Mobile Computing in Medicine: Designing Mobile Questionnaires for Elderly and Partially Sighted People

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Abstract. At the clinical department of Dermatology at the Medical University Hospital in Graz, approximately 30 outpatients consult the pigmented lesion clinic each day. During the visit, the patients are asked to complete a questionnaire, which is necessary, both for the clinical information system and for a scientific database for research in skin cancer. However, motorically and visually handicapped people usually have problems in completing paper based questionnaires. Consequently, a system was built, using a mobile touch computer with a specially designed interface, in order to assist these people and to allow full mobility within the clinical department, as well as the possibility of completing questionnaires, for example: during a cancer survey even in the open-air swimming resort. The system was developed by applying a User Centered Design including four levels: paper mock-up studies, low-fi prototypes, hi-fi prototypes and the system in real life. Scientifically this work provided insights into the technical possibilities, Human-Computer Interaction and Usability Engineering, user acceptance in the clinical field and the possible optimization potential of clinical workflows.

Keywords: Human-Computer Interaction & Usability Engineering, Mobile Computing, Information Interfaces, Input Devices and Strategies (mobile touchscreen), Screen design, User-centered Design & Development (UCD).

"Human-Computer Interfaces should not only support more effective and efficient user interaction, but also address the individual end-user requirements and expectations in the variety of contexts of use to be encountered". [1]

1 Introduction

Mobile computers generally present a number of challenges in Human-Computer Interaction (HCI) including the interplay between the appropriate user interface

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design, the device and the social context of the device's use [2,3]. The usefulness of mobile applications in Health Care is commonly accepted [4,5].

To achieve maximum benefits by making both useful and good usable applications, particularly in light of new devices, it is strongly recommended to apply a User-Centered Design (UCD) approach [6]. Some key principles of UCD methods include understanding the users and analyzing their tasks; setting measurable goals and involving the end-users from the very beginning. Based on the experiences within this project and on previous work [7,8,9] we found again that UCD is of particular importance to realize usable and useful applications, especially for mobile devices in such a difficult environment as an outpatient clinic. We cannot too often emphasize, that simple, cheap and easy-to-use solutions can be a step closer to the information society for all, where people are assisted by Information Technology [10].

2 MoCoMed-Graz: Technological Background

As part project of the project Melanoma Pre-care/Prevention Documentation (in German: Melanomvorsorgedokumentation), which is an important step toward fighting skin cancer, the project MoCoMed dealt with the design, development and implementation of a fully functional mobile solution to assist patient data surveys. The initial problem was, that the paper based questionnaires had several disadvantages; including the necessity of retyping them manually into the database, most of all, they were awkward to fill out by elderly and partially sighted patients, or for example by patients with tremor.

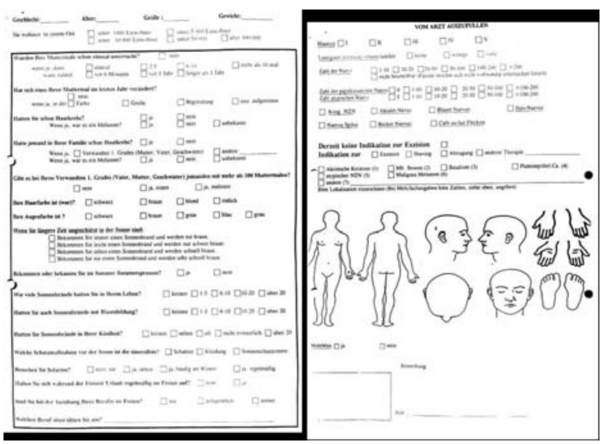

Fig. 1. The original paper questionnaire before this study took place

The initial idea of the use of mobile computers was to ensure that the data acquisition within the clinical department runs smoothly and also that the cancer researcher is allowed to collect data away from the clinic, for example during a survey study in an outdoor swimming pool.

We used an XML interface as the technical protocol, because the data collected by MoCoMed are directly transferred into the countrywide Hospital Information System (which is called MEDOCS and is a customized SAP-product [11]).

The workflow: The patient reports to the central administration desk of the outpatient clinic of the dermatology department. There, they are registered via the MEDOCS administration program into the pigmented lesion outpatient clinic.

At the clinical workplace, an overview of the waiting patients, who have been registered already in the system, but not yet released by a medical doctor, can be seen. In the corresponding column on the clinical workplace, there is an indication of whether or not they have already filled out a questionnaire. This is indicated by means of text and/or a symbol and makes the following differences visible: A questionnaire was filled out on the current day; A questionnaire has been made available to the patient, but not yet completed; A questionnaire, completed by the patient during a previous treatment is available (not from the current day); No questionnaire is available (column is empty). Now the medical doctor or the nursing staff of the clinic can decide whether this patient is to fill out a questionnaire and/or which questionnaire to provide to the patient. After the decision to ask the patient to fill out a questionnaire, an empty questionnaire is created in MEDOCS, by pushing a button. The questionnaire in MEDOCS is registered with a definite user and a unique identification code, so that it is clearly evident that it corresponds to a version from the patient and not the medical doctor. Using an XML communication, the patient identification number (PID), the unique number of the document (document number at the top of the questionnaire) and any further data (e.g. name, date of birth) considered necessary by MoCoMed, are transmitted.

