Designing good healthcare

Improving ulcer monitoring in home care

Felix Isacsson
Abstract

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This thesis seeks to improve the ways in which healthcare professionals can monitor and treat ulcers using mobile technology. The work focuses on designing a well-rounded user experience which is usable in a professional setting. The design presented in the work is based on established design rules and guidelines. The design is evaluated and verified using two usability evaluation methods. These methods are a heuristic evaluation and a cognitive walkthrough. The work also seeks to evaluate what impact user involvement in the development process has on the user experience. This is done using a questionnaire named AnvändbarhetsIndex and it focuses on evaluating the usability of a given system. The results of this thesis show that it is possible to implement the monitoring process while providing a positive user experience and that the user experience is positively impacted by involving the user in the development process.
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1 Introduction

In a world where innovation and digitization comes at a rapid pace[15] it is imperative that fields that can take advantage of this fact do so. It can lead to effectivization of both labour and management if done correctly. With the advent of the personal computer the world has evolved to a place where it is difficult to find a business, facility, or home which is not equipped with one. [3] While the original use for the computer was found in areas such as the military [2], the computer quickly evolved to fit other purposes employed by the general public[15]. To make use of computers in environments where the end user is not a computer expert, the user interface should be intuitive[8]. As such, innovations in computer science are not limited to hardware, but also the ways in which humans interface and interact with the hardware. This particular field of computer science is known as human-computer interaction (HCI).[1]

One such field that seeks to utilize computers to effectivize its work is healthcare. Healthcare professionals use computers to keep notes of patients and their progress in healthcare information systems on a daily basis. Beyond healthcare information systems computers are used for medical imaging using ultrasound or X-rays in order to further examine patients [4]. Healthcare staff come in contact with computers every day and as such it is important that the systems that are used are designed in such a way that they can be easily and effectively utilized.[16]

1.1 Avancerad sjukvård i hemmet

"Avancerad sjukvård i hemmet" (ASiH) translates to "advanced healthcare in the home" and is a form of healthcare which is an option if the alternative is hospital care around the clock.

1.2 ASiH Roslagen

ASiH Roslagen is part of the family-run concern Förenade Care which is operating in both Sweden and Denmark. ASiH Roslagen provides healthcare in the comfort of the patients home in the form of both palliative as well as curative care.

1.3 Problem

When caring for patients in their homes the ways in which one can transmit information between one healthcare professional and another is limited by distance and tools available. When a particularly difficult ulcer is being dealt with the treatment can span over several weeks or months. [10] As such there will be many different nurses who treat the patient and information needs to be passed between the staff with regard to how the ulcer is healing. Parameters such as width and depth must be tracked and while this can be done by taking notes in the healthcare information system it is sometimes necessary to provide visual information. Pictures can prove useful when dealing with particularities in a ulcer. It could be that there is a deviation in the healing process which needs to be seen in order to properly evaluate the course of action to treat it. There exists powerful software on the market which can provide this service but these tools are expensive and to gauge whether such a system would provide enough benefit to the company a prototype will be used.
2 Theoretical framework

2.1 Human-computer interaction

Human-computer interaction (HCI) is a study which draws on several fields for its theoretical base. Since its conception in the early 1980’s it has evolved over the years to draw on cognitive psychology, sociology, and anthropological methods.[1] In a modern society where many interactions are between humans and computers, HCI seeks to understand what makes an interaction positive and draw on that when designing software. It also seeks to identify what makes an interaction negative to a human and to avoid the pitfalls of these designs.

2.2 User experience

User experience (UX) focuses on people and what they experience when interfacing with technologies in various contexts. The experiences are how people act, feel, sense, think, and meaning-making through these interactions [1]. While UX emphasises the actual user interface design, it isn’t strictly limited to it. It also includes the processes surrounding the actual product such as acquiring the product itself, its branding, its design, and its very function. A good user experience can not be defined by a single set of criterions but rather a good user experience is one that satisfies the users needs in a specific context where the product is used.[5]

2.3 Design

Design refers to both the creative process of specifying something new and to the representations that are produced during the process. It is rarely a straightforward process and is usually an interactive one. Design explores both the actual design solutions as well as the requirements; what the system is meant to do and the qualities it should possess. It should be noted that design exists on a spectrum where one end is engineering design and the other end is creative design. Engineering design is where scientific principles and technical specifications are used to produce models prior to construction. Creative or artistic design is where innovation, imagination, and conceptual ideas are employed.[1]

