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Design of Dental Disease Knowledge Base Editor Dialog using ISR-Framework

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Abstract-Dental disease is one of the health problems commonly found in Indonesia. Data from the Indonesian Health Authority indicates an imbalance between the number of handled dental cases and the number of dental specialists who treat them. Technological advances bring significant improvements in the quality of medical services. A reliable Group Decision Support System (GDSS) requires a knowledge base editor for expert knowledge acquisition. A critical aspect in building a knowledge base is the interactive interface design. The problem that often arises is that experts find it hard to use a system because the interface does not meet their expectations. In this study, we analyze the interface requirements for a knowledge base editor with a group of experts. The purpose is to report on the process of designing a knowledge base editor interface with a user-centered expert group using the Information Systems Research (ISR-Framework) framework. We conducted several Focus Group Discussions involving 20 dentists, one dental specialist, and one Information Technology Expert in the GDSS field. The repetitive characteristics of this method help increase the value of user satisfaction. The research results expectedly support the ISR framework as a guide for designing future knowledge acquisition applications.

Keywords: Knowledge Base Interface, Dental Diseases, Information Systems Research Framework

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1. Introduction

Dental disease is one of the most common health problems experienced by people in Indonesia [1]. Based on the results of the Basic Health Research (Riskesdas) of the Indonesian Ministry of Health in 2018, 57.6% of the Indonesian population experienced dental and oral problems. In addition, 93% of early childhood in the range of 5 - 6 years experience cavities [2]. Furthermore, based on data [3], the most common diseases suffered by the elderly are hypertension 63.5%, dental problems 53.6%, joint disease 18%, oral problems 17%, diabetes mellitus 5.7%, heart disease 4.5%, stroke 4.4%, kidney failure 0.8% and 0.4% cancer. This puts dental health problems in second place and oral health problems in fourth. The high number of dental and oral disease cases in Indonesia is not directly proportional to the number of available dentists. Based on data from the Agency for the Development and Empowerment of Health Human Resources [3], the number of specialist doctors in hospitals in Indonesia in 2018 was 66,691 people with the highest proportion being basic specialists (39.4%) and the least proportion being specialist dentists. (3.7%). This shows that there is an imbalance in handling between the number of cases of dental problems and the number of specialist dentists who treat them.

Information technology intervention can be a solution to improve the quality of medical services. Human knowledge is captured in computers to solve problems that usually require expert expertise [5]. By utilizing relevant information from users and the available knowledge base, computers can make decision recommendations [6]. In the case of knowledge acquisition with expert groups, it is possible to gain different experiences and knowledge in the same application domain. Thus, it is necessary to acquire and integrate diverse knowledge from expert groups when building an effective Group Decision Support System (GDSS).

A reliable GDSS requires a knowledge base editor for expert knowledge acquisition. The presence of an interactive interface design is one of the important aspects in efforts to acquire and integrate knowledge from expert groups to produce a decision. Previous research [7], stated that the success or failure of a system depends more on

the communication and interface capabilities of the system than on processing speed or problem-solving abilities. Most experts are experts in a specific domain. They tend to use computer technology to complete tasks and solve problems in their work. The user interface has an influence on the ease of use of the system by doctors [4]. In practice, the problem that often occurs is that users have difficulty using the system because the interface that is built is not according to their wishes. A good interface allows an expert to enter his knowledge correctly and more completely. The use of computer-based systems to carry out knowledge acquisition can be a challenge for decision-makers.

This research was conducted to analyze the needs of the knowledge base editor interface with the expert group. The purpose of this study is to report on the process of designing a knowledge base editor interface with a user-centered expert group (User-Centered Design/UCD) using a model called the Information Systems Research framework (ISR-Framework) [8]. This model has not been widely applied to the health application domain compared to other models such as Participatory Design [9]. An important research question [10] was adopted in the analysis process as a guide in developing the interface requirements. In a previous study, [10] stated that human-computer interaction in perspective can be analyzed through 3 questions, namely:

a. What do users see on the system?
b. What should the user know about what he sees on the system?
c. What can users do with the system to achieve the goals of using the system?

