

Development of a Web-Based Medical Terminology Learning Application Integrating Medical Term Components and Definitions

Ayuk Era Edwina Noviana^{1*}, I Made Sudarma Adiputra¹, Made Wahyu Aditya¹

¹Diploma Three Medical Record and Health Information Study Program, STIKES Wira Medika Bali

Email: ayuera31199@gmail.com*

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ABSTRACT

Background: Medical terminology is an essential competency for Medical Records and Health Information students because it supports accurate clinical documentation and diagnosis coding. However, students often experience difficulties in understanding medical terms and identifying their constituent elements, including prefixes, roots, and suffixes. Currently, few web-based medical terminology applications integrate medical term definitions together with prefix, root, suffix, and meaning information stored in a database into a single platform. This study aimed to develop a web-based medical terminology application as a learning medium. **Methods:** This study employed a Research and Development (R&D) approach using the Waterfall software development model. The application was developed using PHP and MySQL. User-entered medical terms were searched against a relational database containing predefined medical terms and prefix, root, suffix, and meaning information stored in the database. Matching records were retrieved and displayed, whereas unavailable terms generated search suggestions. The application was evaluated for functionality, interface design, and usability using black-box testing, interface design assessment, and the System Usability Scale (SUS) by two media experts and nine Medical Records and Health Information students. **Results:** The application achieved an average black-box testing score of 98%, indicating very valid functionality. Black-box testing confirmed that the application functioned as intended by retrieving and displaying predefined medical terminology records (e.g., bronchitis and rhinoplasty) together with the corresponding prefix, root, suffix, and meaning information stored in the database, while generating search suggestions for unavailable terms. The interface design assessment scored 96%, while the System Usability Scale achieved a score of 93, corresponding to Grade A+ with a Best Imaginable user experience. **Conclusion:** The developed application is feasible as a learning medium for medical terminology. The application assists users in understanding medical terms by displaying medical term definitions together with prefix, root, suffix, and meaning information stored in the database.

Keywords: Education, Professional; Medical Informatics; Medical Records; Students; Terminology as Topic

INTRODUCTION

Medical terminology is a fundamental component of health information management and plays a crucial role in ensuring accurate clinical documentation, disease classification, and communication among healthcare professionals (1). Proficiency in medical terminology enables healthcare personnel to interpret clinical information consistently and supports the accuracy of diagnosis coding, which is essential for maintaining high-quality health information services (2). In Indonesia, diagnosis coding has been established as one of the core competencies for Medical Records and Health Information professionals, emphasizing the importance of mastering medical terminology throughout professional education (3). Therefore, strengthening medical terminology competence is essential to prepare future health information professionals capable of supporting safe, accurate, and effective healthcare services.

Advances in science and technology have significantly influenced the development of education by improving learning quality and preparing human resources to meet the demands of the digital era (4). This trend has accelerated the integration of digital learning into health professional education, providing students with more flexible and accessible learning opportunities (5). In Indonesia, this development is also aligned with the Regulation of the Minister of Education, Culture, Research, and Technology of the Republic of Indonesia No. 53 of 2023, which emphasizes that higher education should be implemented effectively, inclusively, and adaptively in response to the advancement of science and technology (6).

Web-based learning media can be accessed through the internet, enabling students to learn anytime and anywhere (7). Although various digital learning resources have become increasingly available, learning medical

terminology remains challenging because students are required not only to memorize medical terms but also to understand the meanings and relationships among their constituent elements, including prefixes, roots, and suffixes (8). Websites consist of interconnected web pages that can be accessed via the internet (9). In Medical Records and Health Information education, this understanding is essential because accurate interpretation of medical terminology directly supports clinical documentation and diagnosis coding. Therefore, the development of interactive web-based learning media has the potential to facilitate a more systematic understanding of medical terminology and its structural components.

Recent studies have demonstrated that digital learning interventions can improve students' understanding of medical terminology and strengthen their ability to decode complex medical terms, supporting the integration of digital approaches into health professional education (10). Previous studies have developed various digital resources to support medical terminology learning, including medical terminology flashcards (11), web-based applications for clinical coding practice (14), and website-based applications focusing on procedure terminology within specific body systems, such as the respiratory system (1). While these studies have contributed to digital learning, they primarily focused on specific learning contexts or limited medical terminology content. Consequently, there remains a need for a comprehensive web-based learning application that enables users to search medical terms and access predefined terminology component information, including prefixes, roots, suffixes, and meanings, within a single platform.

Despite these developments, challenges in learning medical terminology remain among Medical Records and Health Information students. Preliminary observations and informal interviews conducted with students of the Medical Records and Health Information Study Program at STIKES Wira Medika Bali indicated that students relied on multiple learning resources, including textbooks, presentation slides, PDF documents, and internet search engines, to understand medical terminology. Because these resources were accessed separately, students had to switch between different learning materials to identify medical term definitions and understand their morphological components, making the learning process less efficient. These findings also reflect the practical need for such a comprehensive learning platform among Medical Records and Health Information students.

