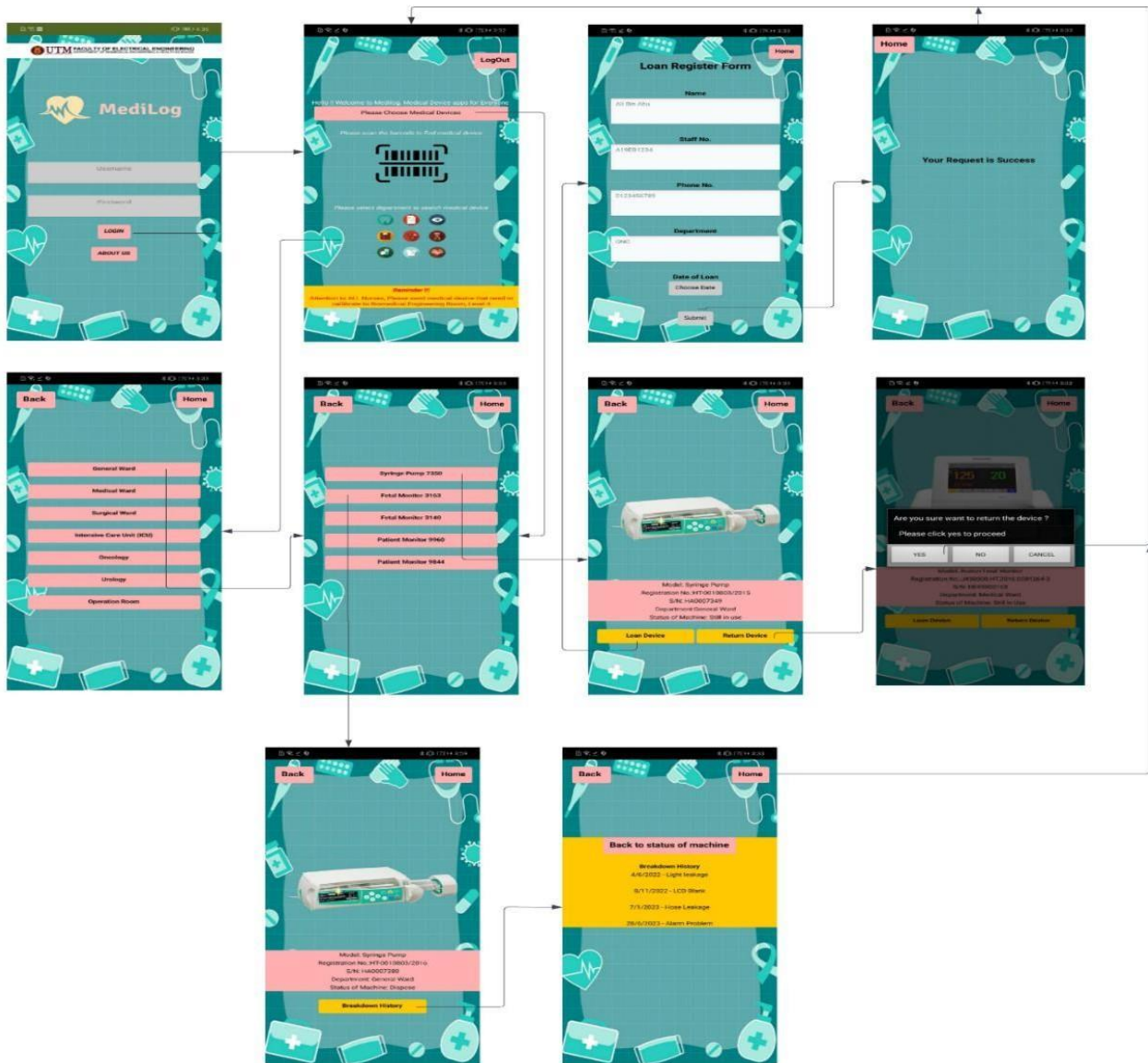


Figure 4. Wire framing of mobile apps.

The main page (Figure 5(b)) offers a user-friendly interface, acting as a centralized hub for accessing diverse features, functionalities, and information within the system. It incorporates elements such as a Logout button, a welcoming message, options for medical devices, a Barcode scanner, a list of departments, and user reminders. Users can seamlessly execute actions, view data, initiate processes, and navigate to specific pages by interacting with these elements. The design of the main page is crafted to showcase the system's capabilities in a user-centric manner.