At the terminal, the patient is equipped with a touch based Tablet PC and a code, with which he/she can login to MoCoMed and complete the questionnaire following a touch based application. The authentication at MoCoMed is necessary for data security reasons, so that no patient can access other data and patients avoid mistakes or errors. After the questions have been answered and the questionnaire is completed, MoCoMed transfers the questionnaire into MEDOCS. The corresponding column in MEDOCS now shows the status "questionnaire was filled out on the current day". This process must take place with the minimum possible delay, in order that the workflow of the outpatient clinic can continue undisturbed. As soon as the patient completed the questionnaire the XML file containing the answered is stored on the server, subsequently transferred to MEDOCS by using a remote function call (RFC). The XML document containing all answers of a patient includes of course the unique identification of each question. Further technical background of MoCoMed is not described in detail here, since we concentrate in this paper on the user-centered development including the scientific experiments and their findings.

3 MoCoMed-Graz: User Centered Design and Development

The first step in this project was to determine the project requirements and the clinical context. This is highly important in order to identify the end users. It is necessary to differentiate between the primary end-users, the secondary end-users and the stakeholders. However, the stakeholders influence, or are influenced by, the system but are not the actual users. A precise specification of end users is unavoidable, which includes the typical end user characteristics, e.g. age range, computer literacy and physical limitations (disabilities). Within a clinical development it is necessary to adapt the usability of the system to the lowest common denominator.

Technical Environment. At first we proposed the use of touch based Tablet PCs; however, the fear of problems, including petty larceny, destruction, misuse or misunderstanding, emerged immediately, particularly with regard to the lack of keyboard. Stakeholders proposed to solve this by installing a kiosk touch-station [12]; however, while this would solve some problems, it would totally disable our goal of total mobility. The solution was a trade-off, which later proved to be an absolute optimum: We decided to build a client-server system with a thin client solution at the front-end using a highly mobile device (Skeye-Webpanel). In order to reduce the danger of theft, the mobile device was mounted on a specially designed adjustable wheel table, whenever the medical staff leaves the patient to complete the questionnaire in private.

Physical Surrounding. The aim was to capture as much as possible information about the future workplace and physical conditions. Actually, the work atmosphere within an outpatient clinic is difficult, hectic and chaotic. For example, the noise level made several ideas of providing audio feedback inappropriate. Also, both low and high levels of lighting have an impact on end-users (office versus outdoor swimming pool, where sunlight is always a problem and causes glare on the screen). However, we also considered room and furniture because the characteristics of the installation place must be studied in order to operate the system safely and comfortably. We also carefully studied user posture; in our case it is possible to use the mobile device within a total mobile setting or on the adjustable wheel table (e.g. sitting versus standing and looking down at a display).

Context. The social and organizational context is most often neglected but is essential for the success of any system. Some factors within our project included general structure (e.g. hours of work, group working, job function, working practices, assistance, interruptions, management structure, communications structure, IT policy, organizational aims), and also attitudes towards the system, as well as work characteristics (e.g. job flexibility, performance monitoring and feedback, discretion, valued skills).

It is important to consider the staff and management structures in which the (proposed) system will operate.

Especially, the role of the end users must be considered, especially with respect to new procedures associated with the system, thereby maintaining level of status and activity satisfaction. When a new system is implemented, users often require support in learning how to use it and in solving problems. The possibility of offering support should be calculated and suitable support mechanisms should become part of the user requirements specification.

In our case privacy was also a key issue, and considerations that end users want to feel safe and secure in performing their tasks. If the system does not give the impression of safety (avoidance of loss of privacy) and security (assurance that only the medical staff is accessing the information provided) users will not perform well.

Level 1: Lo-Fi Prototyping: Paper Mock-Up. The term paper mock-up means "to prototype the screen designs and dialogue elements on paper" [13,14,9]. It again proved itself an easy and efficient method. With standard office supplies, each interface element (e.g. dialog boxes, menus, error messages, sliders (see figure 3)) has been sketched. This led to an easy creation of alternatives since it encouraged more suggestions due to the ease of alteration. We performed studies at this level with N=10 different people (see e.g. figure 2), the experiments were continued until no further findings were to be gained.


