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PAPER

Criteria for User Interface Design in Performance Evaluation and Guidelines of Medical Mobile Apps for Beginner Developers

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ABSTRACT

This study created a performance evaluation form specifically designed to assess user interfaces in medical apps, with a focus on educational and preventive aspects. Developed in collaboration with a diverse group of usability and design experts, the form was structured around heuristic principles and rigorously refined using content accuracy evaluations and consistency index analyses. This meticulous process resulted in a comprehensive 145-question tool that successfully met rigorous evaluation standards. Emphasizing the necessity of early integration of user interface considerations in the development process, this tool is crucial for enhancing app usability and quality. It provides immense value to novice developers by addressing common design challenges such as disorganized layouts and privacy concerns, ensuring that mobile applications are not only user-friendly but also highly effective in interactive design scenarios. This approach facilitates the development of apps that are optimally designed for user engagement and functional precision in medical contexts.

KEYWORDS

mobile applications, evaluation criteria, medical app

1 INTRODUCTION

Currently, an era marked by advanced and modern technology is being shaped by the study, development, and evolution of information technology. Consequently, countries and regions worldwide are witnessing a complete transformation from previous times. There is a concerted effort to integrate modern information technology into medical development and treatment (digital health) to enhance public health services. The trend of increased and widespread use is evident, particularly in developing systems aimed at improving the quality of life for all. This is facilitated by popular applied information systems such as mobile applications, which often have a front-end system responsible for inputting or displaying crucial

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health information to users. Therefore, they are considered highly effective tools [1] and [2]. As a result, many countries have embraced this technological advancement, significantly enhancing overall life quality by overcoming limitations through the application of modern information technology. This indirectly reduces both the time and cost of government services. Data indicates that this trend aligns with people's technology usage and behavior. Nowadays, there is a growing focus on healthcare, with health information-providing applications becoming extremely popular. They are now used as tools in treatment processes at both primary and secondary levels, aiding in symptom tracking, surveillance, and public medical education. The world is increasingly adopting this advancement in information technology [2–6]. In terms of system design and development, a common issue is that many applications fail to meet user needs in terms of user interface design and system usability. Problems often arise from unclear designs, non-responsive layouts, complex and difficult-to-use systems, and inconsistent application component formats [7–9]. Consequently, these systems do not effectively meet usage requirements. Therefore, testing system performance, particularly the user interface and functions, is crucial in determining how well a system meets user needs. Various methods exist for testing system performance to enhance efficiency. Expert testing using personal knowledge and experience is one approach. A study on system performance measurement found that benchmarking-based performance testing using an evaluation model is more effective and identifies more errors than expert-based evaluations [10]. Using experienced individuals for system performance evaluation may be a better approach to planning system testing guidelines. This is because they bring direct experience in system design and development, offering a well-informed perspective on system testing. They can systematically plan tests, unlike development teams or particularly interested amateurs who may lack resources, knowledge, and experience. This is a limitation in system design and development, especially in the testing process. Although heuristic system performance evaluation methods are increasingly discussed, creating test cases, particularly for those without software engineering or computer skills, may not be adequately knowledgeable or understanding.

The evaluation items for measuring the efficiency of the system user interface and functions for applied information in medical applications in the prevention and education category will assist evaluators who lack knowledge and experience, making assessments easier and more convenient. Using a question list as a framework for evaluating each user interface design in the application can help identify potential system issues and their related categories. However, various limitations, such as time, budget, and other factors, hinder amateur developers from developing efficient systems [11]. Thus, the study question is: how can the development of a heuristic evaluation tool, guided by the design thinking process, improve the effectiveness and ease of conducting system performance evaluations for user interfaces and functions in medical applications, particularly in the prevention and education categories, for evaluators with limited experience?

To address this issue, this study will focus on evolving the heuristic evaluation method into a testing tool. It will be developed into a tool that facilitates developers and testers lacking knowledge or experience to conduct system performance evaluations in terms of user interface and functionality. It specifically targets application-based information systems related to medical applications in the prevention and education category. The design thinking process will guide the design and development of system performance assessments based on the heuristic evaluation principle for basically evaluating the ability of a non-skilled or beginner to design a graphical user interface design for mobile application development.

This study is dedicated to analyzing, designing, and developing a straightforward performance evaluation form aimed at measuring the efficiency of system user interfaces and functions in applied information applications, particularly those in the medical field within the prevention and education category. The primary objectives include: 1) analyzing, designing, and developing criteria to measure the effectiveness of system user interfaces and functions for medical applications in the prevention and education category, utilizing a heuristic approach; 2) enhancing the quality of the assessment by evaluating its accuracy (validity) through consideration of the correlation coefficient and the confidence value of the evaluation form.

1.1 User interface and user experience

In the area of digital technology, the design and functionality of a mobile application are shaped by user needs and tailored to mobile platforms [12]. Significantly, the user experience, encompassing emotional responses and ease of interaction, plays a pivotal role in determining the effectiveness of these applications [13]. The user interface, which includes elements such as screens and buttons, is an essential interactive component that facilitates user interaction through various senses [14]. Usability, which refers to how easily users can operate a system and how well it meets their needs, has a profound impact on user satisfaction and the comprehension of the system [15].

In the context of this evaluation process, alignment with the primary objectives of development and study is ensured through assessing these aspects, thereby establishing a factual and practical understanding [16]. A critical method in designing user interfaces to enhance the user experience is heuristic evaluation, which relies on predefined rules and guidelines to focus on accuracy and the identification of system usability issues [17].

In study, the concepts of validity and reliability hold significance. Validity assesses the accuracy of an instrument in measuring what it is intended to measure [18], while reliability guarantees the consistency and stability of the measurement process [19]. Assessments, which consist of various questions, collect essential information, often necessitating evaluators to provide detailed responses [20]. Lastly, heuristics serve as an expert evaluation model, employing straightforward rules to gauge the effectiveness and usability of user interfaces on digital platforms [21].

1.2 Design thinking

Design thinking represents a systematic approach to problem-solving, placing strong emphasis on a deep understanding of the problem and a focus on user needs and preferences [22], [23]. It involves a creative process, idea development, and practical application, with a primary emphasis on empathizing with the target user group. This process is broken down into five steps: empathizing to gain a comprehensive understanding of the user's needs, defining goals by synthesizing information and framing questions to guide problem-solving, ideating, which involves brainstorming and generating ideas without constraints, creating prototypes for user testing to refine ideas, and testing user interface prototypes to collect feedback for further development.

Meanwhile, heuristic evaluation, as proposed by [24], is a model for assessing the usability of systems or prototypes through expert evaluation [11], [22], [25]. This method utilizes a set of heuristics and is valued for its simplicity of implementation, cost-effectiveness, and suitability for early development stages. It does not necessitate the evaluator to possess expert-level knowledge, making it accessible to individuals with basic expertise, such as engineers or design technicians, who can participate in the evaluation process. Furthermore, this approach can be tailored to the specific attributes of the system under evaluation and is not reliant on automated methods, underscoring the importance of the evaluator's personal interpretation.

