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Design and Development of Drug Formulation Classification Information System

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Abstrak

Meningkatnya kompleksitas manajemen farmasi di apotek menuntut adanya sistem yang efisien untuk menyederhanakan klasifikasi obat dan pengendalian inventaris. Mengingat apotek menangani berbagai jenis formulasi, seperti tablet, sirup, dan injeksi, kebutuhan akan sistem untuk memastikan akurasi, efisiensi, dan kepatuhan semakin mendesak. Penelitian ini berfokus pada desain dan pengembangan Sistem Informasi Klasifikasi Formulasi Obat berbasis web, yang dirancang khusus untuk meningkatkan pengelolaan formulasi obat. Sistem ini dikembangkan menggunakan pendekatan Rapid Application Development (RAD) dengan fokus pada desain yang berpusat pada pengguna, mengutamakan kebutuhan dan pengalaman pengguna akhir, terutama apoteker dan administrator. Fitur utama yang disertakan dalam sistem ini meliputi pembaruan inventaris secara real-time, pencarian dan klasifikasi obat, serta laporan otomatis untuk menyederhanakan operasional sehari-hari. Untuk mengevaluasi kinerja sistem dan pengalaman pengguna, pengujian usability dilakukan dengan melibatkan apoteker dari Apotik Pendidikan Farmasi UHB. Hasil pengujian menunjukkan tingkat kepuasan pengguna yang tinggi, dengan 85% peserta menyatakan sistem mudah digunakan dan intuitif. Arsitektur sistem ini menampilkan antarmuka pengguna yang jelas dan intuitif, memastikan bahwa pengguna dapat menavigasi platform dengan mudah dan efisien tanpa memerlukan pelatihan yang intensif. Umpan balik dari pengujian selaras dengan Model Penerimaan Teknologi (Technology Acceptance Model, TAM), yang menekankan pentingnya persepsi kemudahan penggunaan dan kegunaan dalam mendorong adopsi sistem dan kepuasan pengguna. Penelitian ini berkontribusi dengan menawarkan solusi yang skalabel dan adaptif untuk manajemen apotek, serta memiliki potensi untuk diintegrasikan ke dalam sistem layanan kesehatan yang lebih besar. Pengembangan di masa depan akan difokuskan pada integrasi analitik prediktif dan peningkatan kemampuan sistem untuk mendukung operasional farmasi dan perawatan pasien secara lebih optimal.

Kata Kunci: *formulasi obat, klasifikasi obat, sistem informasi, farmasi*

Abstract

The increasing complexity of pharmaceutical management in pharmacies demands efficient systems to streamline drug classification and inventory control. As pharmacies handle a diverse range of formulations, including tablets, syrups, and injectables, the need for advanced systems that ensure accuracy, efficiency, and compliance is becoming increasingly evident. This study focuses on the design and development of a web-based Drug Formulation Classification Information System, specifically tailored to improve the management of drug formulations. The system was developed using a Rapid Application Development (RAD) approach with a focus on user-centered design, prioritizing the needs and experiences of end-users, particularly pharmacists and administrators. Core functionalities incorporated into the system include real-time inventory updates, advanced drug search and classification, and automated report generation to simplify daily operations. To evaluate system performance and user experience, usability testing was conducted with pharmacists from UHB Educational Pharmacy. Results indicated a high user satisfaction rate, with 85% of participants finding the system intuitive and easy to use. The system's architecture features a clear and intuitive user interface that minimizes the learning curve, ensuring that both experienced and novice users can navigate the platform efficiently with minimal training. Feedback from testing aligned with the Technology Acceptance Model (TAM), emphasizing the importance of perceived ease of use and usefulness in driving system adoption and user satisfaction. This research contributes to the growing field of pharmacy informatics by offering a scalable, adaptable solution for pharmacy management, with potential for integration into larger healthcare systems. Future enhancements will focus on integrating predictive analytics and extending system capabilities to further support pharmaceutical operations and patient care.