2.3.1 PACT

People, activities, contexts, technologies, acronymised PACT is a framework for thinking about design. The designer needs to understand the people who will use the product, the activities people will want to undertake, the contexts in which the activities will take place, and lastly the technologies which will be employed in the design.[1]

People

People are different in many ways and as such one design may fit one person but not another. Difference can be of physical nature such as height or weight. One person can have a different sense of sight from another and so on. These differences can range from color blindness to hearing impairment and need to be taken into consideration when designing experiences for a wide user base.[1]

Besides physical differences there are also psychological differences. One such difference is spatial ability; people with good spatial ability will find it easier to navigate a website or application.
than people with poor spatial ability. Therefore the environment needs to be designed with the user with poor spatial ability in mind. This can be achieved by ensuring that the navigation is clearly indicated by signs and directions. [1]

Especially relevant to the thesis is social differences. Designing for heterogenous groups versus homogenous groups differs widely in terms of what design decisions can be made. For heterogenous groups where personal background and the goal of using the system can vary widely, the design needs to be generalized for a wide userbase both in terms of signage and language. Likewise, when designing for homogenous groups where the people are broadly similar and seek to achieve the same things very different design decision can be made.[1]

Activities

When designing user experience the designer needs to consider the characteristics of activities which will be undertaken using the system. It is a broad term that encompasses many different activities ranging from simple tasks to lengthy and complex tasks. One needs to take into consideration the temporal aspects of the activity, such as how often it will be undertaken, as this determines how much emphasis needs to be put on efficiency. Another important aspect is vital to consider what happens when errors are made and account for this in the design.[1]

Contexts

Activities all happen in a context, so one can not be considered without accounting for the other. The context is the environment in which the activity occurs and needs to be accounted for when making design decisions. One needs to consider where the system will be used; it could be in a public area or in a private area. Both social and physical context matter and it is important to consider with whom the user will be in the presence of when using the system, and the physical location in which the system will be used.[1]

Technologies

Technologies is the very medium that UX designers work with. Systems generally consist of hardware and software which together take input data and generate output data.[1] This is determined largely based on what is available and in use where the system is to be used. For instance personal computers or smartphones.

2.3.2 Applying the PACT framework

When scoping a problem with the PACT framework one needs to consider each aspect of PACT; people, activities, contexts, and technologies. One way in which to do this is by working with the target userbase through interviews[1]. When eliciting the requirements and requests for the system, end users will be interviewed in order to establish these. The interview questions are designed with PACT in mind.

2.4 Interface design guidelines

The user interface (UI) is the interface that facilitates the communication between the user and the system. Visual interface design is a central component of UX design as it combines graphic
design, industrial design, and visual information design. Designers need to know about graphic
design with regard to what shape, size, colour, orientation, and texture screen objects should be.[1]
These guidelines are derived from our understanding of the psychology of people.

2.4.1 Perception

Proximity

Objects appearing close to each other in space or time tend to be perceived together. For instance,
a prompt containing three buttons: "Don’t save", "Save", "Cancel". The two latter buttons can be
grouped together and placed away from the former to indicate that they are a pair and to separate
them from the potentially ambiguous "Don’t save".[1]

Continuity

Continuity is used to indicate that what is visible on the screen is not a whole set of elements, but
rather a subset of it. For instance, a scrollbar can indicate that there are more elements yet to be
seen in a list.

2.4.2 Memory and attention

Short-term memory

George Miller (1956) argued in Psychological Review [12] that short-term memory is limited to only
7±2 ’chunks’ of information. This has been used in HCI to suggest that menus should be restricted
to about seven items. While this is disputed and some work indicates that the capacity is closer
to three or four items (Cowan, 2002).[1] Central to this is the fact that the short-term memory is
limited and as such a designer should not expect the user to remember a lot of details.

Chunking

Chunking means grouping information into larger, more meaningful units, minimizing the demands
on working memory.[1] This in practice could be menu sections with generic but descriptive names
which expand to reveal more specific menus or actions.

Time limitations

Short-term memories persist for only around thirty seconds. Presenting important information to
the user must be persistent and rather than flashing the information briefly, the user should be
prompted to acknowledge that the message has been received.[1]

Recall and recognition

Recalling is the process by which one actively searches the memories to retrieve a particular piece
of information. Recognition on the other hand involves searching the memory and then deciding
whether the piece of information matches what is in the memory store. Recognition is generally
easier and quicker than recall.[1]
2.4.3 Colour

Colour is important when conveying information. Aaron Marcus presents five rules for designing with colours in "Graphic Design for Electronic Documents and User Interfaces (1992) [11].