1.3 Categorizing and classifying data into a system (taxonomy)

In this study, systematic data management and analysis techniques, encompassing categorization and classification, are employed to create a taxonomy. Taxonomies, as described by Baum, are often developed through either observation (inductive reasoning) or the utilization of existing concepts (deductive reasoning) [26]. The process entails the creation of intuitive arrangements of contrasting layers and concepts, referred to as "Typologies" or "Mind maps," which serve as foundational models. This classification method finds extensive application in education and various fields, necessitating thorough study and knowledge for effective differentiation and categorization. For example, in the context of system design for mobile devices, elements such as keyboards, voice commands, or touchscreens are organized into primary and subcategories, emphasizing their significance. Here's a revised version of the sentence for clarity and flow: As DePoy [27] outlines, the design analysis process involves grouping similar items, identifying distinctions within categories, and elucidating the relationships between them. This is often presented in the form of concept maps or structures. Such a process underscores the pivotal role of taxonomy in study and management. It aids in simplifying complex tasks by identifying commonalities and disparities and revealing connections between concepts [28], [29]. This approach, incorporating empirical experiments and indicators, begins with data and employs techniques such as category analysis or statistical methods to classify data into coherent categories with the aim of identifying similarities and appropriately categorizing them [26], [28].

1.4 Related research

Content related to mobile design. This study delves into the challenges of human-computer interaction (HCI) in designing software for mobile devices, a field that has gained significant importance due to the widespread use of these devices [30]. The focus is on understanding the unique aspects of HCI in the context of mobile application development, utilizing the academic research assistant (RA) tool, which employs qualitative data analysis techniques to analyze the relationship between humans and computers in mobile app design. The study investigates various factors related to mobile devices, including their types, differences, and limitations. It provides a comprehensive overview of mobile interaction design from an HCI perspective, encompassing both hardware and software constraints in mobile application design. This study highlights the importance of understanding these factors in creating designs that support and enhance daily life quality. It emphasizes the designer's effort to comprehend the user's viewpoint, underscoring the significance of user involvement in the interactive design process. This approach aims to ensure that mobile application designs are not only functional but also resonate with the users' needs and preferences, thereby improving the overall user experience in the realm of mobile computing.

Content related to user interface design. The study conducted by Saha focuses on the challenges and considerations in the development process of mobile application interfaces, particularly in the realm of human-computer interaction (HCI) [7]. Emphasis is placed on the importance of creating interfaces that are not only usable but also effective, aligning with the principles of user-centered design (UCD). The intricacies of HCI, UCD principles, and the usability constraints that influence the design process are delved into. Shneiderman's "Eight Golden Rules" are adopted in this study, providing a comprehensive perspective on the design process and its guiding principles. The unique development paths of various existing platforms are also acknowledged, highlighting the absence of a uniform format across all applications. This observation leads to the conclusion that innovative strategies in user interface design are needed, moving beyond traditional constraints. This necessity is driven by the rapid evolution of technology and mobile devices, as well as the swiftly changing needs and preferences of users in today's era. The dynamic nature of mobile application design is underscored by the study, emphasizing the imperative to adapt and innovate in response to technological advancements and user requirements.

Heuristic user evaluation. The study on heuristic user evaluation in the context of mobile interfaces, particularly for government mobile applications in Saudi Arabia, highlights the growing reliance on mobile devices for accessing government information and services. The study "A Heuristic Checklist for Usability Evaluation of Saudi Government Mobile Applications" by Al-Khalifa addresses the critical need for effective usability in government mobile applications [31]. It reveals that existing applications often lack a comprehensive checklist tailored to the government sector, leading to issues in the user experience.

To address this gap, the authors developed a heuristic checklist based on established usability metrics, specifically tailored for government applications. This checklist was applied to a sample government mobile application and evaluated by four human-computer interaction experts. The evaluation process involved a checklist of 79 guidelines, assessing the applications across two main areas: scope-based and functional usability heuristic evaluations. The scope-based evaluation covered eight application categories, including business, education, and tourism, while the functional evaluation focused on data handling, simple transactions, and more complex transactions.

The findings indicated significant issues in four main areas: disabled functions and errors, inadequate help functions, privacy policy concerns, and poor interface design. These problems highlight the necessity for thorough consideration and improvement in the design of government mobile applications before their release to the public. The study emphasizes the importance of incorporating design expertise into the development process. This study contributes a valuable heuristic list, grounded in Nielsen's heuristics that can be effectively applied in government contexts to enhance the usability and user experience of mobile applications [31].

Based on the heuristic evaluation and usability testing from the user's perspective, they were compared in Table 3.

Related research application design. Many studies highlight the advantages of properly designing applications, showing that applications are more successful in practical use when they meet the users' needs. This exemplifies study that has successfully established good design guidelines, aligning with what our study aims to achieve. By enabling users to effectively utilize the application, it adheres to various relevant design guidelines, as supported by the following related study.

The study details the development of stick, an educational mobile app aimed at enhancing phlebotomy training for Biomedical Laboratory Science students through gamified learning and simulations. It addresses design issues in the user interface by emphasizing intuitive, interactive elements that engage users effectively in learning venous blood sampling techniques. Evaluation of the app's effectiveness in educational settings highlights its potential to complement traditional learning methods, with feedback pointing towards a positive reception and improved learning outcomes. This evaluation suggests that well-designed UI and targeted learning strategies can significantly impact learners' skills and confidence in clinical procedures, indicating a promising avenue for integrating digital tools in healthcare education [32].

In addition, the study explores the impact of a software development course on programming self-efficacy among IT students. It highlights issues related to user interface design and evaluation, revealing how structured educational interventions can positively influence students' self-assessment in programming. Through pre- and post-course evaluations, the study identifies significant improvements in students' self-commitment to problem-solving, algorithmic thinking, and confidence in programming. It underscores the effectiveness of targeted coursework in enhancing students' programming skills and self-efficacy, emphasizing the critical role of user interface design in educational tools for programming education [33].

Furthermore, the study by Igor Efrem and his team introduces an app designed to help expectant parents organize pregnancy-related activities. It addresses the app's user interface design and assesses its usefulness through interviews with important users. The main features are data sharing among parents, medical institutions, and groups for before- and after-birth planning. The review underlines the app's role in aiding future parents, stressing the value of focusing on users when creating health apps, especially in designing easy-to-use interfaces [34].

2 METHODOLOGY

2.1 Content scope

In this study, the utilization of heuristics for examining mobile app user interfaces was investigated. The study employed a literature review method to focus on heuristics used in the inspection and evaluation of mobile devices, exploring their application in various contexts. The study also extended to elements, factors, or limitations associated with mobile devices or smartphones. The objective was to collect and summarize data from diverse sources, using this information to develop appropriate heuristic evaluation tools. These tools were specifically crafted for the examination and assessment of medical apps in the prevention category.

An additional aim of the study was to evaluate the effectiveness of these heuristics in identifying user interface errors in apps. Consideration was given to whether the findings could be transformed into user-friendly guidelines for evaluators lacking specialized knowledge in this area. The application and utilization of these results were also examined.

2.2 Demographical

In this study, the sample was selected based on the requirement for operators to be experts knowledgeable in the domain of use with verbal consent from the respondent. The selection of engineers or system designers was carried out by the study using purposive sampling.

This group of participants was used to collect suggestions or comments on practical criteria for the graphical user interface. The methodology designed by the study, including in-depth interviews and the content of the collected data, dictated the operation. The timeframe and framework were considered appropriate for:

1. Usability experts: Two individuals, each with over two years of experience in usability or system inspection, were selected. These experts, chosen from graduates in related fields or from IT organizations and companies, possess comprehensive design experience, qualifying them as system auditors with a thorough understanding of application components and context.
2. Design experts (developers): Two individuals with more than one year of experience were selected from the group of design experts. These experts, chosen from graduates in related fields or IT organizations and companies, have experience in developing applications previously released to the general public.
3. Experts related to the study topic: Two individuals, each with at least one year of experience, were selected. This final group of experts, chosen from graduates in various fields, may have diverse general ideas but must still possess understanding and knowledge relevant to the job.