These three questions, originally formulated for the design of a Decision Support System (DSS) with a single expert, however, can be applied equally well to the design of a knowledge base editor interface for groups of experts. In its development, several studies were conducted using several tools or methods to carry out the knowledge acquisition process for expert groups such as CADIAG-II/RHEUMA [11] and Word-Net [12]. The interface design developed in this research is based on the Repertory Grid Analysis (RGA) method. RGA is used in this study because it is a technique that is widely used in the knowledge acquisition process [13]. The aim of the study was limited to the design of a knowledge base editor interface for a group of experts in the dental health domain. This study also limits the scope of research carried out by applying RGA to the interface design of the knowledge base editor because in some cases the use of different methods has different interface requirements.

2. Related Research

Research related to interface design for knowledge base editors has been carried out by several researchers, including research conducted by [14] that discusses the ideal interface architecture for the knowledge base of expert groups. The interface consists of two actors, namely the facilitator and the members. The facilitator has an important role in the system to be able to create and manage meeting session details, create a work agenda and set the time for each action and member access rights, manage the details of decision-making activities, group ideas from members, and generate meeting reports. Meanwhile, members can add ideas according to the session, and prioritize ideas by filling out several questionnaires. In addition, members can also add/change resources such as textbooks, videos, journals, etc. Research conducted by [15] describes several design features that can be applied to the knowledge base editor of web contributors using natural language processing using a system called Learner and Learner2. Furthermore, the research conducted [16] investigated whether good information visualization promotes the acquisition of quality from the expert knowledge acquisition process. The results of this study indicate that good information visualization supports the knowledge acquisition process. Concerning appropriate design, this study shows that visualization of information in two dimensions is more suitable to support the knowledge acquisition process than visualization in three dimensions. In addition, this study also confirms that color-coded information visualization slightly improves performance in knowledge acquisition compared to monochromatic.

Research [14], [15], and [16] although focused on designing interfaces for knowledge base editors, did not specifically address the field of dental health. Generally, research related to the dental disease domain focuses on engine inference and knowledge modeling in a knowledge base as in research [34],[35], and [36]. One of the weaknesses that are often encountered in applications or systems is the interface and control of computer systems that do not meet user expectations [30] so that in the end the system cannot be used optimally. A good interface will facilitate communication between the user (who in this case is a specialist dentist) and the computer so that the purpose of developing the system will be achieved. However, there are no studies that focus on discussing this, especially in the field of dental health.

Therefore, based on the studies conducted, there are opportunities to be considered for future research. First, there is currently no common framework that can be used to build knowledge base interfaces with expert groups, particularly in the field of dental health. Most of the knowledge base interfaces reported in the research reviewed are scenario-specific and cannot easily be generalized to other contexts. The next researcher can conduct an analysis related to the mapping of principles that can form a general framework and which can only be applied in certain contexts or systems. Each system has a different character, to some extent, may demand a different design approach. Second, there are very few studies that specialize in the design of knowledge base interfaces for expert groups in the dental disease domain. In fact, in the field of dental health, inflammation of the oral cavity

(oromaxillofacial), for example, can be a complex case and requires the involvement of multiple specialists to treat it [28].

Thus, it is important to present new research to add to the repertoire of GDSS knowledge and technology, especially for groups of dental experts. Therefore, paying attention to this context, this research contributes to providing analysis and provides a framework for building a dental knowledge base interface with expert groups.

3. Methods

In this study, the design of the dental disease knowledge base editor interface by an expert group was carried out using the Information Systems Research (ISR) framework [17]. ISR guides the application of user-centered human-computer interaction research methods to identify user needs, and design preferences, and identify barriers or challenges to acceptance of interface design. The stages of the Information Systems Research (ISR) framework are depicted in Figure 1.