- Use a maximum of 5±2 colours
- Use central and peripheral colours appropriately
- Use a colour area that exhibits a minimum shift in colour and/or size if the colour area changes in size
- Do not use simultaneous high-chrome, spectral colours
- Use familiar, consistent colour codings with appropriate references.

Marcus identifies some colours and their connotations in the west (Western Europe, the United States, and Australia). These are guidelines and are not definitive.[1] Colours and their connotations can vary between cultures and when using colours as an indication one needs to take the context into consideration.

<table>
<thead>
<tr>
<th>Colour</th>
<th>Connotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Danger, hot, fire</td>
</tr>
<tr>
<td>Yellow</td>
<td>Caution, slow, test</td>
</tr>
<tr>
<td>Green</td>
<td>Go, okay, clear, vegetation, safety</td>
</tr>
<tr>
<td>Blue</td>
<td>Cold, water, calm, sky</td>
</tr>
<tr>
<td>Warm colours</td>
<td>Action, response required, proximity</td>
</tr>
<tr>
<td>Cool colours</td>
<td>Status, background information, distance</td>
</tr>
<tr>
<td>Greys, white, and blue</td>
<td>Neutrality</td>
</tr>
</tbody>
</table>

Table 1: The western colour connotations identified by Aaron Marcus[11].

2.4.4 Nielsen’s ten heuristics

In the book Usability Engineering, Jakob Nielsen presented a set of ten usability heuristics in 1994 [13]. These are based on his prior work on usability heuristics with Rolf Molich in 1990[14] and are as follows:

1. **Visibility of system status:**
   The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

2. **Match between system and the real world:**
   The system should speak the user’s language, with words, phrases, and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

3. **User control and freedom:**
   Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through and extended dialogue. Support undo and redo.
4. **Consistency and standards:**
   Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.

5. **Error prevention:**
   Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.

6. **Recognition rather than recall:**
   Minimize the user’s memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

7. **Flexibility and efficiency of use:**
   Accelerators - unseen by the novice user - may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

8. **Aesthetic and minimalist design:**
   Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

9. **Help users recognize, diagnose, and recover from errors:**
   Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

10. **Help and documentation:**
    Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user’s task, list concrete steps to be carried out, and not be too large.
3 Hypothesis and design

Using the theoretical framework presented in section 2 one should be able to design a user interface that is clear and usable for a given group of people, activities, contexts, and technologies. The software will be developed by applying established design rules and guidelines both when eliciting the software requirements and when designing its interface. The questions that need to be answered are:

- What are the requirements for the process of tracking ulcer progress?
- Can the requirements be implemented while applying and abiding by established design rules and guidelines?
- Does involving the user deeply in the development process enhance the user experience?

3.1 End user participation

In order to provide a good user experience the end users will be included in the development of the prototype. These are the healthcare workers at ASiH Roslagen. This is done by interviewing them (interview questions can be seen in appendix A) to elicit the requirements of the system by seeking answers to primarily two questions:

- What is the current process for tracking ulcers?
- What features in the process are absent?

This involves the user in the requirements elicitation which partially fulfills the user participation criteria. Secondly the users will be involved in the process of designing the UI. The UI will be designed in Android Studio which can be partially presented in a drag-and-drop style. By letting the users give input to the actual interface it will be designed with their wishes while also abiding by the design guidelines and rules presented in section 2.

By involving the users extensively the process of design and development the system should properly support work tasks. Beyond this the users should also gain the knowledge to properly use the system. If the flaws in the current process have been properly identified, the new system should contribute to efficiency and effectiveness if implemented in a satisfactory way. With the users involvement from planning to designing and developing, the system should also promote both a healthy work environment and also yield positive experiences with regard to cooperation and coordination.
3.2 Requirements

The two requirements that need to be established are the requirements for both the actual work task in which the software is to be used, as well as the software itself in terms of performance. Both are elicited from staff at ASiH Roslagen using the interview questions found in appendix A.

3.2.1 Tracking ulcer progress

When tracking the progress of an ulcer one needs to keep track of several parameters. To keep track of all these parameters in the system when working out of a phone was deemed too complicated and as such only the most important parameters were chosen to be included.