To address this gap, this study developed a web-based medical terminology application that integrates medical term definitions together with predefined terminology component information stored in the database within a single learning platform. Unlike previous applications that were developed for specific learning contexts, such as clinical coding practice or particular body systems, the proposed application provides a searchable medical terminology database covering a broader range of medical terminology. It enables users to retrieve medical terms together with corresponding prefix, root, suffix, and meaning information stored in the database through a database-driven retrieval mechanism. This integrated approach is expected to facilitate a more efficient understanding of both the meaning and relationships among medical term components. Therefore, this study aimed to develop a web-based medical terminology application that provides medical term definitions together with predefined prefix, root, suffix, and meaning information stored in the database, and to evaluate its functionality, interface design, and usability as a learning medium for Medical Records and Health Information students.

METHODS

This study employed a Research and Development (R&D) approach. Research and Development is a systematic research approach used to design, develop, and validate a product (15). The application was developed using the Waterfall software development model, a Software Development Life Cycle (SDLC) approach (16) comprising the stages of requirements analysis, system design, implementation, and testing (17). The medical terminology search feature was implemented using a database-driven retrieval mechanism. User-entered medical terms were matched with a relational database containing predefined medical terms together with predefined prefix, root, suffix, and meaning information. When an exact term was found in the database, the system retrieved the corresponding terminology record and displayed the medical term together with the corresponding prefix, root, suffix, and meaning information stored in the database. The maintenance stage was not included because the study was limited to application development and evaluation. The study focused on the development and evaluation of a web-based medical terminology application, which was assessed in terms of system functionality, interface design, and usability. The study was conducted at the Medical Records Management Laboratory of STIKES Wira Medika Bali from January to February 2026.

The study population consisted of students from the Medical Records and Health Information Study Program at STIKES Wira Medika Bali. Participants were selected using purposive sampling based on predefined characteristics relevant to the objectives of the study (18). The sample consisted of two media experts with professional experience in information technology and web-based system development and nine Medical Records and Health Information students who had completed the Medical Terminology course. Both groups participated in the functionality, interface design, and usability evaluation of the application.

The application was implemented as a web-based medical terminology learning application that enables users to search predefined medical terms and retrieve corresponding prefix, root, suffix, and meaning information from a relational database. The application was implemented as a web-based software application designed to perform specific functions according to users' needs (19). The system was designed using Context Diagrams, Data Flow Diagrams (DFD), and Entity Relationship Diagrams (ERD). Context Diagrams and DFD were used to model the system functions and data flow (20), whereas ERD was used to define the logical structure and relationships of the database (21). The application was developed using PHP as the programming language and MySQL as the database management system (22), following the implementation stage of the Waterfall software development model. Visual Studio Code was used as the development environment, while XAMPP functioned as the local web server by providing Apache and MySQL services to support PHP-based application development (23). HTML, CSS, and JavaScript were used to develop the user interface and interactive features (24).

Data were collected through application evaluation using black-box testing, interface design assessment, and the System Usability Scale (SUS). Black-box testing was conducted to verify whether the application functions operated according to the specified input and output requirements without examining the source code (25). Representative test cases were developed using the equivalence partitioning technique (26). The black-box evaluation showed that the application successfully retrieved predefined medical terminology records from the relational database based on user input and displayed the corresponding prefix, root, suffix, and meaning information stored in the database. The evaluation also confirmed that unavailable terms generated appropriate search suggestions. Interface design assessment evaluated the quality of the user interface based on layout, navigation, readability, visual appearance, and ease of interaction (27). Furthermore, the System Usability Scale (SUS) questionnaire was administered to both media experts and students to measure the application's usability and overall user acceptance (28).

The collected data were analyzed using descriptive quantitative analysis. Black-box testing and interface design assessment results were converted into percentage validity scores to determine the application's functional validity and interface quality (29). System usability was evaluated using the System Usability Scale (SUS), and the obtained scores were interpreted according to the standard SUS grading and acceptability categories (30). The findings were presented in tables accompanied by descriptive explanations. The calculation methods used for each evaluation instrument are presented in Equations (1)-(3).

The black-box testing validity score was calculated based on the proportion of predefined test scenarios that successfully produced the expected outputs. The percentage validity of black-box testing was calculated using Equation (1).

$$\text{Validity (\%)} = \frac{\text{JSK} - \text{JTSH}}{\text{TSP}} \times 100\% \quad (1)$$

Where:

JSK = Number of test scenarios

JTSH = Number of unsuccessful test scenarios

TSP = Total test scenarios

The percentage validity of the interface design assessment was calculated using Equation (2).

$$\text{Validity (\%)} = \frac{\text{Obtained Score}}{\text{Maximum Score}} \times 100\% \quad (2)$$

The percentage validity scores obtained from black-box testing and interface design assessment were interpreted according to the validity criteria presented in Table 1.