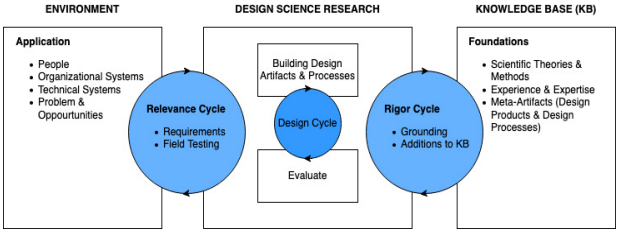

Figure 1. Step of the Information Systems Research framework

In this study, the ISR framework was carried out in 3 cycles, namely: (1) Relevance Cycle or a cycle to understand user behavior and preferences through a series of Focus Group Discussions (FGD) for the Dentist group; (2) Rigor Cycle or cycles to understand user behavior and preferences by conducting studies on theories and artifacts obtained from previous studies and similar applications; (3) The Design Cycle is the design phase that is built and evaluated.

a. The Relevance Cycle.

The technique of collecting data using snowball sampling was chosen to obtain dentists who would serve as respondents in this study. The criteria used in the selection of dentists as respondents are dentists who have practiced for at least 5 years, and can use information technology. At this stage, 2 FGD sessions were held involving more than 20 dentists from various regions in Indonesia from May until August 2020 using teleconference media. An overview of the atmosphere of the FGD session can be seen in Figure 2.

The thematic analysis of the FGD sessions revealed three categories of functional requirements [10] including what do users see on the system? what should users know about what they see on the system? and, what can users do with the system to achieve the goal of using the system? Each of these categories of questions was discussed during the FGD sessions with end-users to identify the desired content and functional requirements of the dental disease knowledge base editor interface. The big picture of this stage can be seen in Table 1.

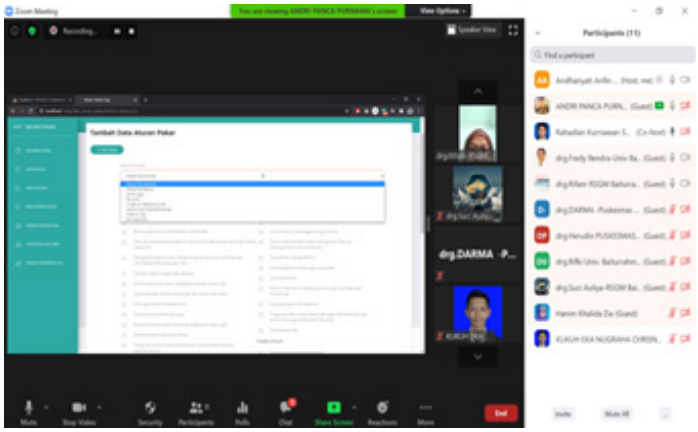

Figure 2. FGD session 1 stage of the Relevance Cycle.

Table 1. Relevance Cycle Results

Functional Requirements	FGD Results
What do users see on the system?	1. Want an easy interface with the procedures for establishing a diagnosis. 2. The desire for an interface that allows for less scrolling and less writing in one field of view. 3. Want an interface that is easy to read, has a consistent organization of information and has an easy flow of information.
What should the user know about what he sees on the system?	1. Symptoms are grouped and written according to the rules of 7 anamneses (The Sacred Seven). 2. The doctor wants an alert if the input given has a wide enough range with the average input value of other doctors' trust so that the doctor can check the input given.

