Using Heuristic Evaluation To Improve the Usability of Electronic Medical Record (EMR) Mobile Interface of the Cardiothoracic Surgery and Anesthesia System (CSAS)

Hasanin Mohammed Salman[a]*, Azrina Kamaruddin[a,*], Lily Suriani Affendey[b], Evi Indriasari Mansor[c], Rahmita Wirza O.K Rahmat[c], Azrul Hazri Jantan[c]

[a]Jabatan Kejuruteraan Perisian & Sistem Maklumat, Fakulti Sains Komputer Dan Teknologi Maklumat, UPM
[b]Jabatan Sains Komputer, Fakulti Sains Komputer Dan Teknologi Maklumat, UPM.
[c]Jabatan Multimedia, Fakulti Sains Komputer Dan Teknologi Maklumat, UPM

Graphical abstract
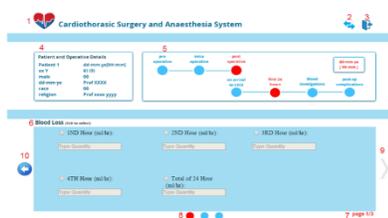
Abstract

This paper presents initial work on mobile user-interface for electronic medical record for cardio experts. The current problem exits when the existing system is left unused by the users, in our case the cardio surgeons due to bad user interface design which involve a heavy cognitive loads and navigation problems. Medical records contain treatment history and relevant experiences related to the patient care. In order to avoid paper based medical record (PMR) drawbacks, most industrialized nations have implemented electronic medical record (EMR). This research aims to evaluate the existing CSAS system usability using heuristic evaluation and then develop an EMR system that overcomes the interface usability problems by designing an effective user interface that is acceptable to healthcare professionals with tablets as the device. Hence, proposing a new user interface prototype taking into account the findings from the evaluation process.

Keywords: Heuristic evaluation, interface usabilit, electronic medical record, mobile interface design

Abstrak

Kertas kerja ini membentangkan kerja awal pada antara muka pengguna mudah alih untuk rekod perubatan elektronik pakar kardio. Masalah sekarang ialah apabila sistem yang sedia ada itu tidak digunakan oleh pengguna iaitu pakar bedah kardio disebabkan oleh kesukaran reka bentuk antara muka pengguna yang melibatkan beban kognitif dan masalah pelayaran. Rekod perubatan mengandungi sejarah rawatan yang relevan berkaitan dengan pengalaman penjagaan pesakit . Untuk mengelakkan kelemahan rekod perubatan berdasarkan kertas (PMR), kebanyakan negara-negara perindustrian telah melaksanakan rekod perubatan elektronik (EMR) . Kajian ini bertujuan untuk menilai kebolehgunaan sistem CSAS yang sedia ada dengan menggunakan penilaian heuristik, dan kemudian membangunkan sistem EMR yang dapat mengatasi masalah kebolehgunaan dengan mereka bentuk antara muka pengguna yang berkesan yang boleh diterima oleh para profesional kesihatan dengan mengunakan alat peranti jenis tablet . Oleh itu, cadangan penggunaan prototaip antara muka yang baru dengan mengambil kira hasil daripada proses penilaian.

1.0 INTRODUCTION

Medical records contain treatment history and relevant experiences related to the patient care. When medical record updated, a written document of the medical history of a patient over time is provided. This medical history forms a database that can support decision making for the specialists and help them in the future courses of medications. Commonly, documentations in the medical field have been handwritten by specialist and filed into paper medical records (PMRs). The shortcomings of PMRs are quite clear; they can be unreadable, incomplete and poorly organized. All of these shortcomings make the quality assurance of health care difficult [5, 6].

In order to avoid PMRs drawbacks, most industrialized nations have implemented electronic medical records (EMRs) [1,8,9]. Electronic medical record (EMR) is "a digital version of the paper charts in the clinician's office, they contain the medical and treatment history of the patients in one practice" [3].

EMRs, once implemented, can provide medical practice and patient by various benefits simultaneously. The use of electronic medical systems has impressively make health data retrieval and manipulation easier, but on the other hand new dimensions of problems have been introduced [7]. 30% of EMR systems fail [1], one of the primary reasons for this failure is the lack of usability in the implementation of the most of failed systems [1, 2].