Table 1. Validity Criteria

Num.	Category	Percentage (%)
1	Very Invalid	0-20
2	Invalid	21-40
3	Fairly Invalid	41-60
4	Valid	61-80
5	Very Valid	81-100

The System Usability Scale (SUS) score was calculated using Equation (3).

$$SUS = (\sum \text{Adjusted Scores}) \times 2.5 \quad (3)$$

For odd-numbered items, one point was subtracted from each response score, whereas for even-numbered items, each response score was subtracted from five. The adjusted scores were summed and multiplied by 2.5 to obtain the final SUS score (28). The interpretation of SUS scores followed the standard acceptability, grade scale, and adjective rating and is presented in Figure 1.

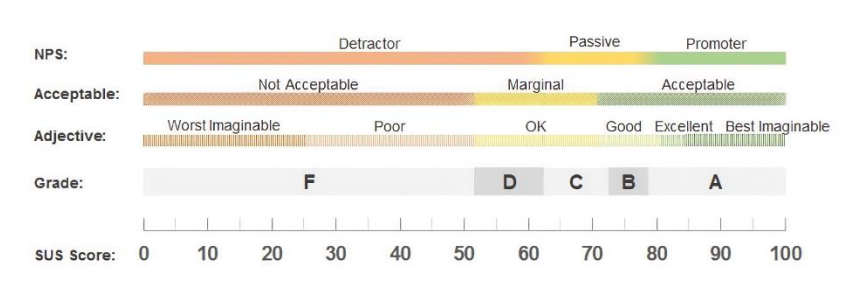


Figure 1. Interpretation of SUS scores

The overall research procedure, including requirements analysis, system design, implementation of the database-driven medical terminology retrieval feature, application evaluation, and data analysis, is summarized in the research stages flowchart shown in Figure 2.

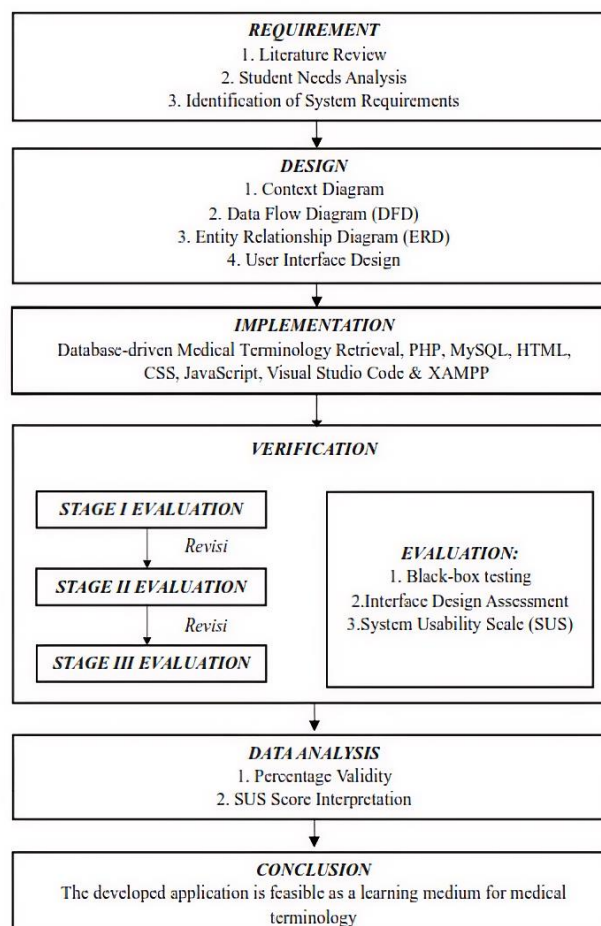


Figure 2. Research Stages Flowchart

RESULTS

Following the implementation of the proposed system design, a web-based medical terminology application was successfully developed. The application integrates medical term definitions together with predefined terminology component information stored in the database within a single platform to support learning for Medical Records and Health Information students. It consists of several main features, including user registration, login, medical terminology search, application guidance, and an administrative module for terminology management. When a valid medical term is entered, the application retrieves and displays corresponding prefix, root, suffix, and meaning information from the database. Representative interfaces of the final developed application including the introductory page, login, account registration, medical terminology search dashboard, user guide, and application information are presented in Figures 3-8.

