Next Generation Equipment in the Intensive Care Unit: Data Collection for Design Guidelines

Marijke Melles and Adinda Freudenthal

ID-StudioLab, Department of Industrial Design, Delft University of Technology Landbergstraat 15, 2628 CE Delft, The Netherlands. <u>M.Melles@io.tudelft.nl, http://studiolab.io.tudelft.nl/melles</u>

Abstract

The process of intensive care nursing needs to be explored in order to reveal possible signals and opportunities for the development of innovative intensive care equipment. However, the effects these new technologies have on the nursing process need consideration as well when defining innovative solutions and related design guidelines. This paper argues that for this purpose traditional user research methods should be complemented with methods that reveal future needs and make tacit user knowledge more accessible. It is proposed that generative tools are used in a focus group setting, combined with cultural probes. The results confirm that these tools actually have the potential of revealing cues concerning next generation equipment and design guidelines. The paper closes with a discussion regarding the need to incorporate the essential values of work in (future) design requirements.

Keywords: intensive care unit, medical equipment, context-aware systems, design guidelines, cultural probes, generative tools.

1 Introduction

Advances in product technologies have created a diversity of new opportunities for the development of intensive care equipment. One example of such an advance is the ability of devices to be 'context-aware'. Context-aware devices can be made to behave differently depending on, for instance, the location, the environmental situation, or the task of the user. For example, such systems can change their input modality from manual to speech driven in situations where sterility of both hands is required, or provide adaptive embedded support to users depending on their level of experience. Technological developments like these could have a huge impact on the process of intensive care nursing. Implementation will change the work process, thereby ideally solving current problems. However, the total scope of resulting changes for the intensive care nursing process needs to be considered when designing new intelligent technologies.

Focus of our research is the effect of context-aware technologies on the work process of intensive care nurses, including changed interaction styles and functionality associated with these technologies. The result of this study will be design knowledge concerning next generation intensive care equipment. This will be in the form of design guidelines, insights into user behaviour and context constraints, as well as case studies evaluating new guidelines by means of prototypes.

2 Approach

Throughout our study the approach is user-centred. By this we mean that the end users and their needs and values are the driving force behind the development of the design knowledge (Preece et al., 2002). To achieve this a participative ergonomic approach is taken, actively involving end-users (i.e. intensive care nurses) during all stages of research and development. Collaboration with nursing departments of several Dutch hospitals facilitates our user-centred approach.

To organise our research we use the method of grounded theory as an overarching structure (Melles et al., 2002). According to this theory we aim at developing design knowledge from systematically obtained data acquired in several rounds in which preliminary guidelines are evaluated and adapted interactively.

Table 1 illustrates our research design. Step A will be discussed briefly. The focus of this paper will be on the methods used in B and their usefulness in gaining preliminary design guidelines and signals for innovations. Therefore, the methodology of B will be discussed more extensively in the remainder of this paper.

	Data-gathering techniques	Good for*	Results	
A	Literature, observations, and interviews	Understanding the context of intensive care nursing; Exploring issues.	Preliminary overview of influences and constraints concerning the process of intensive care nursing; Conceptual framework.	
В	Participatory sessions - cultural probes - generative tools - focus group interviews	Obtaining a deeper understanding of the process of intensive care nursing; Making tacit user-knowledge more accessible; Collecting multiple viewpoints.	Overview of phenomena that define the process of IC nursing in context, including problems, needs and values; Preliminary design guidelines; Signals for innovations.	
С	Scenarios and storyboards	Gaining insights into the effects of new technologies on the (future) nursing process; Testing the preliminary guidelines.	Design guidelines Insights into user behaviour Insights into context constraints	
D	Prototypes	Testing the guidelines.	Design knowledge	

 Table 1. The different stages of our research. Results from a preceding stage are input for our next step.

 (*partly based on Preece et al., 2002)

A. Literature, observations, and interviews: An initial study was conducted to identify the influences and constraints intensive care nurses encounter in the execution of their work (Melles et al, 2002). We participated in several shifts at a range of intensive care units and interviewed intensive care nurses and other related medical personnel. These studies combined with literature research resulted in an overview of problems encountered by intensive care staff (Feenstra, 2002; Melles et al., 2002), as well as a conceptual framework (Melles et al. 2002).