- **Type**: ulcers can be of several types such as an ulcer resulting from a surgery complication, a traumatic ulcer, pressure ulcer, venous or arterial ulcers.
- **Localization**: where on the body the ulcer is located.
- **Dimensions**: dimensions of the ulcer. One needs to track width, length, as well as depth to keep track of whether the ulcer is progressing well or not.
- **Smell**: Smell is an important parameter as it can provide additional information about whether the ulcer is healing or not.
- **Appearance**: A description of the appearance of the ulcer.
- **Bacterial culture**: Whether a bacterial culture test has been taken from the ulcer or not.
- **Photographic documentation**: Images of the ulcer in addition to the description of its appearance. Photographic documentation allows for easily sharing the information with other members of staff or other instances of healthcare.

These seven parameters are deemed to be of highest importance and are reasonable to keep track of when working out of a phone at a patients home.

3.2.2 Current process and its limitations

The process used by ASiH Roslagen today is done by taking notes and registering these in the healthcare information system at the end of the day. This means that the notes need to be very descriptive in order to properly convey the state of the ulcer and the delay between inspecting an ulcer and recording its status can be very long.

An important feature missing from the current process used by ASiH Roslagen is photographic documentation and the possibility of maintaining the entries in the healthcare information system remotely.

3.2.3 Software

The software is to be developed for phones running Android and specifically the phone intended for testing the prototype is a Samsung Galaxy Xcover 4. The phone runs Android 8.1 and as such it supports all but the latest API level (28) of Android. This will need to be taken into consideration.
when using external libraries.

It is important that the application is quick to launch with as few steps as possible to register new patients, register new ulcers and other parts of documentation. As photographic documentation is a key feature of the system it should be easy to, for a given ulcer, register a new set of images and other details are possible to leave out, making them optional. The following set of actions are seen as required:

- **Create new patient**: Creation of a new patient. Patients are recorded by name.
- **Create new ulcer**: Ulcers are tied to a patient and each patient can have several registered. These are recorded primarily by type and secondly by localization.
- **Create new ulcer record**: Each ulcer has a set of records. When a new record is made it is registered by creation date and should instantly open the camera allowing one to make photographic documentation, followed by optionally adding the remaining parameters.
- **Deletion**: Each object created by the three aforementioned actions should be possible to delete.
- **Edit**: Each object should be editable in terms of name, type or localization. The parameters kept track of in an ulcer record are also to be editable.

The items can all be presented in list form. For flexibility's sake the parameters kept in the ulcer records (where applicable) are to be free-text inputs. Dimensions are to be tracked in centimeters. Photographs are expected to be viewed with the basic functions one can expect from a photogallery such as pinch to zoom and swiping to scroll through images.

While the pre-existing software provides features such as synchronization between the application itself and the healthcare information system, the prototype will not, due to time limitations as well as patient record integrity.

### 3.3 Design

#### 3.3.1 Applying the PACT framework

When coming up with a design one needs to consider the PACT framework and go through each part of it. This was taken into consideration and questions pertaining to it can be found in appendix A.

- **People**: The team intended to use the prototype is comprised of similar individuals on a professional level. All members of the team are healthcare professionals with no notable physical or psychological differences that are of importance to the design of the program. No differences in colour coding or symbol meanings could be found between the field of healthcare and general use and as such no special precautions will be taken when designing colour coded UI elements. As all members are swedish speaking and the prototype will be used strictly within the team the language used in the program will be swedish.
• **Activities**: The activities that will be undertaken using the system can be found in section 3.1.2.

• **Contexts**: The environments in which the activities will occur are incredibly dynamic in terms of physical location. As the team does all treatment in the homes of patients, it has been decided that no sound alerts will be used.

• **Technologies**: This was perhaps the most important finding during the interview process. Originally the software was planned to be designed for PC and office use but during the interviews several members of staff at ASiH Roslagen raised the point that while they’re at the office daily, the majority of the time is spent outside of the office. This would mean that software designed for PC would find limited use in practice. Based on this it was decided that the software is to be designed for Android and tested on a number of cellphones used in the daily work at ASiH Roslagen.

### 3.3.2 User interface

While the user interface should be clear and well presented, time limitations put some constraints on the amount of details put into the presentations. Details such as animated screen transitions and other such features will be cut if needed.

The design closely follows Material, which is an adaptable system of guidelines, components, and tools that support the best practices of user interface design[6]. One key element is the Floating Action Button (FAB)[7] which is the primary action on a given screen. The goal of the application is to have the FAB be the primary way of quickly navigating through the application and performing work tasks.