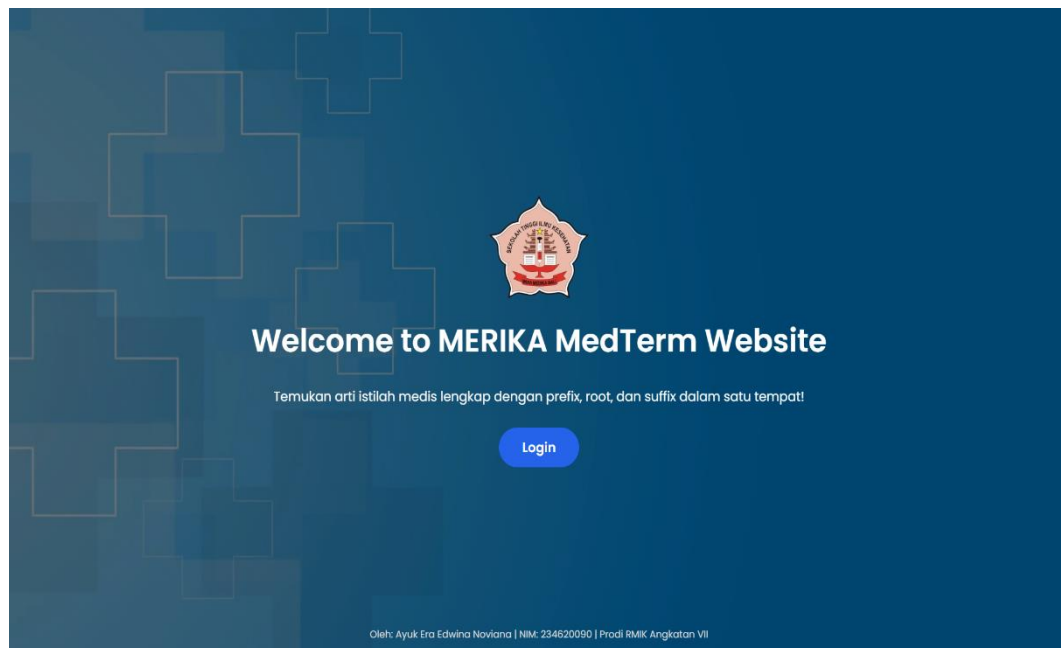


Figure 3. Landing and Introductory Page of the Application

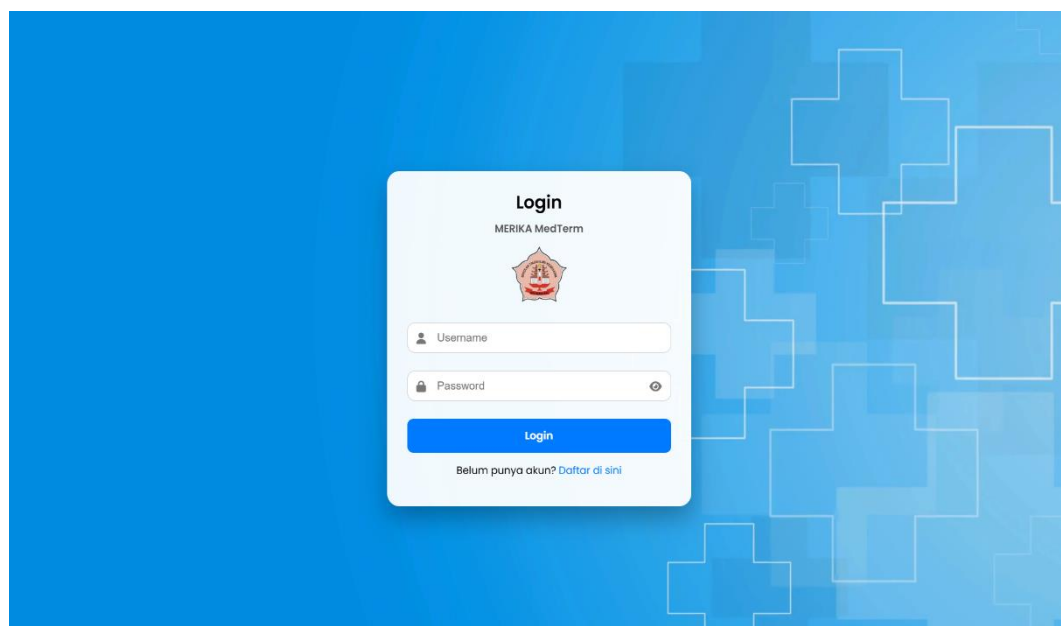
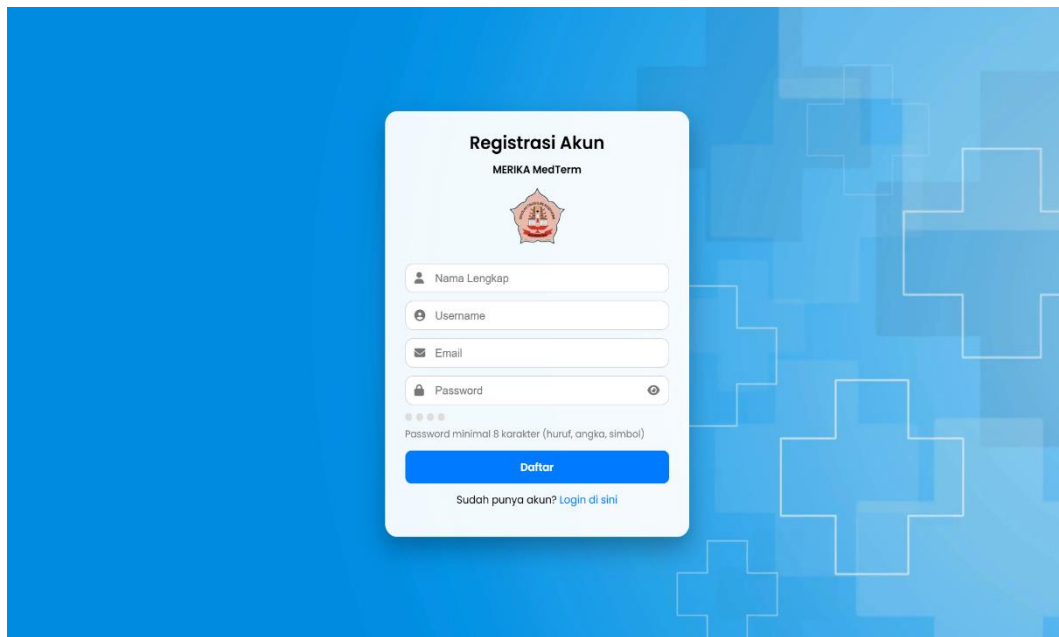
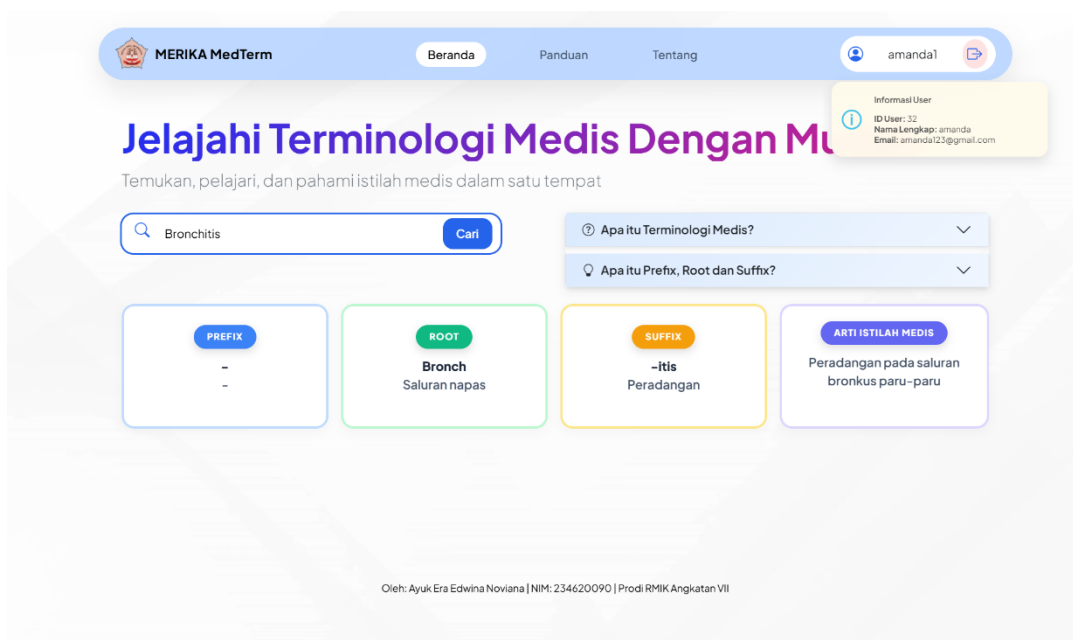