Experts from all three areas, as mentioned above, participated in the evaluation process from the beginning, ensuring accuracy. Each evaluator assessed and reviewed the heuristic question list, a checklist validation form designed by the study. During the evaluation, opinions on each question item were recorded, along with additional data on suggestions or recommendations. This data was then analyzed and synthesized to develop new knowledge. From the perspectives of the experts involved in the previously mentioned areas, a heuristic evaluation form emerged, which these evaluators used to investigate issues encountered with the application user interface.

2.3 Evaluation criteria

Heuristic assessments were created based on conclusive guidelines to detail the evaluation criteria for various aspects. This process involved recommendations on the rate of change for selecting an appropriate number of evaluators based on empirical results. The chosen number of evaluators ranged from three to five people.

Data indicated that this number of evaluators could find comprehensive usage problems with up to 80 percent accuracy [24].

The studied designed a format for evaluating the checklist validation questionnaire to confirm the validity of the checklist validation form. This validation process was crucial to ensuring that the tools used could accurately measure the intended objectives. It involved assessing the suitability of the questions in the instrument, ensuring they covered the content or construct meant to be measured, in line with the studied purpose of creating assessments for inspections or heuristic evaluations.

Experts determined errors or shortcomings by evaluating the consistency of the question list with the content. They examined each question to decide whether it accurately measured the intended content. The results were based on the experts' opinions, which were likely to be consistent, indicating the accuracy of the content.

The study also used a format for interpreting satisfaction levels based on the Likert scale. Evaluators had the option to choose one answer from five levels, using the interval scale to measure the rate. This method helped in assessing the accuracy of the questionnaire, with an IOC (Index of Item Objective Congruence) value for questions ranging from 0.80 to 1.00 being considered acceptable.

2.4 Research operation

The study involved analyzing, designing, and developing a straightforward performance evaluation form. This form was used to measure the effectiveness of user interfaces and functions in information applications, specifically in preventive and educational medical applications, using a heuristic approach. The process included assessing the form's validity to determine qualitative values. The final step involved using this evaluation form to test the efficiency of the system's user interface. This testing was conducted through a case study on an applied information system designed for basic self-diagnosis and treatment. Thus, to achieve the study goal, the methodology followed the principles of design thinking theory, which encompasses a total of five steps [22], [23].

Empathize

1. The study involved analyzing, designing, and developing a straightforward performance evaluation form. This form was used to measure the effectiveness of user interfaces and functions in information applications, specifically in preventive and educational medical applications, using a heuristic approach. The process included assessing the form's validity to determine qualitative values. The final step involved using this evaluation form to test the efficiency of the system's user interface. This testing was conducted through a case study on an applied information system designed for basic self-diagnosis and treatment. Thus, to achieve the study goal the methodology followed the principles of design thinking theory, which encompasses a total of five steps.
2. Factors and limitations of mobile device design. The study examined factors influencing mobile device design and their limitations. This included studying mobile device evaluation techniques, operating systems, types of devices, and human-computer interaction challenges. The focus was on how these factors affect mobile device characteristics and application design, using data categorization and classification techniques (taxonomy) to design effective heuristic assessment items.

3. Development of a usability evaluation questionnaire. Information from various sources, including literature reviews, was analyzed to create a questionnaire for evaluating application usability. The questionnaire format was based on yes-or-no questions, considering consistency with general usage contexts and insights from literature reviews. The study classified questions from the literature based on frequency criteria, covering main and sub-heuristics. The first set included 367 general questions, supplemented by 272 questions specific to mobile devices or smartphones, focusing on the design context.

Define. In this step of the study's problem-solving analysis and synthesis phase (define), a checklist of questions was evaluated by experts through in-depth interviews. The quality of the assessment is evaluated by evaluating its accuracy (validity) through consideration of the correlation coefficient and the confidence value of the evaluation form. The experts involved included two system usability experts with over two years of experience, two design experts (developers) with more than a year of experience, and two experts in fields related to the study topic, each with at least a year of experience. During the evaluation, each expert independently assessed each question on the checklist validation form, providing ratings and comments. The scoring criteria were divided into three levels: +1 for agreement with the question's alignment with the objective, 0 for partial agreement or uncertainty, and –1 for disagreement. Communication between evaluators was not permitted during the evaluation process. After completing the evaluations, the data from the experts' forms was collected. This data was then analyzed and synthesized to derive results, which were summarized in the subsequent step of the study.

The data from expert group interviews, recorded in questionnaires, was analyzed and synthesized using a passive approach. The studied calculated the average scores from each evaluator for each question. A tool named 'Quality Criteria' was employed to categorize the questions and determine the assessment's quality. The precision of the measurement, or validity, was considered using the Index of Item Objective Congruence (IOC), calculated through a statistical formula. Based on the calculated scores, questions with an average IOC of 0.50 or higher were initially retained. Those with lower values were re-evaluated, taking into account the evaluators' comments, to decide whether they should be discarded or included with other questions. This process of data analysis and synthesis aimed to ascertain the accuracy of the measurement for its intended purpose and the appropriateness of the questionnaire. In total, 180 assessment questions were evaluated, and 26 questions were selected.

Ideate. After the quality analysis of the evaluation form's question set, which included measuring validity and establishing criteria for heuristic assessment scope, the study designed implementation guidelines. Evaluators were tasked with completing the interface evaluation, which could take 1–3 hours based on system complexity. The evaluation was divided into two parts or conducted in two iterative rounds. In the first round, evaluators independently tested the system to understand its functionality and scope. In the second round, they conducted evaluations within a specific framework or scenario designed by the study.

The heuristic evaluation form required evaluators to record various details, including the number of questions, identified problems, content relevance, adherence to design principles, and severity level of issues. They also provided recommendations or solutions. Evaluators used a Likert scale to indicate the severity of problems, which is suitable for closed-ended questionnaires. This scale ranged from 1 (not affecting system use) to 5 (serious issues rendering the system unusable).

The process aimed to identify design problems or errors inconsistent with established principles.

Development an assessment and testing methods (prototype). A prototype heuristic assessment form was created using data from 180 assessment questions, which included 154 general heuristic guidelines and 26 mobile device-specific heuristics. This prototype was developed by analyzing and synthesizing problem-solving processes and considering the scope of evaluation item inspection. The form was designed to be consistent and suitable for various evaluation stages. It aimed to effectively detect defects or errors in user interface design. The form's design ensured that assessors could accurately and comprehensively record information, facilitating easy and convenient analysis of the data.

Performance evaluation form by experts and system testing (prototype testing). This step involves testing the effectiveness of the assessment through a case study on an application-based information system related to medical applications in the prevention and education category, focusing on the system's user interface and functions.

In the performance evaluation phase of the study, experts were divided into two groups for prototype testing. In this experiment, a smart ICT medical application was used for assessment and evaluation based on the results of analyzing, designing, and developing criteria to measure the effectiveness of system user interfaces and functions.

The first group consisted of usability experts with over two years of experience, and the second group included design experts with more than a year of experience. Additionally, a third group involved experts related to the study topic, each with at least a year of experience. This division was based on the [24] recommendation of having 3–5 experts to effectively identify issues in heuristic evaluations.