Functional Requirements	FGD Results
What can users do with the system to achieve the goals of using the system?	1. Doctors can enter and edit confidence values in each rule. 2. Doctors can see the average value of other experts' trust in a rule. 3. Doctors can include rules for differential diagnosis, as a comparison to the main diagnosis.

b. The Rigor Cycle

This Rigor Cycle stage begins with looking for many previous studies and similar applications related to the research topic and problem domain. Literature from scientific publications that specifically discuss the design of knowledge base editor interfaces for expert groups in the dental disease domain was not found. Therefore, the literature search was extended to the literature with a general discussion but still related to the topic and problem domain. The literature search strategy used consisted of literature sources, restrictions (year of research publication and language of instruction), topic, problem domain, and focus. The year of publication and the language of instruction is not limited to a particular year and language due to the lack of the latest literature that is directly related. The period of the literature obtained is from 1989 to 2018. Literature sources are taken from IEEE, Springer, Google Scholar, Google Book, and Google Patent, both in the form of journals, proceedings, scientific articles, books, and patent documents, on a national and international scale. The total literature obtained is 10 kinds of literature.

1) The results of the literature review are related to the knowledge acquisition process.

According to Dieng et al. [18], the design of a knowledge base for expert groups must take into account the similarities or differences in the domain of expertise of the experts involved and their roles. Experts with the same domain of expertise have the possibility of using different settlement methods. Developers can model more specific pieces of expert knowledge. This is intended to find the possibility of conflict, the possibility of working together and how to reach a consensus or even maintain differences in viewpoints between experts, and how to check the consistency of knowledge. To speed up the process of extracting medical knowledge from dental hygienists, a hybrid method can be used, Zhang et al. [19] divided the procedure into three, namely:

- Collect raw data describing the symptoms and construct the concept of the model. These data were obtained through polls and interviews with patients and dental health experts.
- The expert knowledge acquisition process can be assisted by special tools, namely an object-oriented Knowledge Acquisition (KA) editor and a web-based interface to help collect expert knowledge automatically.
- Dental health experts carry out the process of integrating data and information into a dental health ontology

In addition, semantic web technology can be an approach to the knowledge acquisition process when designing the knowledge base editor Bakraceski et al [20]. The semantics of the web make the editor more understandable to experts because this technology uses a natural language approach so that users can more freely manage data in the way they like.

2) The results of the study of applications in the topic and domain of Health

The process of searching for several applications resulted in several findings:

- Knowledge-Based Electronic Clinical for Dentistry [21]. Many of these applications are equipped with a GUI and the majority adopt the check box and drop list features.
- DDES (Dental Diagnostic Expert System), has a mechanism to collect expert knowledge automatically by providing an object-oriented knowledge acquisition editor. The dialog model used is a windowing system (WS) feature that uses a lot of text input displayed in tables and drop-down scrolls [19].
- CIViC, a knowledge base editor for the clinical interpretation of cancer variants from the expert community, contains an overview of therapies, relevant prognoses, diagnostics, and predisposing conditions of heritable and somatic variants of all types [22]. This application provides a variety of features that can elaborate and validate knowledge from multiple experts in one discipline/domain of expertise or across disciplines. The collaboration model applied is inspired by online collaboration tools such as GitHub and Biostars.

3) The results of the literature review are related to user interface design.

Many types of dialog style models can be used in the design of the knowledge base editor interface, including Graphical User Interfaces or GUI, Windowing System (WS), Icon-based system (IBS), System menu (SM), Form-Filling Dialog (FFD), and Natural Language Processing (NLP) [23].

Based on the results of a study of several kinds of literature, the following recommendations are given:

- Experts in the field of dental health have long and busy working hours. Therefore, the interface design must pay attention to the user's character and efficiency [24].
- The more dominant/preferred types of dialog style models are the System Menu (SM), especially in the

check box and drop list features, Windowing System (WS), Form-Filling Dialog (FFD), and Icon-Based System (IBS) [21], [23]. Text entry is still required in some cases.