**Colours**

The colour scheme was chosen along with the end users and chosen to both comply with their requests and the colour associations outlined in section 2.4.3. A warm orange colour was chosen for the action buttons to indicate action and blue was chosen for text containing information. The background was given a warm and neutral colour to imitate the look of paper which would comply with the real-life equivalent of the system while also remaining neutral. Colours are kept to a minimum and as such comply with the guideline of roughly 5±2 colours present at any time.

**Lists**

It has already been established that most information available in the application will be presented in lists. However a list can be presented in various way to make it clear that for instance something is interactable or not. All lists in the application are designed similarly, thus providing continuity for the user in terms of visuals and what features are to be expected. Naturally the lists are sorted alphabetically to allow for the user to easily locate specific entries. Each list item is presented on a card which appears slightly elevated which provides a visual feedback that the item can be interacted with. The header of each list contains a description of its context as well as a button which provides new buttons with actions which are initially hidden. These buttons provide features which are normally not required in the primary work tasks and toggling their visibility prevents accidental inputs, saving the user time and patience. Similar to the elevated list items, the buttons
all appear slightly elevated, providing the user with a visual cue that it can be interacted with.

![List header showing necessary information, button used for editing the list, and slightly elevated list item.](image1)

**Figure 1:** List header showing necessary information, button used for editing the list, and slightly elevated list item.

**Text input**

All text input provides a hint which is both visible when the input field is empty as well as when the user is entering text. This alleviates the need for the user to remember what the field was intended for once they start typing.

![Text field hint being visible though text has been entered.](image2)

**Figure 2:** Example showing the text field hint being visible though text has been entered.

**Patient list**

The patient list is the main screen of the application and is what the user is presented with when first launching the application. The first screen the user is presented with is the list of patients. When the list is empty it should be clear that an action is expected by the user. This is done by having the FAB be clearly visible and an indication in the middle of the screen that the list is empty, thus prompting the user to search for possible actions to take. The FAB provides the user with an only available action and thus the user is quickly introduced to how the application functions.

By clicking the FAB the user is prompted with a new screen containing a text input field with
a hint suggesting that the expected input is a name. The text input field requests focus upon launch and opens the keyboard, ensuring that the user can quickly perform the expected action. Again the FAB is used to navigate further, prompting the user with a new screen with two text input fields abiding by the same design. Once the FAB has been clicked again to finalize the creation of a new patient and a new ulcer the application automatically creates a new ulcer record and opens the camera, prompting the user to begin photographing the ulcer. While the process has many more actions performed under the hood, the user only experiences a few of these, giving the user an impression of a quick and efficient process.

**Ulcer list**

Tapping a patient brings up it’s registered ulcers. These are presented in a similar way to the patient list and allow for the user to quickly see the patients’ ulcers. Similarly to the patient list the FAB quickly allows the user to register a new ulcer in a process similar to that of registering a new patient, with the first text input excluded. This means that the user can quickly register multiple ulcers during a visit with as few screen taps as possible.
Ulcer records

Each ulcer entry in the previous list contains an ulcer record. This record is not named by the user but is done so automatically when creating a new one by fetching the current date and time. When creating a new record by tapping the FAB the user is provided with a camera view immediately which allows for quickly adding new records with photographs on repeat visits. When the user is done with the camera, one tap on the FAB brings the user to the view containing the seven parameters to keep track of.

Figure 3: Full view of the ulcer details. In the editing state all parameters are shown and the FAB is used to finalize the input.
Ulcer details

When inspecting a specific ulcer after manually navigating through the lists, or directly after taking photographs for a new ulcer, the user is presented with the fourth and final view. The screen space is divided into two parts, with one containing the parameters kept track of in text, and one containing the images taken by the user. Tapping an image brings up a full screen photo gallery which provides all the features which can be considered standard for a gallery, such as pinching to zoom and sliding to scroll through photographs.

Figure 4: Details for a particular ulcer. Any detail field left empty during the editing process is culled from the view.
3.4 Hypothesis

The proposed design closely follows the theoretical framework presented in section 1 and every step of the proposed work flow has been developed alongside the end user. This design has a deliberately small number of steps required for each work task that is to be performed. At every step it is made clear for the user what actions can be made by utilizing the FAB as well as colour schemes which indicate what is a neutral element or an element used for taking action. As each step of the work flow conforms to the same standard while still differentiating slightly as to make clear for the user at which ‘depth’ one is viewing the patient, it should allow for the user to familiarize with the design quickly. The colours chosen are contrasted against each other in a way that colour blindness does not make it unusable by a possible colour blind user. Lists are maintained and presented in an alphabetical sorting order where entries are primarily letter based such as the patient names and ulcers themselves. Individual ulcer entries are sorted by creation date to make chronological sense of the tracked ulcer. As the design adheres to the theoretical framework the hypothesis is that this should provide a positive user experience.
4 Methodology