The testing process was conducted in two rounds. In the first round, evaluators independently assessed the system's general functionality and scope. The second round involved a more detailed evaluation of specific parts, focusing on design flaws or inconsistencies with established principles. Each evaluator recorded their findings on a form.

The results from these evaluations were then collected to test the effectiveness of the heuristic evaluation model. This involved analyzing the reliability and summarizing the performance test results, particularly in identifying errors in the application. The findings were used to refine and improve the evaluation form. A second round of testing was conducted, and the results were again analyzed for reliability and summarized. These results were compared with those from the first round to assess improvements and changes.

Finally, a heuristic evaluation form was created based on the finalized approach, incorporating the insights and data gathered from the two rounds of testing. This form aims to provide a reliable and effective tool for identifying errors in user interface designs.

3 RESULT

3.1 Result of empathize

The study investigated the information content accessed by patient groups using health information services. It was found that accessing these services often involves high fees or other losses, and the services provided are not comprehensive enough to fully meet patient needs. This includes issues in communicating information effectively, which impacts patient understanding of basic symptoms, observations, follow-up care, or precautions.

Despite the wide availability of services through various technological channels, applications serving as one such channel often fail to meet user needs. This is due to factors such as uninteresting or unsuitable application conditions for users and concerns over the reliability, accuracy, and correctness of the information provided.

The study also involved evaluating the user interface design and elements used in creating prevention and medical education applications. This evaluation analyzed 20 applications, categorized into three groups: 13 applications providing medical information and seven offering various health services. These applications were all available as free downloads from the App Store and support Thai. The selection criteria for these applications were based on the number of downloads and user comments for each application. This approach helped in understanding the data and scope within the context of the identified problems. From Table 1, the analysis was conducted on the specific functions of 100 applications found in the Application Store, including both the Apple and Google Play Stores. This analysis took place between February 1, 2021, and September 2021. Ten necessary related functions, which constituted the primary function of the medical application, were taken into consideration. The applications were searched using keywords related to medical applications that provide information and promote various health services.

Table 1. Functional analysis of 100 applications

No.	Functional	Number of Applications Found to be Used in the Design	Percentages
1	Store historical data (personal information, search results)	70	14.03
2	Providing detailed information/content	70	14.03
3	Communication	63	12.63
4	Registration	61	12.22
5	Help, advice/support	60	12.02
6	Data analysis	52	10.42
7	Search for disease/symptom information by symptom category or keyword	49	9.82
8	Notification of descriptive information/news	37	7.41
9	Payment/Payment	28	5.61
10	Location search map	9	1.80

In a deep analysis of Table 1, which was analyzed from 100 applications to understand the majority of application functional compatibility with the first 10 priorities, the analysis focuses on the percentage of specific components present in ten essential functions within a medical application.

Table 2. Analysis of percentage specific components from 10 functions

Functions	Components
Storing Historical Data	– Text and image content
	– Organized layout with boxes, labels, and component lists
	– Menus with buttons and toolbars
	– Navigational elements like navigation bars and tabs
	– Scrollable presentation views
	– Selection and input options, including keyboards and toggles
Providing Detailed Information/Content	– Text content
	– Layout organization with labels
	– User interaction through buttons, toolbars, and pull-down menus
	– Navigation bars for ease of movement
	– Scrollable presentation views
Communication	– Text and image content
	– Boxed layouts with labels and component lists
	– Navigation bars for easy access
Registration	– Text and image views
	– Component list layouts
	– Buttons for actions
	– Alerts for notifications
Help, Advice/Support	– Text and image content
	– User interaction elements like buttons, toolbars, and menus
	– Editable menus for customization
Data Analysis	– Text content and labels
	– User interaction elements like buttons and toolbars
	– Navigation bars and scroll views
	– Segmented controls and status indicators
Searching for Disease/ Symptom Information	– Text content
	– Organized layout with boxes, labels, and lists
	– Buttons and toolbars for actions
	– Search fields for targeted queries
	– Scroll views for comprehensive display
Notification of Descriptive Information/News	– Text content
	– Organized layout for easy access
	– Buttons for actions
	– Navigation bars and related options
	– Segmented controls for selection

(Continued)

Table 2. Analysis of percentage specific components from 10 functions *(Continued)*

Functions	Components
Payment Processing	– Text and image content
	– Organized layout with boxes, labels, and lists
	– Buttons for actions
	– Navigation bars and scroll views
Location Search Map	– Text content
	– Boxed layouts with labels and lists
	– User interaction elements like buttons, edit menus, and toolbars
	– Search fields and message groups
	– Scroll views for detailed presentation

The result from Table 2 indicates the individual or functional features of applications, as defined by theoretical results. It's been found that key elements used across all 100 applications are interconnected and share a link with their functional goals. The design of applications for prevention and medical education was summarized, focusing on the specific components unique to each application. These components are typically used for specific purposes or in certain activities.

The study revealed issues with component design in prevention and medical education apps. While each app served similar purposes, problems arose due to varying user interfaces. Common issues included the use of confusing symbols or elements and the complexity of accessing data, which hindered proper application use. This included challenges in layout, color, size, and other factors fundamental to heuristic principles. Additionally, the study found no differences in how elements or features were used for entering information, navigating, or in the app's operational response, including status updates and more. These aspects could be anticipated in each app's design and compared against standard criteria, leading to a design framework that aligns with established design standards. For instance, if a data collection component or state monitoring is employed in an app, it's possible to predict when users will engage with specific activities. Such insights help meet evaluation criteria, ensuring a well-designed application.

3.2 Results of determination

The analysis process involves using expert feedback and basic principles to establish criteria for application design, focusing on open-ended questions to gather diverse opinions, and adhering to current design principles. The study emphasizes the importance of designing medical applications based on main principles, user group needs, and expectations, ensuring usability and ease of use. It highlights the need for careful consideration of various elements in application systems, even within the same category, and the importance of not losing sight of the main objective, which is user satisfaction. The process includes a thorough evaluation of design principles, user interface considerations, and the functionality of the application, ensuring simplicity, error reduction, and user independence. The design should also consider symbolic elements such as size, color, and icons for easy understanding and recall. Ultimately, the data collected from expert interviews and application developers is systematically analyzed using taxonomy to categorize application features, ensuring alignment with heuristic principles and user expectations, as detailed in 13 categories. Figure 1 shows the list of heuristic usability criteria evaluated for application.

Based on the review of application and expert sources, the study systematically analyzes heuristics and data sets to understand relationships in application system design, focusing on three key areas: design, user interface, and usage. It identifies common issues such as lack of adherence to standard principles, poor user interface design, and inadequate consideration of user group needs, leading to confusion and reduced usability. By linking these aspects and applying in-depth taxonomy analysis, significant relationships are found, particularly in achieving consistency and standardization based on heuristic principles. This approach facilitates the creation of efficient applications with well-considered design elements such as menus, input fields, and symbolic communication, ultimately enhancing the user experience and interface effectiveness.