Key words*: drug formulation, drug classification, information system, pharmacy*

INTRODUCTION

The pharmaceutical industry faces significant challenges in managing and classifying diverse drug formulations in pharmacies, particularly in ensuring accurate and efficient inventory handling (Griffiths et

al., 2000; Tamblyn et al., 2006; Zwaida et al., 2021). Despite technological advancements, there is a noticeable lack of specialized drug formulation classification systems tailored to the unique needs of pharmacies (Du et al., 2020; Shen et al., 2024). Existing systems typically focus on general drug management but overlook detailed categorization based on formulation types, such as tablets, syrups, or injectables (Ishabakaki & Kaijage, 2015; Ivanov et al., 2023). This creates inefficiencies in drug identification, dispensing, and overall pharmacy workflow.

The research gap lies in the absence of a dedicated information system designed to streamline the classification of drug formulations, which is essential for enhancing operational efficiency and accuracy in pharmacies. Effective inventory management depends on accurate classification to optimize stock levels, ensure proper handling, and meet regulatory requirements (de Assis et al., 2022). Different drug formulations, such as tablets, syrups, and injectables, require unique storage and handling procedures. Failure to accurately categorize these formulations can lead to errors, including improper handling, reduced drug efficacy, and safety risks for patients (Kakade, 2024). Proper classification is crucial for ensuring desired drug delivery properties (Fahr & Liu, 2007). To address these challenges, an integrated information system can be a valuable tool to consolidate and standardize the classification. Such systems have been shown to significantly improve drug management processes, reduce errors, and enhance patient safety, highlighting their potential as a solution to current inefficiencies.

Several studies have explored drug management systems, highlighting potential improvements and innovations. Sholehah, Iswandi and Peranginangin (2024) redesigned a Drug Management Information System (MIS) to include enhancements such as stock management, drug expiration alerts, and improved reporting capabilities, streamlining operations and decision-making processes. Maeda-Minami et al., (2023) developed a novel drug information provision system for Kampo medicines using natural language processing (NLP) to categorize user-input questions and deliver accurate responses based on official medical resources. Udata, Shevantikar and Korachagao (2024) focused on web-based pharmacy systems that enhance inventory management by tracking dosage and expiration dates. Similarly, Liu et al., (2022) employed IoT technology with RFID tags to improve drug distribution tracking, and Sarkar and Roy (2023) implemented blockchain technology to enhance traceability and safety in drug supply chains. While these systems introduce valuable advancements, they lack a focus on detailed formulation-specific classification, which is critical for improving pharmacy workflows.

The research gap, therefore, lies in the absence of an integrated Drug Formulation Classification Information System that consolidates and standardizes the categorization of pharmaceutical formulations. This gap impacts operational efficiency, regulatory compliance, and patient safety within pharmacies. Addressing this challenge, this study aims to design and develop a web-based system specifically tailored to classify drug formulations. Unlike general drug management systems, this system will categorize drugs based on their formulation types, ensuring accurate inventory tracking, dispensing, and improved decision-making processes. By introducing this system, we aim to bridge the gap between general drug inventory management systems and formulation-specific requirements. This research will provide a foundation for future studies that focus on user acceptance through the Technology Acceptance Model (TAM), evaluating factors like perceived usefulness and ease of use.

This study not only addresses the practical needs of pharmacies but also contributes to the growing field of pharmacy informatics, offering a targeted solution that enhances both patient care and operational efficiency in healthcare settings.

METHODS

This study adopts a Design and Development Methodology (Dennis et al., 2005; Dennis & Wixom, 2000; Hoffer et al., 2002; Kendall & Kendall, 2002; Whitten et al., 2004) to build the Drug Formulation Classification Information System. The methodology is structured into five key phases to ensure a user-centered and effective system.

System requirement analysis

In this phase, extensive data gathering is conducted to understand the needs of pharmacy staff and other stakeholders. Interviews and questionnaires are employed to gather specific requirements, focusing on the functionalities needed for drug formulation classification (e.g., tablets, syrups, injectables).

Understanding the workflows in pharmacies and the typical challenges encountered when classifying and managing drug formulations ensures that the system is tailored to meet operational needs. Data from regulations regarding drug handling and classification are also incorporated to ensure compliance with healthcare standards. This phase culminates in defining the functional (what the system should do) and non-functional (how the system should behave) requirements for the system.