However, another impression from this first study was that users are not always

aware of their exact needs, or may not regard particular pieces of information as useful to the study. This is a well-known phenomenon, described for example by Mattelmaki and Battarbee (2002) and Preece et al. (2002). Therefore, our user research methods needed to be supported with approaches that made tacit user knowledge more accessible without a clearly defined research question (Sanders, 2001; Mattelmaki and Battarbee, 2002). Sanders claims that user research methods should be divided into three areas, namely 'say', 'do', and 'make', which should be explored simultaneously. 'Say' and 'do' relate to interviews and observations. 'Make' relates to methods that let subjects draw, build or write about their expectations, dreams and ideas. Methods that are based on these 'make'-principles are called generative tools (figures 3 and 4).

B. Participatory sessions: The participatory sessions presented in this paper consist of cultural probes, focus group interviews, and focus group interviews combined with generative tools. We will first explain the general use of these tools and techniques. The application of these tools and techniques in our study will be described more elaborately in the methods section.

Cultural probes: A cultural probe is a specially designed package containing items like a camera, postcards or a diary (figures 1 and 2). The probe is sent to the participants, who subsequently complete the exercises from their home or work environment (depending on the theme of the probe) in their own time (Gaver et al, 1999; Mattelmäki and Battarbee, 2002). Motivating and sensitising the participants for a following workshop or interview are the main goals. The results are meant to inspire the designresearcher. Hence, assignments are not designed for statistical processing.

Focus group interviews: Focus group interviews rely on a common interest between the participants. The discussion contributors provide data through sharing and comparing knowledge (peer-to-peer discussion). The information gained is qualitative and consists of backgrounds for behaviour, and opinions, rather than statistically secure data (Stewart and Shamdasani, 1990; Bruseberg, 2001).

Generative tools: There are a number of different generative tools. For this study we used tools made up of two-dimensional components (images and words), aiming to elicit a deeper grasp on user experiences. Participants are provided with images, words, pencils, and a background (the toolkit, for example figure 3) and are asked to create a collage about a certain topic (e.g. their daily work flow, figure 4). The components of the toolkit are simple and ambiguous and can be composed in a variety of ways. They range from literal to abstract and from photographs to sketches. The range of meaning of the components can be extended through the use of pens (Sanders, 2001). Subsequently, the participant is asked to explain his or her visualisation to other participants of the workshop.

Aim of this study: In this paper we will demonstrate the use of cultural probes, focus group interviews, and generative tools applied within focus group interviews in a medical context. The usefulness of these techniques in revealing opportunities and signals for innovations and new design guidelines concerning the development of future intensive care equipment is explored. To illustrate our conclusions some intermediate findings will be presented.

3 Methods

The study presented in this paper consisted of two stages, which we called participatory sessions. We started the first participatory session by distributing a cultural probe amongst our participants, which preceded the first focus group interview. For this first group interview we made use of generative tools. Three months later the second participatory session started; another cultural probe was followed by a second focus group interview.

Participants were intensive care nurses working in a university hospital in the Netherlands. This hospital has seven intensive care units (i.e. neonatal, paediatric, surgical, neurosurgical, thoracic, internal, and coronary care units). For this study, a panel was composed of seven intensive care nurses, one nurse from each unit. We deliberately choose one nurse per unit instead of seven nurses from a single unit. Hence, the participants did not know each other and did not work together (so there were no social or formal hierarchies). This stimulated a free debate during workshops. The nurses participated on a voluntary basis.

3.1 Participatory session 1

The objective of the first participatory session was to adjust and elaborate our understanding of the context in which the nursing process takes place as described in our conceptual framework (Melles et al., 2002).



Figure 1. The cultural probe that preceded our first workshop.



Figure 2. The second cultural probe.

The cultural probe preceding the workshop was designed based on the understanding we gained about intensive care nursing in our earlier study (Melles et al., 2002). This probe contained a booklet, a Polaroid camera and several pencils, packed in a plastic envelope (figure 1). The booklet contained three exercises. The first exercise related to the physical work environment. Participants were asked to draw a map of their work environment illustrated with pictures. The second exercise was about the equipment used. The nurses were asked which equipment they thought to be beautiful, ugly, irritating, pleasant, reliable or unreliable. They were asked to make a Polaroid picture of the equipment mentioned and to give a brief commentary. The third exercise was about the shift, and their emotional state at the end of a shift.

A week prior to the first session all panel members (n=7) received this probe. The nurses were asked to return the probe at the start of the following workshop. They

all returned it.

The actual workshop involved four intensive care nurses from the panel. During this workshop a moderator, being one of the authors, led the group through the different topics. The entire workshop lasted for two and a half hours.