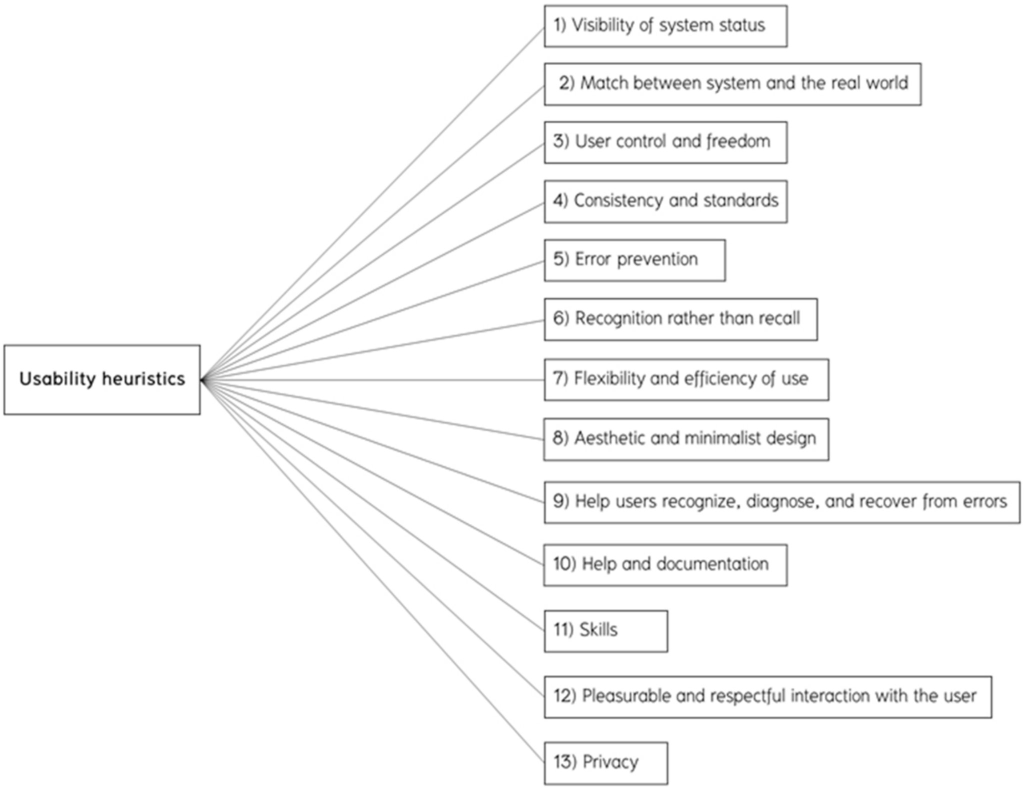

Fig. 1. List of heuristic usability criteria evaluation for application

3.3 Result of ideate

After analyzing the data and identifying inconsistencies between the application user interface design process and performance evaluation, a solution is proposed to align these processes for better outcomes. This involves using data summaries for in-depth analysis and synthesis, aiming to develop and improve both processes simultaneously for richer results. A heuristic assessment approach, based on study data, is used to evaluate user interface performance, enabling early detection of system errors during design and development. This approach involves in-depth interviews with experts and a detailed analysis of interface components and their characteristics in context. The user interface design is then structured through a framework or model, detailing the intended use of each element and enumerating heuristic relationships based on established criteria, as outlined. The evaluation form shown in Figure 2 is used to evaluate the application.

Number Questions	specifying the problems (Function, Screen, Location)	Detail problem	Againt principle (Heuristics)	Againt Subheuristic	Severity level					Comment/Suggested solution
					1	2	3	4	5	

Fig. 2. Evaluation application form

3.4 Result of development an assessment and testing methods (prototype)

To develop a prototype set of questions for designing and evaluating specific contexts of use in certain areas of an application system for an initial user interface evaluation form, Table 3 indicates the comparison of heuristic evaluation and usability testing results from the user's perspective, corresponding to a list of general heuristic evaluation approaches.

Table 3. Comparison of heuristic evaluation and usability testing from the user's perspective

Evaluation Criteria	Option 1 Usability	Option 2 Heuristic	Remarks
Objective			
1. The purpose is to find usage problems.	✓	✓	–
2. Evaluate a system or product only in terms of its intended use.	✓	–	– Efficiency in avoiding mistakes until satisfaction and ability to learn [35].
Operational			
3. The test is conducted by a group of users who have no experience or limited professional involvement.	✓	–	– Efficiency in avoiding mistakes until satisfaction and ability to learn [35].
4. Testing is conducted by experts with specific skills related to user experience.	–	✓	– Suitable for testing at all stages of development and requires no prior planning [11]. – Supported by surveys and evaluations where evaluators are free to decide on the operation of the system [36].
Inspecting/Finding Problems			
5. Evaluating and identifying real problems from actual problems.	✓	–	–
6. Help identify potential/hidden problems.	–	✓	– Evaluation by identifying serious usability problems that users may encounter and taking steps to improve them first [35]. – Early identification of areas of confusion and opportunities to improve the overall user experience [11].
7. Assessing potential problems.	–	✓	
Operational Characteristics			
8. Set specific tasks for users.	✓	–	–
9. Set guidelines and checklists for evaluators as guidelines for consideration.	–	✓	– The evaluation process is repeated at least 2 times. Investigate the interactive fluidity and collection elements of the system [36]. – Operation is simple. Fast and budget-friendly [11].

(Continued)

Table 3. Comparison of heuristic evaluation and usability testing from the user's perspective *(Continued)*

Evaluation Criteria	Option 1 Usability	Option 2 Heuristic	Remarks
Testing			
10. Test the system using the "one screen at a time" method.	✓	–	– Usability testing or testing situations generally requires users to complete various tasks within a specified time frame [35]. – While testing, general information including inconsistencies was observed and noted. such as behavior, usage characteristics, suggestions and opinions [35]. – Able to work with prototypes in the initial stages until the end of the process [35].
11. Case scenario	✓	–	
12. Help improve the proper functioning of the program/system by including thorough evaluation during the development phase.	–	✓	
13. It is time consuming and expensive as it involves the participation of many users.	✓	–	– Post-editing is more expensive and difficult to implement [11].
14. There is a low cost because it uses only a specific group of experts.	–	✓	– Testing takes little time, is easy to perform and provides quick feedback [11], [35]. – A quick and easy way to identify usability problems with little time and resources [37]. – Efficient and cost-effective methods for evaluation [37].

Table 4. List of general criteria for user interface assessment for mobile devices before revision

Heuristics
1. Visibility of system status
System status feedback
– Are there system feedback notifications provided for each operator action? [38]
– If error messages are presented through pop-up windows, do they permit users to easily identify the field in error? [38]
Location information
– Is the logo both meaningful and easily identifiable, with sufficient visibility? [39]
– Is there a link available for accessing detailed information about the enterprise, website, or webmaster? [39]
– Are there established means of communication with other elements? [39]
Response times
– Are the response times aligned with users' cognitive processing capabilities? [38]
– Are the response times suitable for the given task? [38]
– In the event of noticeable delays (exceeding fifteen seconds) in the system's response time, is the user informed about the ongoing progress? [38]
– Efforts towards reducing latency [40]
Selection/input of data
– Is there comprehensive visual feedback in menus or dialog boxes to facilitate user understanding?
– This includes clarity on which choices are selectable, clear indication of the selected item, obvious cues about the possibility of deselection, visual feedback on the current cursor position, and clear visual indicators for options already selected, especially in scenarios where multiple selections are possible. [38]
– Is the present status of an icon clearly and readily discernible? [38]

(Continued)

Table 4. List of general criteria for user interface assessment for mobile devices before revision *(Continued)*