4.1 Tools

Usability evaluation

Evaluating the usability of a system serves to identify potential problems once a stable version of
the technology is available [1]. There are different ways in which you can evaluate a system with
regard to UX. One can include the end-user to evaluate the usability or one can include people
with experience in UX. For the purposes of this thesis the end-users, healthcare personnel at ASiH
Roslagen, will be involved in order to evaluate the usability of the system. As the amount of staff
employed and available is limited the data gathered must be qualitative rather than quantitative.
The following tools have been utilized in order to evaluate the system:

4.1.1 Cognitive walkthrough

A cognitive walkthrough involves a UX analyst stepping through the cognitive tasks that must be
carried out in interacting with technology. The process requires an understanding of the end-user
and a set of concrete scenarios representing both common and uncommon sequences of activities
(see appendix B). During the scenarios the analyst will ask four questions: Will the people using
the system try to achieve the right effect? Will they notice that the correct action is available? Will
they associate the correct action with the effect that they are trying to achieve? If the correct action
is preformed, will people see that progress is being made towards the goal of their activity.[1]

4.1.2 Användbarhetsindex

Användbarhetsindex (AvI) translates to usability index and is a questionnaire developed by Iordanis
Kavathatzopoulos at Uppsala Universitet. The questionnaire seeks to evaluate usability of
an IT system. What AvI seeks to describe are the processes behind usability; user participation,
knowledge support, and networking for coordination and cooperation. AvI focuses on whether the
preconditions for these processes exist, to allow them to arise and to function in a satisfying way.[9]

It is focused on six areas of usability: development, use, competence, utility, stress and health,
and relations. For instance, user participation during the construction of an IT system is necessary
in order to produce knowledge, through personal or group dialogue, about what would be the most
usable solution for a certain activity.[9]

AvI contains two variants: one questionnaire containing either 46 questions or 16 questions di-
vided into six subscales. These subscales correspond to the six areas of usability mentioned prior.
Kavathatzopoulos describes these subscales as follows:

- **Development**: usability is dependent on user participation during system construction.
- **Use**: how well the system supports work tasks.
- **Competence**: acquiring knowledge and skills.
- **Utility**: contributing to efficiency and effectiveness.
- **Stress and Health**: promoting healthy work environment.
• \textit{Relations}: Facilitating cooperation and coordination.

AvI will be employed prior to deploying the new software in order to establish what the initial condition is in terms of usability of IT systems at the workplace. Once the software has been developed and used by the staff at the workplace it will be employed again to measure whether the software has provided any benefit to the company and its staff.

4.1.3 Heuristic evaluation

A heuristic evaluation refers to a number of methods in which a UX analyst examines a proposed design to see how it measures up against a list of heuristics for good design.[1] These heuristics are Jakob Nielsen’s ten heuristics (see section 2.4.4). The heuristic evaluation will be performed while performing the common scenarios used in the cognitive walkthrough. Any problems encountered during the heuristic evaluation will be noted and granted a severity rating between 1 and 3, ranging from minor to major problems. Solutions for the problems will be presented but not implemented. The heuristic evaluation is performed by the author and no other participants.

4.2 Participants

4.2.1 Participants in the cognitive walkthrough

For the cognitive walkthrough it was opted to include key users instead of the entire workforce in the interest of time and efficiency. Key users are both experienced staff members at ASiH Roslagen. Prior to performing the walkthrough the participants were given instructions for performing a cognitive walkthrough as described in Designing User Experience by David Benyon[1] as well as given the scenarios as seen in appendix B. The participants are as follows (in addition to the author):

• Nurse, Female, age 27
• Nurse, Female, age 35

4.2.2 Participants in the AvI-questionnaire

For the AvI-questionnaire it was opted to include as many users as possible in order to get a quantity that would be somewhat satisfactory. The participants are all staff members at ASiH Roslagen and are as follows:

• Nurse, Female, age 27
• Nurse, Female, age 35
• Nurse, Female, age 49
• Nurse, Female, age 54
• Nurse, Female, age 46
• Nurse, Female, age 57

21
• Nurse, Female, age 37
• Nurse, Female, age 23

4.2.3 Participants in the heuristic evaluation
The heuristic evaluation was performed by the author using the scenarios found in appendix B as well as the heuristics defined in section 2.4.4.