- The interface needs to be equipped with a GUI because the existence of this GUI feature has received great acceptance from users. After all, it is more attractive and user-friendly [21], [23]. The GUI features in the editor used by many experts need to pay attention to aspects that represent the user, for example, two-dimensional icons (images) or one-dimensional usernames (plain text usernames) [25].
- Efforts to manage the knowledge of expert groups need to be facilitated by several supporting features such as [22], [26], [27]:
  - Typeahead suggestions or autocomplete, i.e recommendations to users appear immediately when the user writes the text.
  - Automatic warning of possible duplicates
  - Detailed documentation in all entry forms
  - Validation of inputs and a mechanism for checking the correctness of the reasoning rules in the knowledge base
  - Advanced search feature
  - Group Forum feature provides discussion facilities between experts, which is equipped with information on discussion themes, discussion dates, and times
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Based on the Rigor Cycle, it is known that most studies are carried out in the context of a single expert or in the same domain, and very few are conducted in the context of groups of experts in different domains (multi-specialist). The context of expert groups in different domains (multi-specialist) is considered more challenging because the actors involved are more heterogeneous and the boundaries between them are often blurred [29]. There are different characteristics to some extent when developing interface designs with groups of experts in different domains. Therefore, paying attention to this context is important and interesting for future research.

c. The Design Cycle

The purpose of the design cycle is to follow up on the findings from the Relevance Cycle and Rigor Cycle and refine the design to increase the likelihood of technology acceptance. At this stage, two design sessions were conducted for the knowledge base editor with an expert group (Develop/Build and Evaluate).

Each successive design session is based on what was learned from the previous session. Design sessions are an iterative process in which expert respondents provide feedback on the interface, provide ideas on the design, and explain aspects of the interface, and functions that they consider important.

1) Building Design

Design Phase 1. At this stage, the design of the various dialog editors of the dental disease knowledge base was developed by the expert group from the results of the Relevance and Rigor Cycle processes that had been carried out previously. In addition, in this phase, several inputs were also explored through questionnaires to the same respondents at the Relevance Cycle stage related to interface requirements, namely: Presentation of Symptom Input Forms, Input of certainty values from experts, and display of GDSS results.

Figure 3 shows the results of the poll conducted. In the presentation feature of symptom input in the knowledge base, 60% chose to use a combo box with a search feature, 15% chose text input with natural language recognition, and 25% chose to use a radio button (Figure 3a). According to respondents, using a combo box with a search feature based on the text entered by an expert can help the data input process to be faster. Furthermore, there is a recommendation that the name of the symptom must pay attention to the 7 pearl history rules (The Sacred Seven) so that doctors can easily find the symptom in question. For the value feature of expert confidence in the emergence of hypotheses due to evidence, 80% chose the form of a slider, and 20% chose the form of text input (Figure 3b).

Based on the recommendation of a specialist dentist, the display to determine the certainty value is indeed better in the form of a slider which also displays the numerical value. Doctors feel more confident using a slider than entering numbers directly. Furthermore, in the display feature of the GDSS results, 70% of respondents feel that they do not need to display the average value entered by other experts, and 30% feel the need to know the average value of certainty entered by other experts. In this case, the specialist feels that it is not necessary to know the certainty value entered by another specialist, but in certain cases, the expert states that the presence of an average value can give an idea if it is not his domain of expertise (Figure 3c).

Design Phase 2. At this stage, improvements are made to the design of various dialog styles from the results of the evaluation carried out. At this stage, we also conducted interviews with a Specialist Dentist and a Technologist. Information that specializes in the field of GDSS development In general, the system is considered to meet the needs of experts, but several recommendations are quite important to add, namely the existence of a menu to add rules for comparative diagnosis.

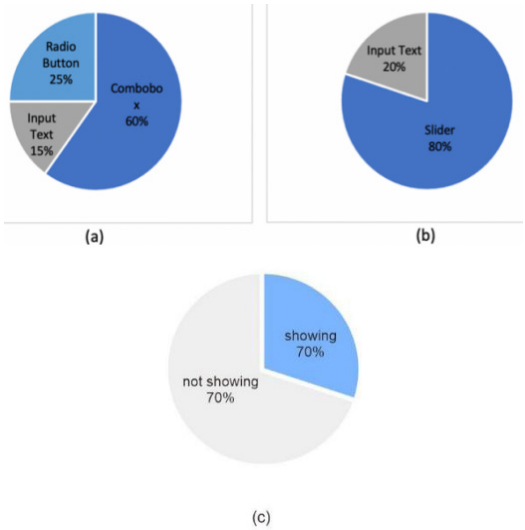


Figure 3. Needs Features of the Dental Disease Knowledge base editor: (a) Presentation of symptom input in the knowledge base; (b) input of certainty value from expert; (c) GDSS Result Display.