Figure 4. Login Page



The image shows a registration form titled "Registrasi Akun" for "MERIKA MedTerm". The form is centered on a blue background with a white cross pattern. It includes input fields for "Nama Lengkap", "Username", "Email", and "Password". Below the password field, there is a note: "Password minimal 8 karakter (huruf, angka, simbol)". A blue "Daftar" button is at the bottom of the form, and a link "Sudah punya akun? Login di sini" is below it.

Figure 5. User Account Registration Page



The image shows the main dashboard of the "MERIKA MedTerm" application. The header includes the logo, navigation links "Beranda", "Panduan", and "Tentang", and a user profile section for "amanda1". The main content area features a search bar with "Bronchitis" entered and a "Cari" button. Below the search bar, there are four colored boxes: "PREFIX" (blue), "ROOT" (green), "SUFFIX" (orange), and "ARTI ISTILAH MEDIS" (purple). The "ROOT" box shows "Bronch" and "Saluran napas". The "SUFFIX" box shows "-itis" and "Peradangan". The "ARTI ISTILAH MEDIS" box shows "Peradangan pada saluran bronkus paru-paru". At the bottom, there is a footer with the text: "Oleh: Ayuk Era Edwina Noviana | NIM: 234620090 | Prodi RMIK Angkatan VII".