4.3 Procedure
Initially an AvI-questionnaire was given to the staff members of ASiH Roslagen in order to establish how well the current system in use performs with regard to usability. After the proposed design had been finalized it was installed on an Android phone and was given to the staff members of ASiH Roslagen for internal testing using their own theoretical scenarios for which the system would be used. Once the internal testing was finished the cognitive walkthrough was performed by the key users under the authors supervision. The cognitive walkthrough was followed by the heuristic walkthrough, performed by the author. Lastly, the second AvI-questionnaire which was given to all the participants of questionnaire 1 in order to evaluate how the proposed design measures up against the pre-existing system.
5 Results

5.1 Findings, cognitive walkthrough

- Undoing a recent change (edited name for instance) is not properly communicated and the user has a limited time window for initiating an undo action.
- Undoing a deleted patient or ulcer is not communicated and the user has a limited time window for initiating an undo action.
- If the user is not familiar with floating action buttons it could be unclear what the expected action is when the patient list is empty.
- When editing details of an ulcer it is unclear which state the application is in when all details are filled out. No indication of whether it is in an editing state or finalized state.

5.2 Results from the first AvI-questionnaire

The first AvI-questionnaire was given prior to testing the new application and answers are given based on the current system in place at ASiH Roslagen. Results are based on the answers of 8 members of staff at ASiH Roslagen.

- Development: 1.75 (max: 20)
- Use: 12.25 (max: 25)
- Competence: 4.75 (max: 10)
- Utility: 1.75 (max: 5)
- Stress and Health: 6.25 (max: 10)
- Relations: 5 (max: 10)

5.3 Results from the second AvI-questionnaire

The second AvI-questionnaire was given after members of staff got to test the new application and answers are given based on the current system in place at ASiH Roslagen. Participants got to test the system on and off over a period of 3 weeks and were used in hypothetical scenarios. Results are based on the answers of 8 members of staff at ASiH Roslagen.

- Development: 14.5 (max: 20)
- Use: 14.4 (max: 25)
- Competence: 6.75 (max: 10)
- Utility: 3.5 (max: 5)
- Stress and Health: 6.75 (max: 10)
- Relations: 7 (max: 10)
### 5.4 Findings, heuristic evaluation

<table>
<thead>
<tr>
<th>Severity</th>
<th>Heuristic violated</th>
<th>Description</th>
<th>Proposed solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3</td>
<td>Creating new ulcer and intentionally leaving it without pictures will forcefully launch camera when inspecting the details of said ulcer.</td>
<td>Only force camera open when first creating the ulcer. When navigating to the ulcer normally it should not force open camera.</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>When editing ulcer details and all details are already filled out, it is unclear which state the system is in. (editing or finalized state)</td>
<td>Add indicator showing editing or finalized state.</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>There is no help section or explanatory texts for certain actions.</td>
<td>Add help mode in which clicking on buttons shows an explanatory text.</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>Certain dialogues such as creation of directories and sub-directories contain superfluous information expressed in technical terms.</td>
<td>Remove text-popups that show that directories have been created.</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>Accidentally creating a new patient or ulcer leads to the creation process and no emergency exit exists. Only using the &quot;back&quot; button on the phone which leads to many presses to first close the keyboard, then going back to the previous view.</td>
<td>Add emergency exit button to creation views.</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>When opening a large image gallery for a given ulcer it can sometimes take up to 5 seconds to open it due to unoptimized code. It is unclear which state the system is in at that point.</td>
<td>Add a &quot;swirling&quot; loading icon or something to that effect in order to properly communicate that the system has received the users command and is performing an action.</td>
</tr>
</tbody>
</table>

Table 2: Results generated by the heuristic evaluation.
6 Summary

6.1 Discussion

6.1.1 AvI-questionnaire

Looking more closely at the results of the AvI-questionnaire, one can see clearly that a very large difference between the two questionnaires can be identified in the section Development and should not come as a surprise. In the existing system used by the staff at ASiH Roslagen there is very little contact between the end user and the developers of the system. This is in stark contrast to working closely with a single contractor on site. While the result is not very surprising it is a positive one. One question that deserves mention is "Have you participated in the work surrounding development and improvement of the technology?" in which all participants gave a 0 rating in the first questionnaire. In the second questionnaire the same question averaged 3.75.

One category that surprised was the category Utility which contains a single question "Do you feel that the system is a good aid for your organization to achieve its goals in an efficient manner?" which averaged only 1.75 out of 5 in the first questionnaire while achieving a much better 3.5 out of 5 in the second questionnaire. This could be due to the close involvement with the development of the new system in which the end user can specify very clearly what the workflow should look like and how the system should behave in order to perform work tasks in an efficient manner.