Figure 3. The toolkit used in the first exercise of our first session

Figure 4. Intensive care nurses creating collages in the first participatory workshop

First the participants were asked to reflect on their own probe that they handed in at the beginning of the session. Focus of this discussion was the second exercise in the probe about the equipment. This reflection provoked discussion among the participants, which was brought to an end by the moderator after approximately 30 minutes.

Subsequently the nurses were asked to do two exercises using generative tools. For both exercises the participants were asked to visualise their own thoughts or experiences by means of a toolkit (figures 3 and 4). The toolkit used in the first exercise consisted of 96 words and 78 images. The toolkit used in the second exercise consisted of a different set of 96 words, and this time without images. Subsequently, each participant was invited to explain his or her result to the other participants. All eight presentations were immediately followed by a discussion among the participants, in their own jargon.

Exercise 1: Recollect a situation which could have had serious consequences for the patient, but which was somehow intervened by you, a colleague, or somebody/something else. Visualise this situation including all its influences, causes, and consequences.

Exercise 2: How would you describe your own work process? Which people and factors influence the execution of your tasks?

Analysis of the first session: The workshop was videotaped and transcribed afterwards. Of each story related to a collage the main topics and issues relevant to the research question were identified and colour coded according to the analysis method described by Stewart and Shamdasani (1990). Subsequently pieces of the coded material were sorted so that all material relevant to a particular topic was placed together. Next, each topic was briefly described. The topics were compared to and elaborated with themes found in literature (Melles et al., 2002) and found in the observations and interviews accomplished in the first orientation stage (Feenstra, 2002). The resulting list of topics formed the input for the second participatory session.

3.2 Participatory session 2

The objective of the second participatory session was to deepen our insight of the problems most often encountered in the work of intensive care nurses, as well as their most valued work conditions. Again, we first sensitized our participants with a cultural probe.

The second cultural probe consisted of 24 cards, each with a short description of a situation in the intensive care unit, which could potentially lead to problems (figure 2). These situations were deduced from the resulting list of topics that closed our first session. Each card contained three questions: (1) Do you acknowledge this situation as a problem; (2) Do you experience this situation as a problem yourself; (3) If so, do you believe this situation can have severe consequences for the patient. Participants were asked to choose between yes and no. They were invited to motivate their answers on the back of each card. If they liked they could illustrate their answers with a Polaroid picture (a camera was provided). Two empty cards were provided for describing any problematic situations not mentioned on any of the cards. On two other cards the nurses were asked to create two top tens. One top ten concerned situations that could lead to the ten most severe consequences for the nurse. All panel members (n=7) received this second probe and they all returned it.

The second workshop involved three intensive care nurses from the panel. All three had participated in the first workshop as well. Again, the workshop started with a reflection on the probes, they were asked to hand in at the start of the workshop. Participants were invited to motivate their top tens. Subsequently, the moderator (being the same as in the first workshop) led the group through a number of topics using focus group interviewing techniques. Topics like 'your ideal colleague', 'what do you need to know about your patient', and 'what do you need to know about your work environment' were discussed. The workshop lasted for two and a half hours.

3.3 Analysis of the 1st and 2nd session

Based on our conceptual framework (Melles et al., 2002) and the collages of the second exercise made during the first session we defined six actors that interact with the intensive care nurse while executing her work: (1) patient; (2) equipment; (3) physician; (4) colleague-nurses (team); (5) other medical staff; (6) family. These six actors defined the six categories which we used for our first subsequent coding step. All transcripts of both sessions were coded for the nurse to who belonged the quotation and for the category. Subsequently, the quotations per category were clustered and labelled as different phenomena. A phenomenon was defined as an (inter-)action between the participating nurse and one of the actors, following the work on phenomenology of Dourish (2001). Examples of phenomena are transfer of shift, monitoring the patient, or adjusting the equipment. We named around 30 phenomena. Figure 5 illustrates our approach and visualisation techniques, showing a small selection of the processed data. Note that the categories 'other medical staff' and 'family' are left out. For our analysis of the transcripts we used ATLAS/ti, a software application for the qualitative analysis of textual data, based in part on grounded theory methodology (Thomas Muhr Scientific Software Development, 1997).

As a last step these 'phenomena fields' (one per nurse) were examined per field (within subjects) and compared with each other (between subjects). We used three techniques for the identification of signals for innovations or design guidelines: (1) cross-linking tasks within subjects to define new and needed functionality; (2) identifying conflicting requirements between subjects as possible signals for the need of specific context-awareness in devices; (3) identifying problems and needs related to the phenomena mentioned within subjects to define design guidelines.