Figure 6. Main Dashboard for Medical Terminology Search

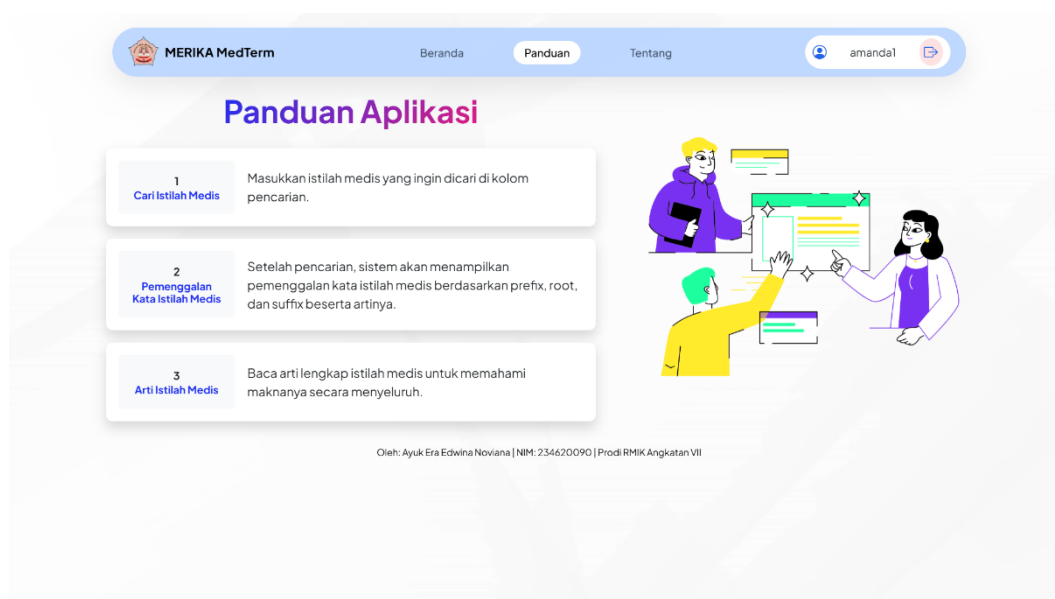


Figure 7. Platform Usage Guidelines and Tutorial Page

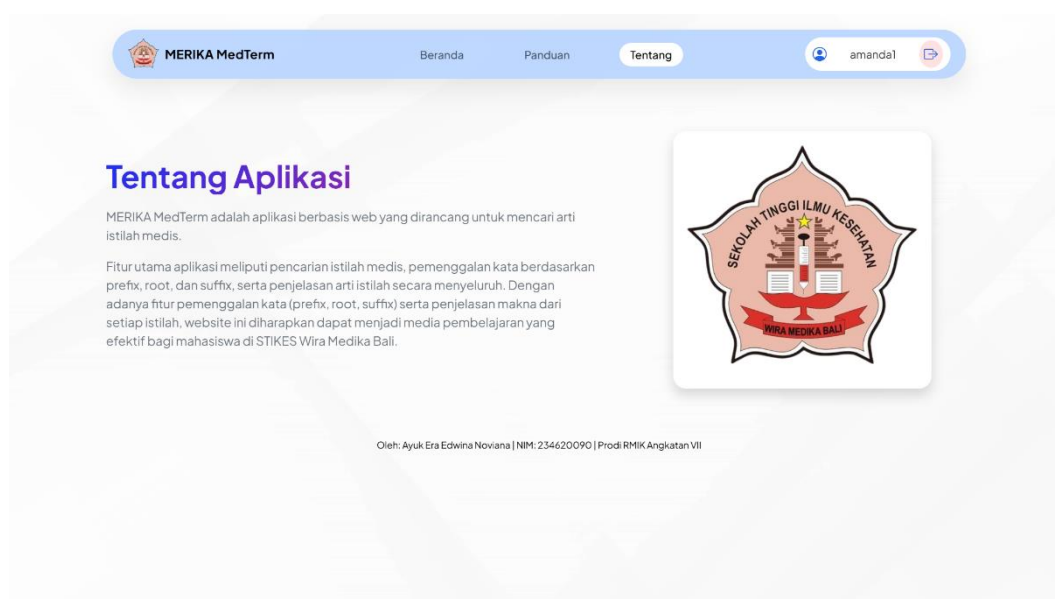


Figure 8. Application Information and System Details Page

The first-stage evaluation was conducted after the initial implementation of the application. The first-stage evaluation involved two media experts with expertise in information technology and web-based system development and nine Medical Records and Health Information students who had completed the Medical Terminology course. Data were collected using black-box testing, interface design assessment, and the System Usability Scale (SUS).

The first-stage results demonstrated satisfactory levels of system functionality, interface quality, and usability. During black-box testing, participants showed that the application successfully retrieved predefined medical terminology records according to the expected outputs and displayed the corresponding prefix, root, suffix, and meaning information retrieved from the database. For unavailable terms, the application generated appropriate search suggestions. Nevertheless, several recommendations for improvement were identified by both media experts and students, leading to revisions before the second-stage evaluation. The results of the first-stage evaluation are presented in Table 2.

Table 2. Results of the Stage I Application Evaluation

Num.	Evaluation	Media Experts (n = 2)		Students(n = 9)	
		Score	Category	Score	Category
1	Black-box Testing	100%	Very Valid	99%	Very Valid
2	Interface Design Assessment	90%	Very Valid	86%	Very Valid
3	System Usability Scale (SUS)	86.25	Acceptable, Grade A+, Best Imaginable	80.28	Acceptable, Grade A+, Good

Based on the recommendations obtained during the first-stage evaluation, several revisions were implemented to improve the application's functionality, interface consistency, and overall user experience. These revisions included strengthening password security requirements, standardizing the system language, improving application notifications using toast messages, adding logout confirmation, and refining the application layout and interface. In addition, icons and color variations were incorporated into the introduction page and navigation menu to enhance visual appearance and usability.