While seeing slight improvements, the remaining categories remain largely the same. Competence saw a slight increase which makes sense given that the users took part in the development process and could gain some mastery of the system through that. The limited time frame of using the new system would also explain why the score is not higher. Stress and health saw very little change which could be explained by the fact that the profession is a highly stressful one and the efforts to reduce stress and work related health issues are not single handedly solved by software introduced into the workflow. Relations saw minor increases to the average and this does not come as a surprise either. The goal of the new system is to improve co-operation and performing the work tasks at hand. It should come as little surprise that this area was slightly improved by close co-operation between the developer of the system and the end users. Lastly, looking at Use, the purpose of the design was mainly to replicate the work process and improve it in terms of efficiency. This explains the smaller increases to Use, whereas Utility saw a much more substantial increase.

6.1.2 Heuristic evaluation

While several issues were identified, none were given a severity rating of 3 which should be seen as positive. The issues do not risk the integrity of the patient database and are limited to minor inconveniences. The solutions proposed should be easy to implement and would most likely solve the identified problems.

6.2 Conclusion

The 3 fundamental questions that this work seeks to answer are:

- What are the requirements for the process of tracking ulcer progress?
• Can the requirements be implemented while applying and abiding by established design rules and guidelines?

• Does involving the user deeply in the development process enhance the user experience?

The requirements for the process of tracking ulcer progress have been identified and established along with healthcare professionals. The requirements are based on established literature in the field as well as experienced nurses.

While the system is a prototype it can be seen that these requirements can be successfully implemented while still abiding by established design rules and guidelines. This is supported by the evidence generated by the results of both the heuristic walkthrough as well as the cognitive walkthrough.

The AvI-questionnaire supports the theory that the involvement of the user in the development process does in fact enhance the user experience. While certain areas of the questionnaire saw limited increases they were still increases of some magnitude. Certain areas saw major increases to them which supports the hypothesis.

While the evaluations of the system are smaller in scale they give indication of supporting the hypothesis. It was clear that the cognitive walkthrough was difficult for someone not experienced in UX and HCI and would have been better suited to perhaps perform alone. Some important issues were identified by the less experienced participants however so it should not be dismissed too easily.

6.3 Future work

With more time and experience it would have been very interesting to see the prototype enter it’s imagined final form, where it is seamlessly integrated with the healthcare information system. This would mean that the healthcare staff can finalize the details of the patients records remotely and then see the information present in the healthcare information system, along with the pictures taken of the ulcer. Further optimizing the code would also be beneficial for the system as some sections of it, more specifically the picture gallery can be slow at times when there are many pictures present.

Had there been more time it would have been interesting to implement the proposed solutions from the heuristic walkthrough and perform both the heuristic as well as the cognitive walkthrough once more and see whether the issues were eliminated. Experiences from other software development projects says that new issues would arise but one can never know. Had there also been more time and possibility for the participants to use the prototype in a real environment it would have been very interesting to see the results generated from the AvI-questionnaire. Would the results generated be largely the same? Or would they see further increases due to the user seeing it in use in an actual work environment?
References


Appendices

Appendix A

1. What is the current process for tracking ulcers?
2. Is there any feature that is missing from this process?
3. Is there a special colour coding used in healthcare which deviates from typical use?
4. Where does the majority of the work take place?
5. What technological devices are most commonly used?
6. What technological device is the team, as a whole, most comfortable using?
7. On what technological device would the system be best put to use?

Appendix B

Common scenarios

- **Scenario 1**: Register a new patient in the system. The ulcer should have a properly defined type and localization. Take a picture of the ulcer and register the necessary parameters for the ulcer.
- **Scenario 2**: The user has made a mistake when registering a new ulcer. Both the type and the localization need to be changed.
- **Scenario 3**: The registered patient is no longer under the care of the user. The patient needs to be deleted from the database.
- **Scenario 4**: The user has accidentally registered two ulcer records and needs to delete one.

Uncommon scenarios

- **Scenario 1**: The user has forgotten to take pictures of a given ulcer. The user needs to go back to the latest record and take pictures.
- **Scenario 2**: The user has taken photographs of bad quality and needs to delete them.
- **Scenario 3**: The user has accidentally renamed a patient and needs to undo the change.
- **Scenario 4**: The user has accidentally deleted a patient from the database. The user needs to undo this deletion.