3.3 List of Department and List of Medical Devices

In the List of Department feature (Figure 5(c)), users can select their desired department to explore a comprehensive list of medical devices. Upon selection, a list of medical devices categorized by department is displayed, allowing users to choose a specific device based on its name and serial number.

Certain medical equipment, such as mechanical ventilators and defibrillators, are considered essential assets within a healthcare setting. Hospitals house various systems and medical devices crucial for healthcare operation. Clicking on the "Search by List" and "Department" options (Figure 5(d)) yields a detailed list of medical devices, facilitating users in searching for devices by name and the last four digits of the serial number.

Detailed information about medical devices, including model name, registration number, serial number, affiliated department, and machine status, is presented in Figure 6. If a machine is still in use, users have the option to click on "Loan Device" for device loan transactions or "Return Device" for returning the borrowed device. In the case of a disposed machine, a breakdown history is provided, allowing users or the Biomedical Engineering Management System (BEMS) to

investigate the reasons behind the machine's disposal. This comprehensive information aids in managing and understanding the status and history of medical devices within the healthcare facility.

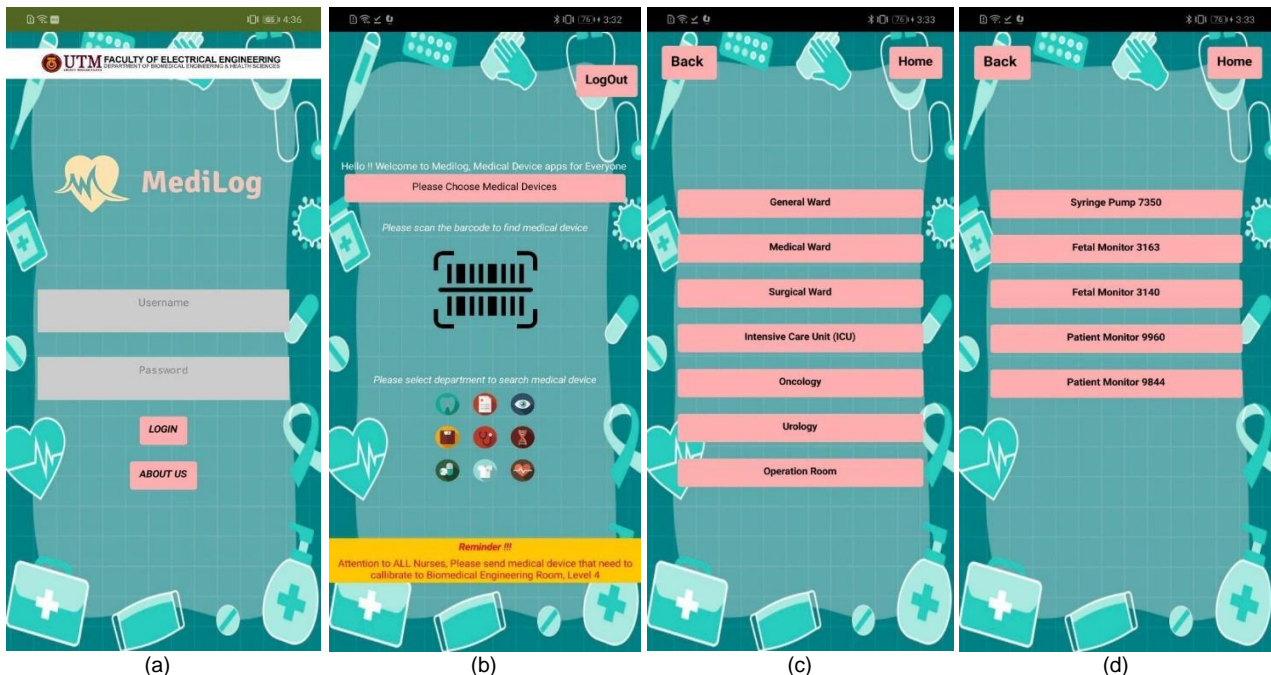


Figure 5. (a) Login page, (b) Main page, (c) List of Department page and (d) List of Medical Devices page.

3.4 Loan and Return Device Features

If the user wants to borrow a device from another department, they can use this feature to submit a loan form (Figure 7). The data will then be submitted to a database, which will show who loaned the device. When the user wants to return the device, he or she will click the button and then click yes, after which the user will be returned to the main page.