Following the implementation of the first-stage revisions, the application was re-evaluated using the same evaluation instruments involving the same two media experts and nine Medical Records and Health Information students. The results of the second-stage evaluation are presented in Table 3.

Table 3. Results of the Stage II Application Evaluation

Num.	Evaluation	Media Experts (n = 2)		Students (n = 9)	
		Score	Category	Score	Category
1	Black-box Testing	93%	Very Valid	100%	Very Valid
2	Interface Design Assessment	97%	Very Valid	91%	Very Valid
3	System Usability Scale (SUS)	93.75	Acceptable, Grade A+, Best Imaginable	83.89	Acceptable, Grade A, Excellent

Compared with the first-stage evaluation, the second-stage evaluation demonstrated improvements in interface design validity and System Usability Scale (SUS) scores following the implementation of the recommended revisions. Based on the recommendations obtained during the second-stage evaluation, several minor revisions were implemented to improve system performance and consistency. These revisions included restricting the password length indicator to the registration page, adding duplicate email validation during user registration, and correcting the functionality of the user profile icon.

After implementing the second-stage revisions, a final evaluation was conducted using the same assessment instruments involving the two media experts. The results demonstrated that all assessed aspects achieved the highest scores obtained throughout the evaluation process and are presented in Table 4.

Table 4. Results of the Final Evaluation

Num.	Evaluation	Media Experts (n = 2)	
		Score	Category
1	Black-box Testing	100%	Very Valid
2	Interface Design Assessment	100%	Very Valid
3	System Usability Scale (SUS)	100	Acceptable, Grade A+, Best Imaginable

The final evaluation confirmed that all assessment aspects achieved the highest possible scores, indicating that the revisions successfully addressed the issues identified during the previous evaluation stages. The overall evaluation results are summarized in Table 5.

Table 5. Summary of Evaluation Results

Num.	Evaluation	Stage I	Stage II	Stage III	Average	Category
1	Black-box Testing	100%	93%	100%	98%	Very Valid
2	Interface Design Assessment	90%	97%	100%	96%	Very Valid
3	System Usability Scale (SUS)	86.25	93.75	100	93	Acceptable, Grade A+, Best Imaginable

Overall, the developed application achieved an average black-box testing validity score of 98%, an interface design validity score of 96%, and an average System Usability Scale (SUS) score of 93. These findings indicate

that the application fulfilled the predefined evaluation criteria in terms of functionality, interface design, and usability and is suitable as a web-based learning medium for medical terminology.

DISCUSSION

This study successfully developed a web-based medical terminology application that integrates medical term definitions together with prefix, root, suffix, and meaning information stored in the database within a single learning platform. The application was designed to facilitate students' understanding of both the meaning and relationships among medical term components by retrieving predefined medical terminology information from an integrated database. Previous studies have demonstrated that digital learning media can improve students' understanding of medical terminology, particularly when learning activities emphasize prefixes, roots, and suffixes (10). Furthermore, learning medical terminology by understanding its morphological components has been shown to reduce the complexity of medical vocabulary and improve students' comprehension of unfamiliar terms (31). In Indonesia, previous web-based applications developed by Pramono et al. and Apriliani et al. successfully supported clinical coding practice and medical terminology learning; however, these applications focused on specific learning objectives and did not provide medical term definitions together with prefix, root, suffix, and meaning information stored in the database within a single application. Therefore, the application developed in the present study extends previous work by providing an integrated database-driven learning platform for medical terminology.

The black-box testing results demonstrated that the developed application achieved a very high level of functional validity, with an average validity score of 98% across the three evaluation stages. Black-box evaluation confirmed that the system successfully retrieved predefined medical terminology records according to expected outputs and evaluated software functionality rather than the correctness of medical terminology decomposition or users' terminology knowledge. This finding indicates that the application's core functions, including user registration, authentication, medical terminology search, retrieval and display of predefined medical terms together with corresponding prefix, root, suffix, and meaning information retrieved from the database, and terminology management, operated according to the predefined functional requirements. The high level of functionality may be associated with the iterative evaluation process employed in this study, in which revisions based on feedback from media experts and students were implemented after each evaluation stage, progressively improving system performance and resolving functional issues before subsequent testing. These findings support previous studies reporting that black-box testing is an effective method for verifying software functionality by evaluating whether system outputs correspond to the expected results without examining the source code (25). Furthermore, previous studies evaluating web-based applications have similarly reported that iterative functional testing contributes to improving software reliability and ensuring that system features meet user requirements before implementation (32). Therefore, the consistently high black-box testing scores obtained in this study indicate that the developed application is functionally reliable and suitable for supporting medical terminology learning in Medical Records and Health Information education.