Usability is "the effectiveness, efficiency and satisfaction with which specific users can achieve a specific set of tasks in a particular environment" [10]. Usability has been submitted as the most important factor hindering widespread adoption of EMRs since it has a direct and strong relation with clinical productivity, error rate, and user fatigue and user satisfaction [1].

EMR systems are suffered from various usability problems, several of these problems are caused by their complex user interface [7,11]. Many of electronic medical applications have failed because their interfaces are difficult to learn and use, and as a result some clinicians still prefer to use their own paper forms rather electronic systems [7,11]. Usability evaluation is far broader than the simple process of measuring user satisfaction. Just as importantly, usability metrics include measures of efficiency, effectiveness, cognitive load and ease of learning. Usability emerges from understanding the needs of the users, using established methods of iterative design, and performing appropriate user testing when needed. There are a wide range of design and evaluation methodologies, both subjective[13] and objective[14], which are continually growing in sophistication.

This paper presents the heuristics evaluation by experts for the CSAS system [12]. The remainder of this paper is organized as follows. In the next section, the general methodology is described. Section 3.0 presents the pre-evaluation process. Section 3.1, demonstrates the evaluation process. Section 3.2 presents the evaluation results. Section 4 shows the design and finally the conclusion.

2.0 METHODOLOGY

Usability is one of the main factors that dominate the successfulness of any EMR system [1, 2]. Hence, it is essential to have a systematic measurement method that can be used to assess the target system usability [1, 2]. There are many popular techniques used to measure usability such as questionnaire[14], interview[13], and observation.

The proposed prototype system focusing on the interface design was planned to be fully compatible with touchscreen devices especially the tablets. It was selected because its' approach was closely similar to paper[15]. Tablets are associated with ease of use and faster recording[16].

Thus, our methodology is to design a prototype that complies with the merged design principles of EMRs and touchscreen devices on one hand, and considering the CSAS evaluation results on another hand.

The workflow in this work is divided into two main phases, which are the pre-usability evaluation phase and prototype design phase. The details of evaluation phase and design phase are explained in section 3 and 4 respectively. Figure 1 shows the steps that were followed during each phase in this study.
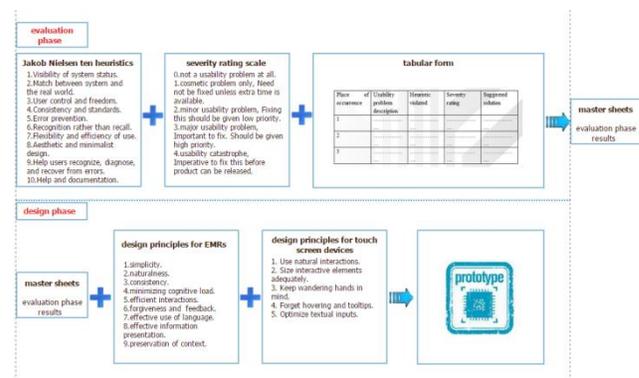

Figure 1 Study methodology

3.0 PRE-USABILITY EVALUATION PHASE

The ultimate goal of the evaluation phase is to identify which parts in existing interface system[12] caused interface usability problems.

The procedure in this phase, as (figure 1) indicates, starts when an evaluator inspects the CSAS interface trying to find the design drawbacks that caused the usability problems. The evaluation will be performed using the heuristic evaluation method, based on ten heuristics provided by Jakob Nielsen[17]. A heuristic evaluation is "a systematic inspection of a user interface to uncover as many of the problems users might have as time allows" [4].

The evaluation and design effort was concentrated on the part of the interface under the Post-operative details section only (indicated by an arrow in figure 2).