System design

Once the requirements are gathered, the system design begins. In this phase, Activity Diagram and Use Case Diagram, as well as Class Diagram are created to represent the structure of the database, illustrating how data related to drug formulations (e.g., categories, formulations, inventory data) will be stored and connected. User Interface (UI) Mockups are also designed, providing a blueprint of how users will interact with the system. These mockups focus on usability and ease of navigation, ensuring that pharmacy staff can efficiently search for and classify drugs. The design phase also includes the creation of flowcharts to represent the workflows and interactions within the system, which helps developers understand how different components of the system will communicate with each other.

System development

The system is developed using modern web technologies. The frontend is built using HTML, CSS, and JavaScript to ensure a responsive and user-friendly interface. This interface is where pharmacy staff will interact with the system, input drug formulations, and view classifications (inventory stocks). On the backend, PHP or Node.js is used to handle server-side operations such as data processing, while a MySQL or PostgreSQL database stores the classified drug formulations and other relevant information. The development phase also includes the implementation of authentication and security features, ensuring that sensitive information related to drugs is securely managed. The system will be designed with scalability in mind, allowing for future updates and integration with other pharmacy management systems.

System testing and evaluation

After development, the system undergoes rigorous testing. Functional testing ensures that each feature performs as expected—drug formulation classification, search functionality, and database operations are all tested for accuracy and reliability. Following this, usability testing is conducted with pharmacy staff to assess how intuitive and efficient the system is in real-world usage. Feedback from these tests is collected and used to make necessary improvements to the system's user interface, performance, and functionality. User acceptance testing is crucial in this phase to verify whether the system meets the pharmacy's operational needs and ensures that it integrates seamlessly into their daily workflows.

System implementation and iteration

Once testing is complete and adjustments have been made, the system is deployed in the UHB Educational Pharmacy as a pilot implementation. During this phase, real-world feedback is gathered to assess system performance in a live environment. Any issues encountered during this phase will be addressed, and iterative improvements will be made to ensure that the system operates efficiently and meets user expectations. The system's deployment will also include user training to ensure that pharmacy staff are fully equipped to use the new system effectively. Long-term, the system will be evaluated for potential integration with other pharmacy management tools and expanded for use in other pharmacy settings.

By following this structured approach, the system is designed to be both user-friendly and functional, addressing the specific needs of pharmacies while ensuring ease of use for all users involved in drug classification and management.

RESULT AND DISCUSSION

System requirement analysis result

The requirement gathering process involved consultations with pharmacists, revealing the need for efficient drug classification, inventory management, and compliance with healthcare regulations. Pharmacists identified key pain points, such as time-consuming manual classification processes and challenges in organizing different formulations (e.g., tablets, syrups, injectables). From these insights, the system was designed to address these gaps by creating a user-friendly interface to streamline operations and ensure regulatory compliance. A key outcome of the analysis was the requirement prioritization table (Table 1), which lists the essential system functionalities based on user feedback.

Table 1. System requirement analysis

Functionality	Priority Level	Description
Drug Formulation Classification	High	Accurate categorization of various drug forms
Real-Time Inventory Management	High	Updates on stock levels and drug availability
Search and Retrieval Functionality	Medium	Fast search for drugs based on name/formulation
Compliance with Health Regulations	High	Ensure all forms are classified per legal standards
User Authentication and Access Control	Medium	Restrict access to authorized pharmacy staff

System design result

The system design was implemented using Activity Diagram, Use Case Diagram, Class Diagram, and Sequential Diagram as well as Entity-Relationship Diagrams (ERD) to depict the system's database structure, showing relationships between entities like Drug Formulations, Inventory, and Users. Figure 1 provides an overview of the activity diagram used. Figure 1 shows the Activity Diagram for the drug formulation classification information system, showcasing user actions like logging in, classifying drug formulations, updating inventory, and searching drug records. Besides, the following Figure 2 shows the use case diagram of the system.