2) Evaluation

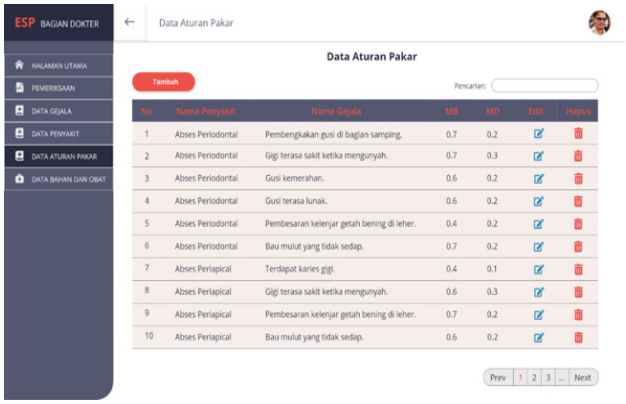
The evaluation process was carried out 2 times, namely: Evaluation of building design phase 1, and Evaluation of building design phase 2. The evaluation involved 20 Dentists, as well as 2 experts consisting of 1 expert in the field of information technology who specializes in the development of Group Decision Support Systems, and a Specialist Dentist who is accustomed to using information technology. Each phase is assessed using a questionnaire to evaluate several criteria. The User Interface Satisfaction Questionnaire from Chin [32] was adapted to evaluate the user interface. To evaluate the user interface, 4 questions in the Screen section are given to the user. The question variables are explained as follows:

- On-Screen Character Reading (score: 1 = difficult.... 9 = easy).
- Task Simplification Highlights (score: 1 = none ..... 9 = very much)
- Information Organization (score: 1 = confusing ..... 9 = clear)
- Order of the process (score: 1 = confusing ..... 9 = easy)

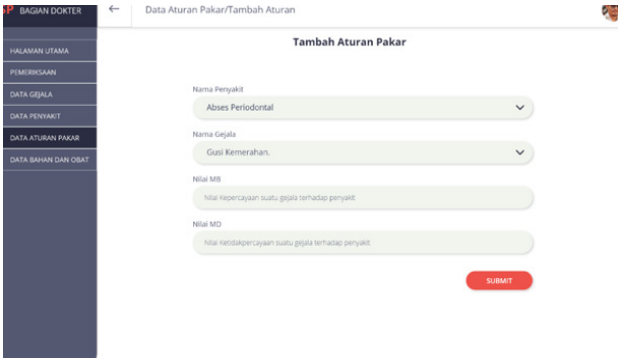
4. Results and Discussion

The results of the various dialog designs of the dental disease knowledge base editor using the ISR Framework have been successfully created with several different display models.

Figure 4 shows an image of the interface of the knowledge base editor with a group of experts in the early version of dental disease. The interface design has included features that accommodate knowledge base reasoning using the Certainty Factor (CF) method, which is filled in by the expert along with the rules. The CF filled in by the expert describes the expert's belief in the relationship between the antecedent and the consequent on the rules of production rules [37]. For example, on the Add Expert Rules page, input facilities are provided for MD (a measure of increased disbelief) and MB (a measure of increased belief) values.



(a)



(b)

Figure 4. (a) Early version rules interface, (b) Early version add rules interface

However, the use of MD and MB labels as shown in Figures 4. (a) and 4(b) cannot be understood by the user. In addition, in the interface design, add rules as shown in Figure 4. (b), filling in the MD and MB values using the text field feature, thus confusing the dentists as to what exactly the value should be, whether it is an integer, a fraction of a percentage.