3.1 The Evaluation Process

The following points summarized the main steps that each evaluator should follow while he/she inspects the system:

1. Evaluator reviews a list of the ten Jakob Nielsen heuristics [17] along with their definitions.
2. The evaluator then individually works through the system to perform the tasks being selected for the evaluation. Evaluator takes the role of the intended system user. When evaluator discovers a usability problem, he/she records it on the tabular form along with the related details (the place of occurrence, the heuristic that it is violated, severity rating, and a suggested solution).
3. After completing the tasks selected for the evaluation, evaluator inspects the system in other ways. (E.g. try to create error conditions scenarios in order to test system response).
4. At the end, the evaluation results are collected, the usability problems are combined and duplicate problems are eliminated. The master sheet will be produced as the final outcome of this phase.

Each review took approximately one hour minutes. In each one, evaluator filled the fields of tabular form.

The outcome of the each of the three expert reviews is to identify the usability defects in the current CSAS interface[12] along with complete details about the heuristics violated, severity, and suggested solutions as indicated in the tabular form.
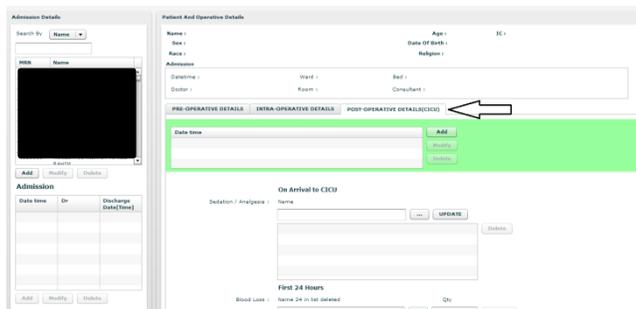

Figure 2 User interface of CSAS [12]

The results in the each tabular form will be combined together in a single master sheet. This step is considered critical because the master sheet serves as the main reference for designers, thus it is very essential to ensure that its content has been correctly extracted from the three tabular forms. In order to correctly compile the results in the separate tabular forms, results were inspected in details to eliminate duplicates before transferring results to the master sheet.

3.2 The Evaluation Results

The first step to solve any problem is to understand it in depth and think on the most appropriate ways to solve it. Hence, the parts of the post-operative details section that caused interface usability problems (as indicated by evaluators), will be studied in details.

Table 1, indicates that one of the interface usability problems is post-operative section contains too many components. To overcome this problem it was suggested to divide this section into for sub-sections (on arrival, first 24 hours, blood investigations, and post-op complications).

All the places in the interface that caused the usability problems under the four sub-sections are identified in the table 1.

A search box or search field is a graphical control element used in computer programs. While performing various activities within the CSAS interface[12], evaluators noticed that name search box doesn't provide its intended function. Or more precisely this search field is out of service.

A widespread problem encountered throughout the CSAS interface is the use of a three dots button (indicated by arrow in figure 3) to do the various required selections. After clicking this button a pop up list will appear, this list allows user to select drugs that he/she add to the patient record, (figure 3) shows this procedure.

It is clear that this method is insufficient, since each time user wants to add a drug (or more than one drug at the same time by clicking on ctrl + click) in the patient record, he/she must click on the three dots button, select from the list, and click select. It's a quite long procedure that requires a series of interactions between user and system. Those interactions consume a lot of user's time and concentration. Thus, in order to make system more usable, it's very essential to redesign this part of system in a manner that provides same functions with fewer steps.

Another issue observed by the evaluators was the unneeded function presented by update button. When user selects a drug from the list appears after clicking three dots button, this selected drug is directly added to the patient record and saved in the system. Hence this presents an unrequired function. In the case user wants to modify a value assigned to any selection, he/she needs to click update, even in this case the function provided by the button is useless as will be clarified in the next paragraph.

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Table 1 The four sub-sections with the places of occurrence

	On arrival	First 24 hours	Blood investigations	Post-op complications
Places of Occurrence	Name text box	Name text box	Name text box	Radio buttons
	Three dots button	Three dots button	Three dots button	The overall sub-section interface design
	Update button	Qty box	Qty box	
		Update button	Update button	

As a box name indicates, Qty box is used to assign a value to its related selection. The first problem with this part of interface is there are no indications/tips to inform users that Qty box needs to be filled together with selection. Another problem is the procedure itself is complicated, to add a value user must click on the selection that they want to assign value to it, click on modify, enter a value in the box, and as a final step user must click on update button to save value.