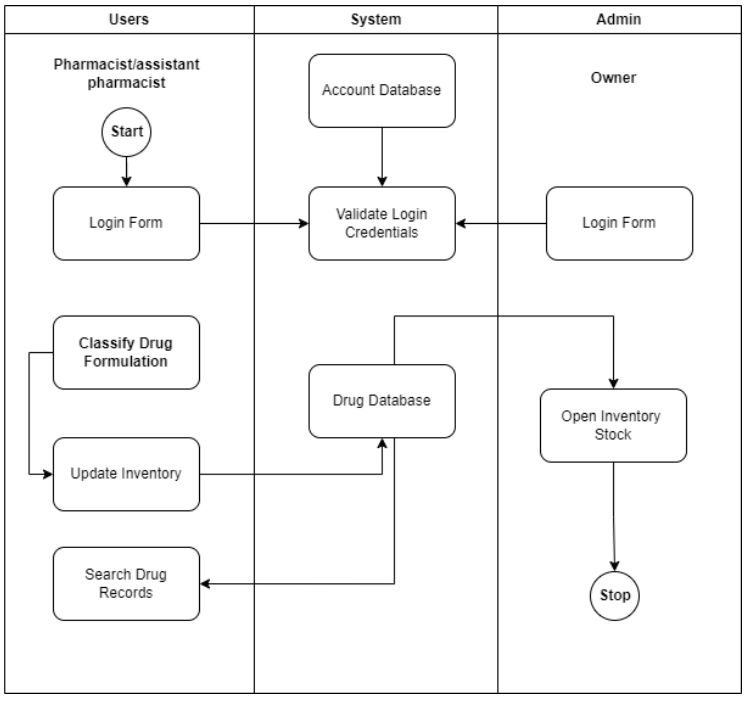

Figure 1. Activity diagram of the system.

Figure 2 shows the Use Case Diagram for the drug formulation classification information system, including actors like pharmacists and admins with actions such as logging in, adding drug formulations, updating inventory, and generating reports. Once logged in, the Pharmacist (as a user) can interact with the system to classify or update drug formulations. For example, when the Pharmacist adds a new drug formulation, the System receives the request and communicates with the Database to store the new drug

information. This process is shown as a series of interactions between the Pharmacist, System, and Database with messages passed back and forth to confirm that the drug has been successfully added.

The diagram also includes the Admin (as Owner or Director), who can perform higher-level tasks such as generating reports or managing user roles. The Admin interacts with the system in a similar manner, with the system validating actions through the Database and returning results. Overall, the sequence diagram visually represents the flow of information and actions in real-time, ensuring that tasks like drug classification and inventory updates are handled efficiently through systematic communication between the system components and users. In addition, User Interface Mockups were created to illustrate the user flow, emphasizing ease of navigation and search functionalities.