Heuristics
2. Match between system and the real world (Mental model accuracy)
Metaphors/mental models
– Utilization of Metaphors [40]
– Are the icons presented concrete and recognizable, fostering familiarity? [38]
– In the case of using shape as a visual cue, does it align with cultural conventions? [38]
– Do the chosen colors align with widely accepted expectations regarding color codes? [38]
Menus
– Are menu choices organized in the most logical sequence, considering the user, item names, and task variables? [38]
– Do menu choices fit coherently into categories with easily understood meanings? [38]
– Are menu titles grammatically parallel? [38]
– In navigation menus, is there control over the number of items and terms per item to prevent memory overload? [39]
Simplicity
– Do related and interdependent fields coexist on the same screen? [38]
– For question and answer interfaces, are questions articulated in clear, simple language? [38]
– Is the language employed consistent with the users' vernacular, and does the menu naming terminology align with the user's task domain? [38], [39]
– Is the language clear, concise, and free from computer jargon while incorporating user jargon when applicable? [38], [39]
– Does the site adhere to the principle of "1 paragraph = 1 idea"? [39]
Output of numeric information
– Does the system automatically include leading or trailing spaces to align decimal points? [38]
– Are integers right-justified, and are real numbers appropriately aligned at the decimal point? [38]
3. User control
Explorable interfaces
– Can users navigate forward and backward between fields or options in dialog boxes? [38]
– In a question and answer interface, is there functionality for users to revisit previous questions or skip forward to subsequent ones? [38]
– Is there clear marking for exits? [39]
– Is the overall website structure designed with a user-centric approach? [39]
– Is there a mechanism to inform users about their current location and provide guidance on how to undo or backtrack their navigation? [39]
Some level of personalization
– Is there functionality for users to customize their own system, session, file, and screen defaults? [38]

(Continued)

Table 4. List of general criteria for user interface assessment for mobile devices before revision *(Continued)*

Heuristics
Process confirmation
– Upon completion of a user's task, does the system await a signal or confirmation from the user before processing further? [38]
– Are users prompted to confirm commands that may lead to drastic or destructive consequences? [38]
Undo/Cancelation
– Can users effortlessly reverse their actions? [38] This is also phrased as "Do function keys that can cause serious consequences have an undo feature?" [41] and "Is there an 'undo' function at the level of a single action, a data entry, and a complete group of actions?" [38]
– Is there a capability for users to cancel ongoing operations? [38]
Menus control
– If users have the option to return to a previous menu, are they able to modify their earlier menu choice? [38]
4. Consistency
Designing consistency
– Are attention-getting techniques employed judiciously? [38]
– For intensity, are only two levels utilized? [38]
– Regarding color, are up to four colors used (with additional colors for occasional use only)? [38]
– Are there no more than four to seven colors, strategically spaced along the visible spectrum? [38]
– Does the system adhere to a limit of twelve to twenty icon types? [38]
– Has the excessive use of all uppercase letters on a screen been avoided? [38]
– Is there a uniform icon design scheme and stylistic treatment maintained throughout the system? [38]
Menu
– Are menu choice lists consistently presented in a vertical format? [38]
– If "exit" is a menu choice, does it consistently appear at the bottom of the list? [38]
– Are menu titles either centered or left-justified for uniformity? [38]
Input fields
– Is there typographic differentiation between field labels and the fields themselves? [38]
Menu/task consistency
– Are menu choice names consistent, both within each menu and across the system, in grammatical style and terminology? [38]
– Does the structure of menu choice names align with their corresponding menu titles? [38]
Functional goals consistency
– Where are the website goals defined, and are they well-defined? Do the content and services delivered align with these goals? [39]
– Does the look and feel of the website correspond with its goals, characteristics, content, and services? [39]
– Is the website updated frequently? [39]

(Continued)

Table 4. List of general criteria for user interface assessment for mobile devices before revision *(Continued)*

Heuristics
System response consistency
– Is the system response after clicking links predictable? [39]
– Are orphan pages avoided? [39]
5. Error prevention
– Are menu choices designed to be logical, distinctive, and mutually exclusive? [39]
– Are data inputs made case-blind whenever possible? [39]
– Does the system provide warnings to users if they are on the verge of making a potentially serious error? [39]
– Do data entry screens and dialog boxes clearly indicate the number of character spaces available in a field? [38]
– Are default values appropriately assigned to fields in data entry screens and dialog boxes when applicable? [38]
6. Recognition rather than recall
Memory load reduction
– Is the demand for high levels of concentration minimized, and is the requirement for remembering information kept within the range of two to fifteen seconds? [38]
– Is all the necessary data a user needs displayed at each step in a transaction sequence? [38]
– After the user completes an action or group of actions, does the feedback convey that the next set of actions can be initiated? [38]
– Are optional data entry fields clearly designated? [38]
– Do data entry screens and dialog boxes provide clear indications when fields are optional? [38]
General visual cue
– In question and answer interfaces, are visual cues and white space effectively utilized to differentiate questions, prompts, instructions, and user input? [38]
– Have prompts been formatted with attention to white space, justification, and visual cues to facilitate easy scanning? [38]
– Do text areas include ample “breathing space” around them? [39]
– Are there designated “white” areas between informational objects to provide visual relaxation? [39]
– Does the system offer clear visibility, allowing users to discern the system’s state and available alternatives by visual inspection? [38]
– Is the use of size, boldface, underlining, colors, shading, or typography effectively employed to indicate the relative quantity or importance of different screen items? [38]
– Is there a notable contrast in colors and brightness between images and background colors? [38]
– Have light, bright, saturated colors been applied to emphasize data, while darker, duller, and desaturated colors have been used to deemphasize data? [38]
– Is the visual page space utilized efficiently? [38]
Input/output data
– On data entry screens and dialog boxes, Are dependent fields displayed only when necessary? [38]
– Are field labels positioned close to fields, with at least one space of separation? [38]

(Continued)

Table 4. List of general criteria for user interface assessment for mobile devices before revision *(Continued)*

Heuristics
Menus
– Is the first word of each menu choice the most significant for clarity? [38]
– Are menu selection defaults appropriately implemented? [38]
– Is there a clear and evident visual distinction between menus that allow users to "choose one" and those that permit them to "choose many"? [38]
7. Flexibility and efficiency of use
Search
– Is the search box easily accessible for users? [39]
– Is the search box easily recognizable for users? [39]
– Are search results presented in a comprehensive manner for users? [39]
– Is the width of the search box appropriate for user interaction? [39]
8. Aesthetic and minimalist design
– Is only essential information for decision-making displayed on the screen, excluding unnecessary details? [38]
– Are field labels succinct, familiar, and descriptive for user clarity? [38]
– Is the layout clearly designed to avoid visual noise, ensuring a clean and focused visual presentation? [39]
Multimedia content
– Does the inclusion of images and multimedia content enhance the overall value of the presentation? [39]
– Are images well-sized, easily understandable, and presented at an appropriate resolution? [39]
Icons
– Does each icon distinctly stand out from its background for clear recognition? [38]
Menus
– Are menu titles succinct, yet of sufficient length to effectively communicate their purpose? [38]
9. Help users recognize, diagnose and recover from errors
Navigation
– Is information easy to locate? [38]
Conversation
– Is the information accurate, complete, and understandable? [38]
Relevance of Information
– Is the information relevant in terms of goal orientation (what can I do with this program?), descriptiveness (what is this thing for?), procedurality (how do I do this task?), interpretability (why did that happen?), and navigational clarity (where am I?) [38], [39]
10. Help and documentation – Can users effortlessly switch between help and their work? [38]
– Is it easy to access and return from the help system? [38]
– Can users seamlessly resume their work where they left off after accessing help? [38]

(Continued)

Table 4. List of general criteria for user interface assessment for mobile devices before revision *(Continued)*

Heuristics
11. Skills
– If the system supports both novice and expert users, it is advisable to provide multiple levels of error message detail [38]
– If the system supports both novice and expert users, it is recommended to provide multiple levels of detail [41]
– Are users positioned as the initiators of actions rather than the responders? [38]
– Do the selected input device(s) align with user capabilities? [38]
– Are important keys, such as ENTER and TAB, designed to be larger than other keys for enhanced usability? [38]
12. Pleasurable and respectful interaction
– Protect users' work [40], also known as "For data entry screens with many fields or in which source documents may be incomplete, can users save a partially filled screen?" [38]
– Do the selected input device(s) align with environmental constraints? [38]
– Does the system support the completion of unambiguous partial input on a data entry field? [38]
13. Privacy
– Are protected areas entirely inaccessible? [38]
– Is there information available regarding how personal data is safeguarded and details about content copyright? [38]

The items for assessing the user interface were reorganized after analyzing a collection of questions tailored to mobile devices (Refer to Table 5).