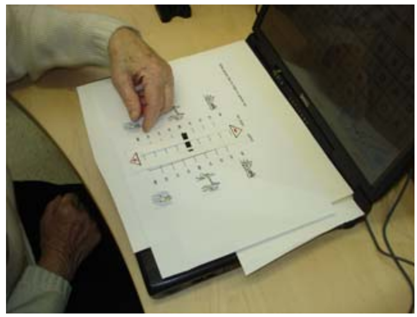

Fig. 2./3. One of our elderly patients is operating the paper mock-up (left), various input possibilities have been tested on paper (right)

Level 2: Hi-Fi Prototyping. In their experiments, Virzi, Sokolov and Karis (1996), [15] discovered that low-fidelity and high-fidelity prototypes have substantially the same set of usability problems. We can only partly agree: during the paper mock-up studies, we discovered more interaction difficulties than during the hi-fi level, where we found more difficulties and problems concerning the content, i.e. the wording and understanding of the questions. However, we can recommend low-fidelity prototypes unless performance measures are required.

Level 3: Real-Life. It is essential to test the final version in full operation within real-life.


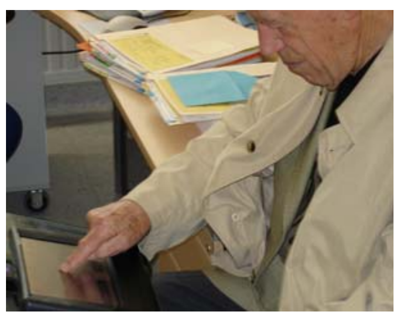

Fig. 4./5. An elderly patient is operating a Hi-Fi Prototype with full functionality; (left), Finally the SkeyePad in real-life operation (right)

4 Lessons Learned: Designing for Elderly and Partially Sighted

Although developing applications for mobile computers is considered to be different than for desktop computers [16,17,18,19], many general guidelines and experiences from desktop interfaces, especially experiences from touch-based interfaces [7,12,9] as well as and general usability engineering methods [20] are applicable.

The intensive study of end users by the application of paper mock-ups resulted in a great advantage and clear benefit. Some advantages were that the first sketches allowed immediate usability feedback. In the beginning of our project we were able to concentrate on abstract interface concepts and not on technological details. It further proved to be inexpensive to produce with a maximum feedback for minimum effort. However, as usual, some disadvantages also appeared: It was relatively difficult to simulate interface behavior and, in combination with the applied thinking-aloud and video-analysis, it needed far more time than was theoretically predicted e.g. according to Beaudouin & Mackay (2003) [21], because they failed to include the preparation time and the post-editing and post-processing time as well.

The high-fidelity prototyping had the advantage, that the end users could be studied in a more realistic setting (users could work with it directly), however, this scenario still does not adequately represent the final system. Concerning the design of the content of the questionnaire, we found that until the final experiments there were iterative improvements possible, including words, phrases and familiar - in the sense of intuition - concepts. It was interesting to observe that the end users chose system functions by mistake. Consequently, they also needed a clearly marked emergency exit button to leave the unwanted screen. We also made everything consistent avoiding different interface elements including words and actions. However, we followed an aesthetic and minimalist design: all dialogues contained no irrelevant information whatsoever.

According to the insights into end users behavior, we also built a special help function (figure 5), wherein, if there is no user input for a certain amount of time, a graphical hint (red arrow) encored the end users to touch the next button. Initially, we thought about audio feedback but the noise within the clinical environment made this inadvisable. The method Thinking Aloud (TA) revealed – with a fairly small number of end users (N=10) – why end users preferred certain interactions, consequently we could optimize both interaction and content. Especially early clues definitely helped to anticipate and trace the source of problems in the early stage of designs in order to avoid later misconceptions and confusion. Disadvantages included: nearly all the people investigated perceived this method as strenuous, it took a lot of time and preparation, and still more than 50% refused to voice valuable information out loud. With this method, there is always the danger that previously computer illiterate end users generally feel inhibited, which consequently slows down the thought processes, thus increasing mindfulness (which is normally good, but creates a bias because it may prevent errors which otherwise would have occurred in actual use). Generally these experiments were time consuming since it was necessary to prepare the end user with a careful briefing. Here, it is interesting to note that some elderly end users refused even to take part in the experiments when they heard the word "computer"; however, if we emphasized that we only wanted to test a newly developed questionnaire, the people were more likely to take part. This is possibly due to the fact that elderly people have had less exposure to computers and therefore have a total misconception of the capability of computers. Generally users interact differently with mobile devices than with PCs (see for example [22,23,24]). This does not quite apply to our case, since we used in our application a device with a resolution of 800 x 600 pixels. However, it is absolutely necessary to reduce the text input to a minimum, it is much easier to select values from a list rather than enter text in an input field.

Final example: One elderly lady within an experiment first were very frightened and said that she does not like computers at all – after she touched-through the application, she asked carefully: "This was a computer?", as we replied yes, she said "… but this was really funny". This proves that the work we do, is important in order to support an information society for all … however there is still much work to do!

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