The interface design assessment demonstrated that the developed application achieved a very high level of interface validity, with an average validity score of 96% across all evaluation stages. This finding indicates that the application's user interface successfully fulfilled the expected design criteria in terms of layout consistency, navigation, readability, visual appearance, and ease of interaction. The progressive improvement in interface quality was achieved through iterative revisions based on feedback from both media experts and students, including refinements to the navigation structure, visual consistency, notification messages, icons, and color schemes. These modifications contributed to a more intuitive and user-friendly learning environment that may support students' engagement during medical terminology learning activities. Previous studies have emphasized that effective user interface (UI) design should consider users' characteristics, interaction patterns, and usability objectives to provide an optimal user experience (33). Furthermore, UI plays a crucial role in website development because poorly designed interfaces may reduce system performance and user convenience, whereas well-designed interfaces improve usability and overall user satisfaction (34). These findings are also consistent with previous studies reporting that continuous interface refinement based on user feedback enhances the quality and acceptability of web-based educational applications (27). Collectively, these findings suggest that the high interface validity obtained in this study indicates that the developed application provides an effective, user-centered, and visually consistent learning environment for medical terminology education.

The usability evaluation demonstrated that the developed application achieved an average System Usability Scale (SUS) score of 93, corresponding to the "Best Imaginable" adjective rating and Grade A+ according to the standard SUS interpretation. This result indicates that the application was perceived as highly usable and well accepted by both media experts and students, suggesting that users were able to interact with the system effectively with minimal learning effort. The high usability score may reflect the benefits of the iterative revision process implemented after each evaluation stage, during which improvements were made to navigation, interface

consistency, visual appearance, notification messages, and user interaction based on evaluator feedback. These improvements enhanced the overall user experience and contributed to greater ease of use during the final evaluation. This finding is consistent with previous studies reporting that the System Usability Scale (SUS) provides a reliable and standardized measure of users' perceived ease of use and overall acceptance (28). Similar findings have been reported in studies evaluating web-based applications using SUS, where higher SUS scores indicate better usability and greater user acceptance (35). Furthermore, the SUS score obtained in this study indicates that the developed application fulfilled the main user experience (UX) criteria, including learnability, efficiency, memorability, minimal errors, and user satisfaction, which are considered essential characteristics of usable web-based applications (36). Taken together, these findings demonstrate that the excellent SUS score obtained in this study indicates that the developed application possesses a high level of usability and is appropriate for implementation as a web-based learning medium for medical terminology education.

Overall, the findings of this study demonstrate that integrating medical term definitions together with prefix, root, suffix, and meaning information stored in the database into a single web-based application provides a more comprehensive learning medium than previously developed applications for Medical Records and Health Information students. Unlike earlier web-based applications that primarily supported clinical coding practice or focused on medical terminology within specific body systems, the present application provides an integrated database-driven platform that enables users to retrieve predefined medical terms together with corresponding prefix, root, suffix, and meaning information stored in the database within a single interface. This integrated approach has the potential to facilitate more systematic learning of medical terminology. Mastery of medical terminology is an essential competency for Medical Records and Health Information professionals because it supports accurate clinical documentation and diagnosis coding. Understanding prefixes, roots, and suffixes further strengthens students' ability to interpret unfamiliar medical terms, while diagnosis coding has been established as a core competency in Indonesia, emphasizing the importance of medical terminology education.

Nevertheless, this study has several limitations. The application evaluation involved a relatively small number of participants from a single educational institution and focused on functionality, interface design, and usability rather than evaluating its effectiveness in improving students' medical terminology knowledge or students' accuracy in medical terminology interpretation through objective learning assessments. Therefore, future studies should involve larger and more diverse participant groups, include multiple educational institutions, and evaluate the educational effectiveness of the application using pre-test and post-test or experimental study designs to determine its impact on students' knowledge acquisition and long-term retention of medical terminology.

CONCLUSION

This study successfully developed and evaluated a web-based medical terminology application that integrates medical term definitions with predefined prefix, root, suffix, and meaning information retrieved from a database as a learning medium for Medical Records and Health Information students. The evaluation results demonstrated that the application achieved high functional validity, interface quality, and usability, indicating its suitability for supporting medical terminology learning through an integrated web-based platform. By providing medical terms together with their related prefix, root, suffix, and meaning information within a single application, the developed system enables students to understand both the meaning and relationships among medical term components more comprehensively, thereby supporting competency development in Medical Records and Health Information education, particularly in diagnosis coding. Furthermore, the application has potential to be implemented as a supplementary learning medium in higher education institutions to support students' access to structured medical terminology information during the learning process. Nevertheless, this study was limited by the relatively small number of participants from a single educational institution and focused on evaluating system functionality, interface quality, and usability rather than assessing students' learning outcomes or the accuracy of medical terminology interpretation. Therefore, future studies should involve larger and more diverse participant groups and evaluate the educational effectiveness of the application using experimental or pre-test and post-test research designs.

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