Figure 5 shows an image of the interface of the knowledge base editor with the expert group in the final version of the dental disease domain. Based on the inputs given by the experts in the FGD session, a significant change to the final version of the rule base interface design, one of which is the improvement of label names. As shown in Figure 5. (a), the fourth column label changed its name using user-friendly diction to "certainty value" and the fifth column label changed its name to "uncertainty value".

Changes to the interface design added to the final version of the rules are the use of the slider feature that replaces the text field feature. The display to determine the certainty value is indeed better in the form of a slider which also displays the numerical value. This slider feature shows how much confidence or level of confidence the

doctor has in the symptoms of a disease. Doctors feel more confident using a slider than entering numbers directly. The dialog model using this slider is an implementation of the knowledge acquisition design for many experts using the Repertory Grid Analysis (RGA) method [31]. After the expert identifies the symptoms and diseases, then the expert provides a grid rating using the slider feature. This slider feature is more user-friendly than the check box and text field features. These changes can be seen in Figure 5. (b).

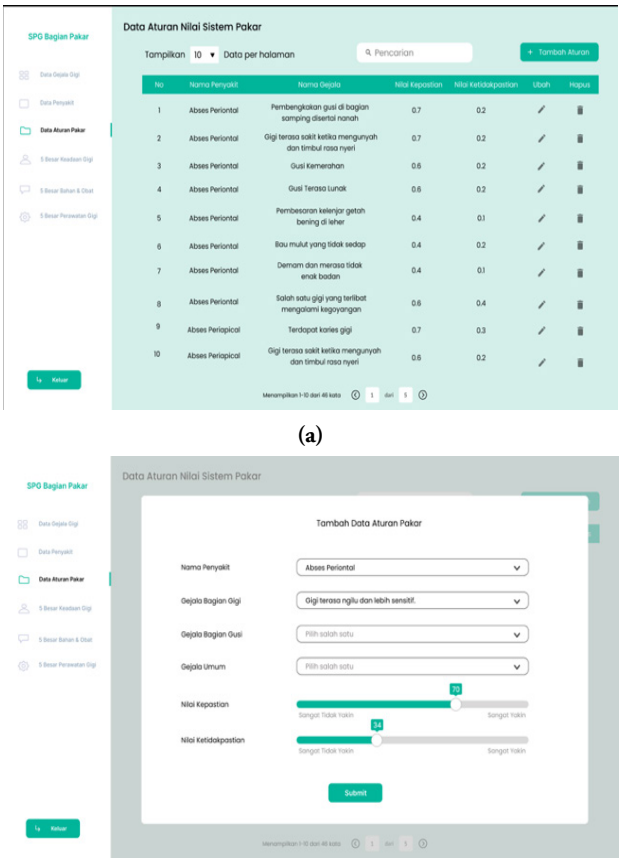


Figure 5. (a) Final version rules interface, (b) Final version add rules interface

Figure 6 shows the average value of each survey component. On-screen character reading resulted in the highest score among all components with a score of 7.6 out of 9. The design produced in the final stage succeeded in increasing the comfort of reading characters on the screen by increasing the font size and reducing on-screen information to reduce stress on character reading. The increase in user convenience by increasing the font size and reducing the information is in line with research conducted by [33].

The value of organizing information got a score of 7.4 out of 9. This satisfaction value increased quite significantly, amounting to 0.6 from the previous score in the first interface design. This can be achieved through rearrangement of the information presented in each menu window by adopting the principles of User Center Design (UCD) for the dialog windowing system (WS) model as proposed in research [21] and [22].