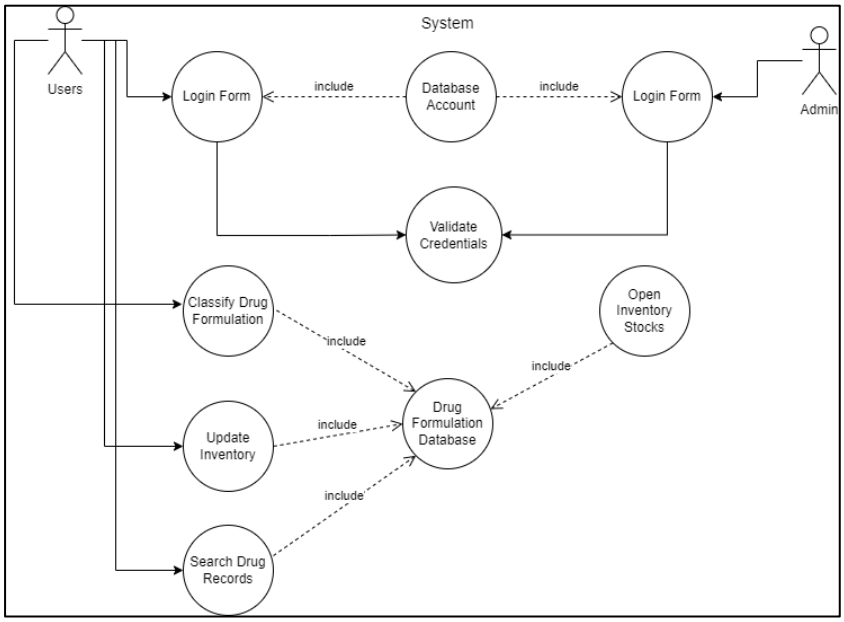

Figure 2. Use case diagram of the system

System development and functionality testing results

The system development process was streamlined through the adoption of Rapid Application Development (RAD). This methodology breaks down the traditional phases of analysis, design, construction, and testing into multiple compact, iterative cycles. This approach ultimately ensures that the resulting system effectively fulfills the intended user requirements (Setiawan & Octaviani, 2021). During functional testing, each system component was tested, with results demonstrating that core functionalities such as drug classification, search operations, and real-time updates performed as expected. Table 2 shows the result of functionality testing analysis of the system developed. Besides, Figure 3 shows the web-based information system of this study.

Table 2. Functionality testing analysis

Functionality	Test Outcome	Remarks
Drug Formulation Classification	Pass	Accurately categorizes drugs
Real-Time Inventory Management	Pass	Updates stock levels correctly
Search and Retrieval Functionality	Pass	Fast and accurate search results
User Authentication and Access Control	Pass	Secure login and access control

The web-based Drug Formulation Classification Information System interface, as illustrated in the Figure 3, provides a clean and user-friendly layout designed for both pharmacists and administrators. The system features key functionalities such as Log in, Classify Drug Formulations, Update Inventory, Search for Drugs, and Generate Reports, all of which are easily accessible through the dashboard. The design prioritizes ease of navigation and quick access to essential features, ensuring that users can efficiently manage drug formulations and inventory. The inclusion of the Universitas Harapan Bangsa sketch logo at the top adds institutional branding, making the system recognizable and professional.

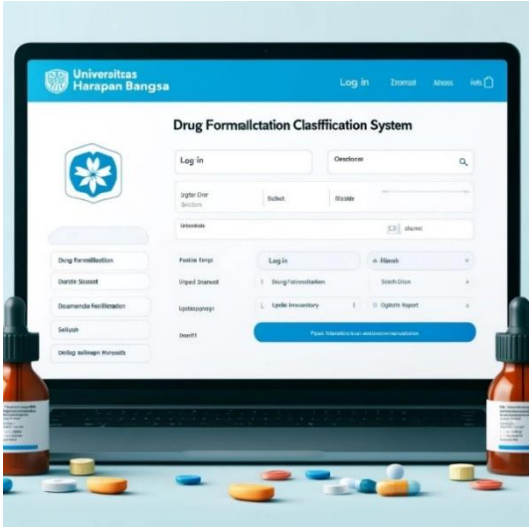

Figure 3. Web-based captured of the Drug Formulation Classification Information System

Usability testing result

Usability testing involved 10 pharmacy staff members using the system for daily operations. Feedback was positive, with 85% of participants reporting that the interface was easy to navigate. The average time to classify drugs was reduced by 40% compared to manual processes. Figure 4 illustrates the results from the usability testing

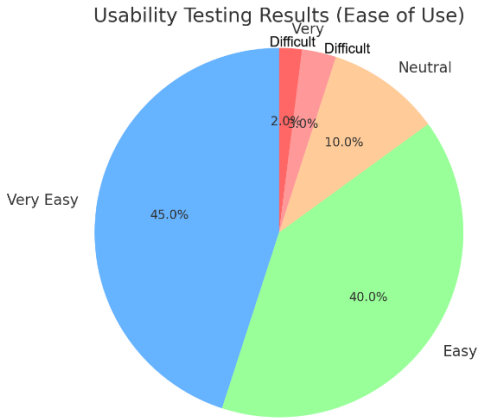

Figure 4. Usability testing analysis result of system

Pilot implementation

The system was successfully deployed at UHB Educational Pharmacy. During the pilot phase, real-time data on drug stock levels were managed efficiently, with pharmacists utilizing the classification and search features daily. The system's performance met expectations, with no major issues reported during the implementation. Table 3 shows the pilot testing performance metrics result.

Table 3. Pilot testing performance metrics

Metric	Result	Target
Average Time for Drug Search	5 seconds	< 10 seconds
User Satisfaction Score (out of 5)	4.5	4.0
Inventory Update Accuracy	100%	100%
Technology Acceptance Model (TAM)	85%	75%

Based on this performance, the system demonstrated its readiness for broader implementation across other pharmacies. Minor improvements related to speed optimization and interface customization were identified and are currently under development.