Table 5. Revised List of general criteria for user interface assessment for mobile devices after expert consideration

Heuristics
1. Visibility of system status
System status feedback
– If the list contains only one item, navigate the user directly to that item [41]
Response time
– Avoid extended durations for splash screens [42]
Selection/input of data
– Address low discoverability issues, where active areas may not appear touchable to users; ensure that touchable elements are visually distinguishable [42]
2. Match between system and the real world
– Na
3. User control and freedom
– Explorable interfaces Accidental activation (lack of back button) [41]

(Continued)

Table 5. Revised List of general criteria for user interface assessment for mobile devices after expert consideration *(Continued)*

Heuristics
4. Consistency and standards
Orientation
– Regarding constraining orientation, users often switch device orientation when faced with challenges. If the application does not support such changes, it can disrupt the user's flow, leading to confusion about why certain functionalities are not working. To provide a smoother user experience, consider supporting orientation changes to accommodate user preferences and actions [42]
5. Error prevention
– To prevent accidental activation and improve user experience, consider incorporating a back button in the interface. This provides users with a clear way to navigate back from unintended actions [42]
– Touchable Areas Are Too Small [42]
– To address issues related to small touchable areas, follow research recommendations suggesting a minimum target size of 1 cm × 1 cm for widgets on touch devices. Ensuring an adequate touchable area enhances user interaction and minimizes the risk of errors due to overly small targets [42]
– To mitigate the issue of crowding targets, avoid placing interactive elements too close to each other. Adequate spacing between targets is crucial to prevent users from accidentally selecting the wrong option, especially in scenarios where fat-finger issues may be prevalent. Providing sufficient spacing enhances user accuracy and reduces the likelihood of unintended interactions [42]
– Padding is crucial in user interface design. Even if the visible part of a target appears small, incorporating invisible target space as padding ensures that if a user taps within that region, their interaction will still register. This approach enhances user accuracy and usability, especially in situations where precise taps are required. Providing adequate padding contributes to a more forgiving and user-friendly interface [42]
6. Recognition rather than recall
Memory load reduction
– Indeed, optimizing the task flow is essential. Initiating the task flow with actions critical to the main task allows users to commence their activities promptly. – Ensuring a streamlined and efficient sequence empowers users to engage with the core elements of the task without unnecessary delays, contributing to an improved overall user experience [42]
7. Flexibility and efficiency of use
Search
– Including a search box and navigation prominently on the homepage is a good practice for websites designed for smartphones and touch phones. This design approach facilitates user interaction by providing quick access to search functionality and navigation options, enhancing the overall user experience. The goal is to make key features easily accessible, considering the unique characteristics and preferences of users on mobile devices [41]
– Ensuring that the length of the search box accommodates the average search string is a practical guideline. It is recommended to aim for the largest size that comfortably fits on the screen, facilitating user input and enhancing the usability of the search feature. This approach acknowledges the diversity in search queries and aims to provide a user-friendly experience by optimizing the size of the search box accordingly [41]
– In cases where a search returns zero results, it is advisable to provide users with alternatives or a link to the full search results page. This approach helps users navigate the absence of results and encourages them to refine their search or explore related options. Offering alternatives or a direct link to the full search results page contributes to a more user-friendly experience, guiding users toward potentially relevant information even when their initial query yields no results [41]

(Continued)

Table 5. Revised List of general criteria for user interface assessment for mobile devices after expert consideration *(Continued)*

Heuristics
Navigation
– Utilizing links to related content is an effective strategy to assist users in navigating quickly between similar topics. By providing these links, you enhance the user experience, enabling seamless exploration of related information and facilitating a smoother journey through your content. This approach encourages engagement and helps users discover relevant material with ease, ultimately contributing to a more user-friendly and informative environment [41]
8. Aesthetic and minimalist design
– Designing recognizable application icons is crucial to ensure they stand out in a crowded list of applications. Iconography that is distinctive, visually appealing, and representative of the app's purpose aids users in quickly locating and identifying the application amidst various options. Prioritizing clarity and uniqueness in icon design enhances the user experience, making it easier for users to navigate and access the desired application efficiently [41]
Multimedia content
– When incorporating thumbnails, it is essential to ensure that users can easily distinguish and understand the content depicted in the picture. Thumbnails should be clear, visually distinct, and representative of the actual content to provide users with a meaningful preview. This practice enhances user comprehension and engagement, enabling them to make informed decisions about whether to explore further based on the thumbnail representation [41]
Navigation
– Avoid replicating a large number of persistent navigation options across all pages of a mobile site. Excessive and redundant navigation elements can clutter the user interface, leading to confusion and a less streamlined user experience. Instead, focus on providing essential and contextually relevant navigation options that support the user's journey within the specific content or task at hand. This approach helps maintain a clean and efficient mobile interface, improving overall usability.
9. Help users recognize, diagnose, and recover from errors
– To signal an input error in a form, it is recommended to clearly mark the textbox or input field that requires correction. This could be done by applying visual cues, such as highlighting the problematic field in a distinct color, adding an error message near the specific input, or using an icon to draw attention. Providing clear and immediate feedback helps users quickly identify and address input errors, contributing to a more user-friendly form submission process [41]
10. Help and documentation
– Focusing on one single feature at a time and presenting only essential instructions for users to get started is a sound design principle. By minimizing cognitive load and keeping instructions concise, users can easily understand and engage with the specific feature without feeling overwhelmed. This approach enhances user onboarding and promotes a more intuitive and user-friendly experience, allowing individuals to grasp the functionality quickly and efficiently [42]
11. Skills
– Na
12. Pleasurable and respectful interaction
Input data
– Acknowledging that users may dislike typing, providing a streamlined input experience is beneficial. For instance, when collecting address information, you can ask for the zip code and automatically compute the corresponding state and town. Additionally, offering a list of towns associated with a specific zip code can further simplify the process, allowing users to select from pre-populated options. This user-friendly approach reduces the effort required from users, enhancing overall satisfaction and efficiency in completing forms or providing information [42]

(Continued)

Table 5. Revised List of general criteria for user interface assessment for mobile devices after expert consideration *(Continued)*