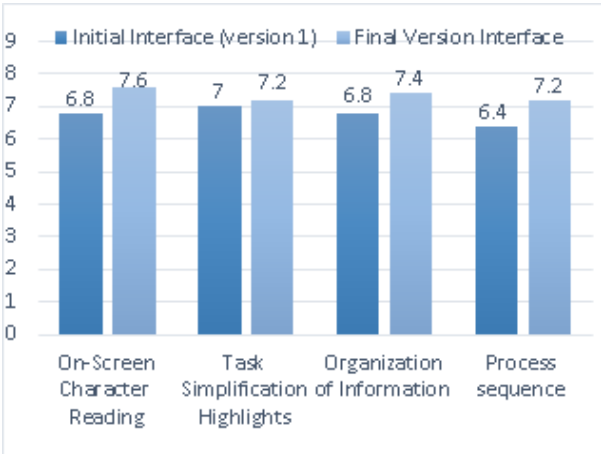


Figure 6. User Interface Design Evaluation Results

The lowest score was obtained from the process flow aspect, namely 7.2 out of 9. Even though it got the lowest score, there was a significant increase in the score, namely 0.8 compared to the first interface design. This increase in value occurred after several streams of expert knowledge management were simplified, for example by changing the value input feature from a text field to a slider and adding a comparative diagnosis menu. It can be concluded that in general the process flow can still be followed by users. In addition, previously in the interview phase with experts and FGD with dentists, it was confirmed that the process flow in the system was following the flow of dental disease diagnosis.

The next lowest score was 7.2 out of 9, the score was obtained from the highlight of task simplification. Not too significant increase in the value of the final design, which is only as much as 0.2 points. If you look back at Figure 5, you can see a comparison of the level of satisfaction between the first design and the final design. That the task simplification aspect in the first interface design has received the best level of satisfaction compared to other aspects (score 7, while others are below 7).

The score from the aspect of highlighting the simplification of tasks with a not-so-significant increase in grades cannot be considered as something bad. In the interview sessions with experts and FGDs with dentists, they felt that the first version of the dental disease knowledge base interface design for the expert group had been able to help them simplify the tasks of a dentist, namely that there were already menus or features that automate their work. experts/dentists, such as checklist menus and combo boxes, then in the final design version a slider feature was added.

In addition, referring to the recommendations from the Rigor Cycle phase, the typeahead suggestion feature is applied when the expert will enter or search for symptoms

and diseases. The error notification feature is also very helpful for experts to prevent them from misbehaving. This change is in line with research [24] that interface design must pay attention to user characteristics and efficiency.

The results of the evaluation show one weakness, the existence of a system workflow that does not fully accommodate the wishes of experts as decision-makers. One of the reasons is that in the implementation of Information Technology applications, there will indeed be an adjustment of the workflow which was originally done manually to be assisted by Information Technology, so it requires time and routine use.

Therefore, based on the results of the interface evaluation, the design in the second cycle was preferred by dentists. This shows that the final design has a more attractive design and is more comfortable for users to use. Repeated characters in the ISR framework can help increase user satisfaction scores.

5. Conclusion

The use of the ISR framework in designing a variety of dental disease knowledge base editor dialog is considered time-consuming and expensive to implement. However, the development of interfaces with this framework has proven to be able to produce a technology that is acceptable to users and easy to use. The repeated characteristics of this method help increase the value of user satisfaction in the user evaluation process. Based on the results of the research that has been carried out, this framework can be used as a useful model to guide the development of knowledge acquisition applications in the future.

Another contribution of this research is that the results of the Rigor Cycle stage that have been carried out can map out two studies that can be carried out in the future where future researchers can conduct analysis related to mapping principles that can form a general framework and which can be applied in the context of knowledge acquisition, as well as there is a need for future research related to the analysis of knowledge base editor interfaces in the context of expert groups in different domains (multi-specialist).

This study has several limitations. The data collection is carried out on dentists who are accustomed to interacting with information technology. In some cases, this cannot be generalized to general dentistry. Very little feedback was received from respondents, this could be because the dentist did not fully understand what was being developed. Furthermore, data collection at the Rigor Cycle stage received only a few studies that could be used to enrich the interface design of the knowledge base editor with a group of experts in the dental disease domain.

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