If user wants to assign values to three selections, he must repeat same procedure for three times. Thus entering value one by one is clearly long and insufficient.

Radio buttons are always require an interaction from the user even when the answer is no. So for the 25 radio buttons we have in this sub-section, 25 responses from the user are required as well. Scrolling down, that caused from arranging radio buttons one under another, is another usability problem in this sub-section of the CSAS interface[12]. Thus, the overall sub-section design contains many drawbacks involving radio buttons as well as scrolling down.

4.0 PROTOTYPE DESIGN PHASE

As mentioned in our methodology, the new interface prototype should overcome the discovered interface usability problems during the evaluation stages, and follow design principles of EMR and touch screen devices.

To make the design process clearer and easier, the workflow is divided into three sub processes, which are:

- Main part design: is the redesign of the part of post-operative details section that caused the higher number of usability problems.
- Other parts design: is the redesign of the part of post-operative details section that caused the lower number of usability problems.
- Overall design: is the redesign of the overall post-operative details section.

4.1 Main Part Design

From the evaluation results, we can note that the main three Places in the post-operative section interface that caused the most of usability problems are: three dots button, Qty Box, and update button.
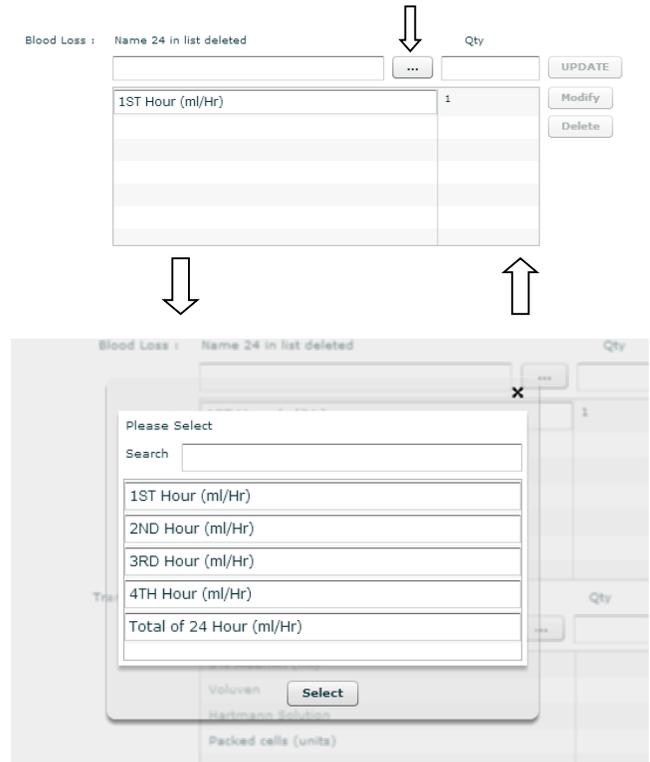

Figure 3 Procedure to do selection after clicking a three dots button

Let's take blood loos part (under first 24 hours subsection) as our staring point to design the proposed prototype. This part was chosen because it contains all the places which have been defined as those caused most of usability drawbacks, also blood loos is the most repeated part in the interface under different names with different drugs/selections in each time. This part was redesigned, and the new design was generalized to all similar parts in the interface.

To add, delete and/or modify any value in the patient record, user should follow all the steps outlined in the table 2. It's clear that those steps are taking a long time from the physicians to be accomplished. Physicians are known that they are busy and have a limited time to give a full attention to the software. Hence, the physician still prefers using her own paper form to

accomplish the various daily work activities than using CSAS [12].

The key to success for any proposed prototype is to design an interface that provides the same functionalities with less number of steps. Taking into account this point in addition to the evaluation results, the prototype of blood loos part has been designed as shown in (figure 4).

Here all the selections are appeared in one screen. To add a selection, user can simply tick on the preferred one and the text box will be activated allowing user to type quantity. The box under each selection contains indication/tip to inform user that this box needs to be filled together with selection.

So instead of switching between two parts of the interface, we have one window on which all operations (add, delete, modify records) can be performed. Table 2 shows the steps required to do add, delete, and modify operations in both CSAS and the proposed prototype.