Heuristics
– Saving user input history and allowing users to select previously entered information is a practical and user-friendly feature. This functionality can enhance the user experience by reducing the need for repetitive typing, especially for frequently used or similar entries. By providing a convenient way for users to select from a history of their previous inputs, you streamline the interaction process and contribute to a more efficient and personalized user experience [42]
– Using defaults that make sense to the user is crucial for a seamless experience. If your application doesn't handle sensitive information and security concerns are minimal, keeping the user logged in by default (with a clear option to log out) is user-friendly. This approach simplifies the user's interactions, providing convenience and reducing the need for repeated logins. However, always ensure that privacy and security considerations align with the nature of the application and user expectations [42]
– When requiring user authentication, consider incorporating graphical passwords as an alternative to typing. Graphical passwords can enhance security and provide a more user-friendly authentication method, as users can interact with visual elements to log in rather than relying solely on typing. This approach can be especially beneficial for touchscreen devices, where graphical interactions may be more intuitive and user-friendly than traditional text-based inputs [42]
– Providing an option for users to view the password clearly while logging in can be a helpful feature. This allows users to verify the accuracy of their entered password, preventing input errors. It can be particularly useful for users who may want to confirm their password before submission, contributing to a more user-friendly login experience. However, always ensure that the option to reveal the password is secure and doesn't compromise the overall security of user credentials [42]
13. Privacy
– For multiuser devices, it's advisable to avoid being permanently signed in on an application. Keeping a user permanently signed in may pose security and privacy risks, especially in shared environments. Instead, implement secure authentication practices and encourage users to log out after each session. This approach ensures that each user's data remains private and reduces the risk of unauthorized access to their accounts on shared devices [42].

3.5 Result from performance evaluation form by experts and system testing

A simple performance evaluation form was designed and developed to measure the effectiveness of the user interface and functions of a medical application, which is educational and preventive in nature, as listed in Table 5. This form was based on heuristic principles and used for testing prototypes. The process involved a focus group of specific target groups, including system usability experts with over two years of experience, design experts (developers) with more than a year of experience, system developers, and two experts in fields relevant to the study topic, each with a minimum of one year of experience. These experts engaged in discussions to share views and knowledge, focusing on aspects such as app design and whether current applications employ an evaluation model that aligns with design criteria considered both before and after the design process.

The performance assessment aimed to measure the effectiveness of the application's user interface design, applying a content accuracy technique based on statistical results through consistency index analysis. The evaluation form, structured with objectives (IOC), categorized scoring criteria into three levels: +1 for agreement with the objective, 0 for partial agreement or uncertainty, and –1 for disagreement. The reliability of the questionnaire was indicated by the results, which were used to determine the confidence value of the assessment based on a Likert scale format. The Cronbach's alpha coefficient was calculated from this data, setting the criteria for a simple performance evaluation. A questionnaire set's average score above 0.80 indicated a high level of confidence in the efficiency evaluation form, making it a suitable criterion for evaluating data collection and summarizing results for consideration during development and for improvements in areas not meeting standard criteria.

In the application's user interface performance evaluation, it was found that 117 items fell below the average value. Items not meeting the average value of 0.50 were reviewed for improvement, considering feedback from evaluators on whether to eliminate or combine questions. The average consistency index's accuracy results were 0.6365, below the required standard, leading to a second round of evaluation. Experts re-examined 117 items with values below the criteria, resulting in 82 items meeting the additional consideration criteria and 35 items being discarded. The remaining items were combined with the 63 questions that passed the first evaluation round, totaling 145 questions for the Application User Interface Performance Assessment, with an average consistency index value of 0.801, which met the standard.

The evaluation assessed discriminatory power and satisfaction using a Likert scale with a 5-level rating scale to develop confidence in the heuristic evaluation form. Experts reviewed the question set for consistency, and the Cronbach's alpha coefficient determined the acceptable confidence value for assessing quality.

The evaluation results showed confidence values from the Cronbach's alpha coefficient, indicating a level of 0.802. This high level of confidence suggested that the assessment was reliable and could be effectively used for real-process evaluation and verification.

4 DISCUSSION

User interface performance evaluation criteria have been studied and designed for applications in prevention and medical education. These criteria have been formulated to enhance assessment quality by evaluating accuracy (validity) through correlation coefficient consideration and the confidence value of the evaluation form, as well as testing in real applications [35], [36]. Many study efforts have focused on user interface design and analysis, employing various tools and often concentrating on specific tasks [8], [12], [15], [18], and [22]. Limited studies have addressed the general user group, especially in the context of mobile devices such as smartphones, which hold significant potential for guiding user interface design [11], [19], [22], [26].

A survey of mobile application designs revealed common issues such as disorganized layouts, small text, privacy concerns, and a lack of customization options. These issues underscore the importance of designing user interfaces tailored to specific user groups, emphasizing simplicity and ease of use to reduce memorization and confusion [8], [10], [12], [42]. The study identified a deficiency in early design criteria for both general and specific user groups, which could negatively impact application development. Rectifying errors at later stages can be challenging. To address these issues, this study employed design thinking and analytical principles to develop effective criteria for evaluating user interface performance. These criteria cater to both experienced and inexperienced designers, aligning with the criteria covered in the evaluation form [10]. The criteria were revised in accordance with the list provided in Table 4, resulting in a refined version that includes essential general criteria for user interface assessment for mobile devices. After expert review and consideration, the number of these general criteria was reduced, ensuring they are both adequate and comprehensive. The finalized criteria for user interface assessment, which are now more focused and pertinent, are displayed in Table 5.

Consequently, the prototype user interface performance evaluation criteria were developed with input from experts in application design and development, collected through online interviews and forms due to the pandemic. These criteria were subsequently tested by a group of specialists in the field to calculate the consistency index and determine assessment method reliability using Cronbach's alpha coefficient. The results indicated the satisfaction of the assessment form, as shown in Figure 2, with areas for potential improvement identified. Some questions received moderate scores, prompting further review and refinement.

In summary, this study establishes the usability, consistency, and correctness of user interface performance evaluation criteria, forming a foundation for more effective and user-centric application design and development. These principles, which encompass design thinking and expert feedback, extend beyond fields such as software engineering and product design, potentially impacting knowledge engineering processes related to accuracy and suitability in designing essential life elements. By considering these criteria early, usability issues can be mitigated, enhancing the overall quality of engineering applications, including environmental monitoring systems, where they ensure accuracy and suitability in measuring key environmental indicators, thus contributing to broader scientific endeavors and societal well-being.

5 CONCLUSION

This study focused on developing and refining user interface performance evaluation criteria for applications in prevention and medical education. The criteria were designed to enhance assessment quality by evaluating accuracy through correlation coefficients and confidence values, and they were tested in real applications. Research in user interface design has often concentrated on specific tasks using various tools, but limited attention has been given to general user groups, particularly for mobile devices.

A survey of mobile application designs revealed common issues such as disorganized layouts, small text, privacy concerns, and a lack of customization options. These findings highlighted the need for user interfaces tailored to specific user groups, emphasizing simplicity and ease of use. The study identified a lack of early design criteria, which could negatively impact application development, and employed design thinking and analytical principles to develop effective evaluation criteria. These criteria, revised and refined, were tested by experts, ensuring they are adequate and comprehensive.

The prototype evaluation criteria were developed with expert input collected through online interviews and forms. These criteria were tested by specialists, and the reliability was determined using Cronbach's alpha coefficient. The results indicated satisfaction with the assessment form, with some areas identified for further improvement.

In summary, this study establishes the usability, consistency, and correctness of user interface performance evaluation criteria. These criteria, incorporating design thinking and expert feedback, form a foundation for effective and user-centric application design and development. By considering these criteria early, usability issues can be mitigated, enhancing the quality of engineering applications and contributing to broader scientific and societal well-being.

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