3.5 Breakdown History

Breakdown history serves as a valuable repository of information regarding the performance and reliability of equipment or machinery. The Biomedical Engineering Management System (BEMS) utilizes this data to discern patterns, identify common failure points, and recognize recurring issues through a comprehensive analysis of previous breakdown incidents. This insightful information becomes instrumental in designing more effective maintenance plans, including the implementation of preventive maintenance schedules, spare parts management, and strategic equipment replacement strategies. By leveraging breakdown history, BEMS enhances its ability to proactively address potential issues, optimize equipment performance, and ensure the uninterrupted functionality of critical healthcare devices.

3.6 Heuristic Evaluation Form Question

Figure 8 displays Heuristic Evaluation questions designed for assessing the application's user interface, aiming to uncover potential usability issues and offer actionable recommendations for enhancement. The evaluation questions are structured across 13 sectors, with a focus on visibility of system status, match between system and the real world, user control and freedom, consistency and standards, flexibility, minimalist design, and skills. This comprehensive approach in the survey helps identify specific areas where improvements can be made to optimize the overall user experience, ensuring that the application aligns with user needs and expectations. The heuristic evaluation acts as a valuable tool in enhancing usability and refining the application to meet or exceed user satisfaction.

3.7 Heuristic Evaluation Feedback

Feedback from four software engineers indicates a positive response to the survey. Notably, 75% of respondents found the design very pleasant, reflecting a favorable view of the application's aesthetics. However, opinions on functionality were divided, with 50% stating that the mobile application is functional, while the other half expressed concerns, particularly regarding the loan form, indicating areas for improvement.

Despite this, all respondents unanimously agreed that the mobile application is user-friendly. The ease of navigation received positive feedback, with two respondents rating it 4 out of 5 and one respondent providing a top score of 5,

highlighting the application's simplicity. One respondent, giving a score of 3, found it average in terms of navigational ease. Notably, all respondents claimed to navigate to their desired pages quickly.

Regarding information and feature accessibility, half of the users expressed that the layout is easy to access and find information, contributing to the overall user-friendliness of the application. Satisfaction levels varied, with half of the respondents deeming their experience good and the other half finding it average.



Figure 6. Details of medical device.

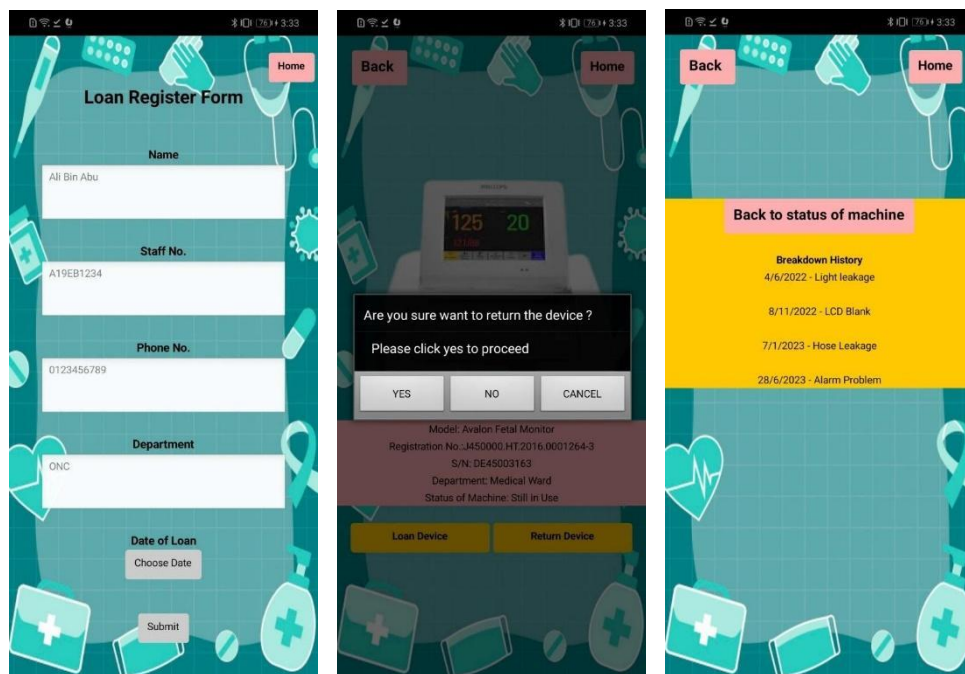


Figure 7. Loan Form and Returning option, and list of breakdown history of dispose machines.