Table 2 Steps required to accomplish basic operations in blood loos part

Operation	Step in CSAS	# of steps	Steps in the proposed prototype	# of steps
add	1. Click on the three dots button. 2. On the popped up selection menu, 3. Click on the required selection. 4. Click on select. 5. To add a quantity to the selection, Click on it. 6. Click on modify. 7. Type the quantity on Qty box. Click on update.	Seven steps	1. Click on the check box. 2. Type the quantity on Qty box.	Two Steps
delete	1. Click on the required selection. 2. Click on delete button. 3.On the popped up conformation message, Click on yes	Three steps	1. Click on the check box (uncheck the box of the data that you want to delete from patient record)	One step
modify	1. Click on the required selection. 2. Click on modify button. 3. Modify quantity on Qty box. 4. Click on update.	Four steps	1. Type new quantity on Qty box.	One step

4.2 Other Parts Design

Since there are interface parts have a different structure than blood loss structure, hence our next step is to redesign those parts also. By referring to the expert reviews results in the master sheet, evaluators defined other places of occurrence which are radio buttons and Interface for post-op complications sub-section.

Evaluators recommended suggestions are to change each radio button with a check box and rearrange items represented in a post complications sub-section into three columns. As a result, the number of interactions required from the user will be reduced, since the user will only tick on a check box when he wants to add data represented by that box to the patient record. The second result is the scrolling down will be minimized because the items will be arranged into three columns instead of one columns, hence the space provided for the post-operative section will be used in a more efficient manner.
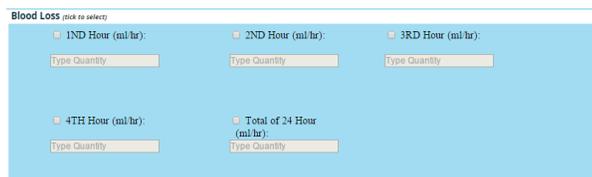

Figure 4 the proposed new interface prototype for blood loos part

4.3 The Overall Design

Figure 5 shows the complete design of post-operative details section. To make the explanation of the design easier, each part in the prototype interface is given a number. The definition of each part is given in table 3 on the next page.
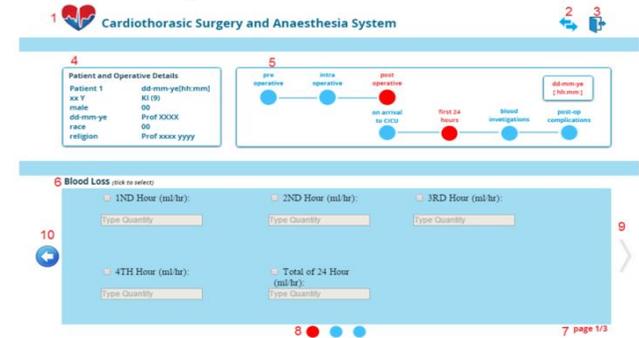

Figure 5 The proposed design of CSAS interface

5.0 CONCLUSIONS

Heuristic evaluation conducted by experts can play a valuable role in assisting the user interface design for critical health system especially for CSAS. Experts involved in the development can provide a very good and in depth on improving the user interface.

The tablets user interface design for CSAS has taken into consideration the design principles and human

factors to make the date entry easy and error free. The proposed user interface design for CSAS hope to help and ensure usability and design consistency across other clinical applications.

Table 3 Prototype parts definitions

Part	definition
1	System logo and name.
2	Select another patient button.
3	Sign out button.
4	Patient and operative details.
5	Navigation panel, the first row of circles represents the three stages of the system (pre, intra and post-operative details). The second row represents the sub-stages under each stage. The red circle represents the current stage/sub-stage.
6	Blood loos part with help message (tick to select).
7	Page number. Each part is represented in one page. In the case shown in figure 7, the first 24 hours sub-stage contains three parts (one of them is blood loos part), so its composed of three pages.
8	Page navigation circles. Those circles represent buttons to navigate through pages. In this case the red circle also represents the current page.
9	Next page arrow. Takes user to the next page.
10	Previous sub-stage. Takes user to the Previous sub-stage.

Acknowledgement

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