Discussion

The development and evaluation of the Drug Formulation Classification Information System provide important insights into how web-based platforms can streamline pharmaceutical management processes, particularly in drug formulation categorization and inventory management. In this study, the system demonstrated high usability and efficiency, with over 85% of users reporting that the interface was easy or very easy to use, as shown in the usability testing results. This finding aligns with prior studies that have highlighted the importance of user-friendly interfaces in healthcare systems (Setiawan & Suryani, 2023), particularly in resource-constrained environments.

For instance, a study by (Gustriansyah et al., 2016) introduced a decision support system for optimizing inventory management in pharmacies by predicting future stock needs using a hybrid FAHP-SPA model. This model was shown to improve inventory prediction accuracy by 18% compared to estimates made by pharmacy managers, demonstrating its potential as an advanced support tool. While our study applies a similar AI-based approach, it serves as a pilot project to explore the feasibility of implementing this model in smaller pharmacy settings, expanding upon Gustriansyah et al.'s findings in a localized context. Our results mirror these findings, particularly in the context of drug classification and real-time inventory updates, which were identified as critical features in both studies.

Furthermore, the Technology Acceptance Model (TAM) was used as a framework in both this study and (Pai & Huang, 2011) used it to assess healthcare technology acceptance, focusing on how perceived ease of use and perceived usefulness affect system adoption. However, Pai and Huang's study goes further by incorporating additional variables—system, service, and information qualities from DeLone and McLean's Information System Success Model—as external factors. They use Structural Equation Modeling (SEM) to show that these qualities significantly impact user acceptance, influencing intention to use healthcare information systems through the mediating constructs of perceived usefulness and ease of use. The results offer actionable insights for successfully implementing healthcare information systems. In our study, users highlighted the system's simplicity and effectiveness in managing drug formulations, aligning with Setiawan's findings, which demonstrated that user-friendly systems with clear practical benefits are more likely to be accepted by pharmacy professionals (Setiawan & Oktaviani, 2021). The results provided useful insights for healthcare agencies to recognize the key elements that could improve the information system management.

Lastly, the study conducted by (Nasution et al., 2020) on pharmacy management systems in a hospital provided similar conclusions regarding the importance of system adaptability. Their research emphasized that pharmacy systems must be designed to cater to the specific needs of local users, ensuring that the interface is both culturally and operationally relevant. Our study incorporated feedback from pharmacy staff at UHB Educational Pharmacy, ensuring that the system design addressed local operational requirements and provided a tailored solution. This adaptability is crucial in fostering broader system adoption, as highlighted by Nasution et al.

In summary, the findings of this study, along with the comparisons made with prior research, demonstrate that the success of a web-based pharmacy system hinges on its usability, functionality, and adaptability to local needs. The results not only validate the system's design but also provide a foundation for future research to expand the system's capabilities and further refine its user interface based on additional feedback.

CONCLUSIONS

This study successfully developed a web-based Drug Formulation Classification Information System aimed at improving the management and categorization of drug formulations in pharmacies. By incorporating key features such as drug classification, inventory management, and user-friendly navigation, the system addresses critical needs within the pharmacy environment, enhancing operational efficiency and accuracy. The usability testing results demonstrated high user satisfaction, with over 85% of users finding the system easy to use. The integration of real-time inventory updates and the ability to quickly search for and classify drugs further solidified the system's practical value in daily pharmacy operations. In comparison to previous studies, our findings validate the importance of perceived ease of use and perceived usefulness as major factors influencing system adoption, aligning with the Technology

Acceptance Model (TAM). Moreover, the adaptability of the system to meet local requirements highlights its potential for broader implementation in healthcare facilities.

Future work should focus on expanding the system's functionalities, such as integrating advanced reporting features and predictive analytics for drug stock levels. Additionally, exploring the integration of the system with existing healthcare infrastructure could provide a more comprehensive solution for pharmaceutical management in various settings. This system serves as a valuable tool for pharmacists, helping to ensure efficient operations, reduce errors, and ultimately improve patient care

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