Heuristic Evaluation Form for Mobile Application 'MediLog'

Assalamualaikum and Greetings,

I am Final Year Student of Bachelor in Engineering (Bio-Medical). Currently, I am conducting a feedback on development of mobile application. I would like to invite you to participate in this survey as part of my project's assessment.

Your responses will remain anonymous and will not be linked to you personally. I assure you that the data collected will only be used for research and learning purposes.

I highly appreciated if you can take a few minutes to answer my survey. Your cooperation, time, and honesty are highly appreciated. Thank you!

fadlinamira@graduate.utm.my [Switch account](#)

Not shared

* Indicates required question

Rate the mobile application's design in term of aesthetic and arrangement of icons and subsections *

Very pleasant to look at

Average Design

Horrendous design

Rate the usability of the apps such as using a preset function or feature *

Function and feature works as intended

Some of the feature works

Do you find the Apps easy to use? *

Yes

No

Rate the ease of navigation of the application such as moving to a different section of the mobile application, on a scale from 1-5 *

1

2

3

4

5

Were you able to navigate to your desired page without consuming too much time? *

Yes

No

What do you think about how information and features are laid out? *

Easy to access and find information

Hard to find specific functions or sections

Overall, what's your experience with the mobile application? *

Good

Average

Bad

As a nurse or doctor (user of this application), do you have any suggestions to improve the website? *

Your answer

or submit passwords through Google Forms

Figure 8. List of Heuristic evaluation form.

3.8 User Interface and Development of Mobile Application

The user interface and mobile application development have been successfully implemented, featuring a test utilizing medical devices from the Clinical Engineering Lab of the Department of Biomedical Engineering and Health Sciences. The application incorporates functionalities like scanning medical device barcodes, with the user interface designed effectively using MIT Apps. While the project faced minor challenges during the user interface development, such as limited font choices, overall success was achieved. The sign-in page database was successfully developed, but the loan system feature faced database integration issues, particularly with Firebase as the MIT App Inventor lacks direct built-in support for Firebase Realtime Database, a cloud-hosted NoSQL database commonly used for real-time data synchronization.

According to a survey of 100 hospital leaders, nearly half of hospitals still rely on manual processes like spreadsheets for supply chain data management. Manual tracking methods, such as Excel spreadsheets, are also prevalent for tracking margins per case in operating room procedures. However, manual processes have their limitations, especially in time-sensitive situations related to patient safety and essential resources. Medical asset tracking through mobile applications becomes crucial in such scenarios. By reducing incidents associated with manual documentation, mobile applications enable users to search for and update data directly, minimizing transcription errors and speeding up data retrieval. The shift from paper-based to electronic documentation improves the overall management system.

The heuristic evaluation forms used in this study prove to be valuable tools in mobile application development for assessing usability and user experience. Mobile applications, being integral to daily life, heavily rely on usability and user experience for success. Ben Terrett's design principles emphasize user needs, requiring thorough research, data analysis, and user input without making assumptions. Empathy towards users' actual needs is crucial. Heuristic evaluation forms offer a structured framework for evaluators, chosen based on specific criteria relevant to mobile application development. Surveys conducted with four software engineers revealed that while MediLog is easy to use, with clear instructions and

industry-standard design, it has room for improvement in terms of functionalities, particularly expanding beyond details of machines and the loan system.

4. CONCLUSION

In summary, the development of this mobile application's user Interface was successfully created using MIT Apps software development. However, challenges arose in developing the database for the loan system, primarily due to limitations within MIT Apps development.

The emergence of the Internet of Things (IoT) has significantly impacted various aspects of our lives, including healthcare. In the hospital setting, IoT enables more efficient tracking and management of medical equipment and assets. The implementation of barcode tags on equipment, medications, and other assets provides real-time visibility into their location, status, and usage. This, in turn, aids in minimizing equipment loss, optimizing asset utilization, and streamlining maintenance workflows. The utilization of a barcode scanner facilitates a transition from paper-based documentation to a mobile application, offering improved tracking capabilities and simplifying the input of medical device data.

The effectiveness of this mobile application was assessed using a heuristic evaluation form, with software developers as respondents. While the majority of project objectives were successfully met, the database-related challenges with the loan form system resulted in partial success. Despite this limitation, the application demonstrates valuable progress and potential for enhancement in future iterations.

ACKNOWLEDGMENT

Special thanks to the Diagnostics Research Group and Department of Biomedical Engineering and Health Sciences of UTM for their contributions and support in this development project under the research grant Q.J130000.2651.15J83 .

CONFLICT OF INTEREST

The authors have no conflict of interest.

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