4 **Results**

We illustrate our approach with four examples of 'signals' we found for possible innovations or design guidelines, see figure 5 and the commentary below. Final results are not presented here.

	<-> PATIENT	<->EQUIPMENT	<-> PHYSICIAN	<-> NURSE
NURSE A <->	INFORM THE PATIENT * Patients regularly ask me about things they've discussed with the doctor but of which there are no written records.' INSTABLE SYSTEM * You can plan and organize each and every detail, However, it takes only a single obstructive patient for your whole organisation to fall apart.' * But I must say, thot's exactly what I like about this job.'	OWNITOR THE PATTENT When a patient indicates a pain in the chest, the first thing I'll look at is his ECS. You check the facts first, then the signals the patient is giving out."	BATA ADMINISTRATION What I miss in the medical record is information about who said what to whom.' In particular the bedside conversations the doctor has with the patient.' Especially during day shifts, with all the chaos going on, it is often forgotten.'	TEAMWORK " 'I find that Jinamour, Mid) very important, being able to longh and have some han so now and then. If that wouldn't be possible anymore, I would be inclined to leave."
NURSE B <->	MONITOR THE PATIENT * When an alarm sounds, I usually start out by looking at the patient's complexion.	Guilliannan Barta an	e et c'angul	eproblem / need 4: value

figure 5. Analysis and visualisation techniques of the qualitative data gathered in both sessions (selection of a 'phenomena-field')

A. Signal for innovation: cross linking tasks between the phenomena 'data administration' (nurse-physician) and 'inform the patient' (nurse-patient)

A problem mentioned by several nurses is the issue that conversations between a physician and their patient are not always administered. Subsequent questions of the patient, who will turn to the nurse for most of his questions, can not be answered by the nurse because she can not recover the original information.

Possible solution is a device that simplifies the administration of 'informal' conversations between physician and patient, including easy retrieval of this information by the nurse.

B. Signal for design guidelines: conflicting requirements about the phenomenon 'monitor the patient' (nurse-equipment)

When a patient is in trouble, some nurses look firstly at their patient and subsequently at the monitor. Other nurses first check the monitor and subsequently the patient. According to their own explanation, their strategy is dependent of the clinical picture of

the patient. Further research should explore this. However, checking the complexion of a patient is location-dependent, while checking an ECG is not. A context-aware designed device adapting itself to the status of the patient or the preferences of the nurse, possibly could adapt to this location (in-)dependence as well.

C. Signal for design guidelines: humour

An often-mentioned fact about the successful introduction of new systems is that they should act as 'team player', collaborating with the user. During both sessions humour is mentioned by all our participants as being one of the most important characteristics of colleagues (spontaneously mentioned n=5; confirmed n=2). Humour is used as a stress-relieving process and is part of the process of working together. Off course, introducing humour is about timing, picking up cues, and sizing up the situation. Designers of medical equipment have to distinguish where the introduction of newly designed systems have an effect on expressed humour. The use of speech technology, for example, can impact the way nurses collaborate and communicate.

D. Signal for design guidelines: unpredictability

Judging unpredictability in an intensive care unit should be done with care. In literature unpredictability is often described as a negative characteristic of the intensive care unit, resulting in stress for the staff, hence providing a potential for human error. Therefore, according to literature unpredictability should be minimized. However, our findings show that handling unpredictable situations is also an important value of work for the intensive care nurse (spontaneously mentioned n=4). It is one of those assets that make up the joy and challenge of intensive care nursing. Designers of medical equipment have to distinguish where unpredictability should be maintained in the new workflow design, and concurrently provide support to act safely in unpredictable situations.

5 Conclusions and discussion

A recent article in a Dutch newspaper (Bemmel, 2003) reports about a research project, examining the possibilities of speech technology in the operating theatre. One of the applications concerns a speech driven anatomical atlas, which can be used by the surgeon without using his hands, hence without desterilising his hands. The advantage, as mentioned in the article, is more information directly available to the surgeon without the use of an assistant, and as a consequence, a reduction of time. As a last remark, one of the interviewed researchers mentioned that the application of speech technology ends a popular habit of the staff in the operating theatre, namely listening to the radio during an operation. This example illustrates a common way of introducing new technologies in a work environment, especially in medical domains. Most new equipment and research is still technology driven and focused on the causes of human error and the efficiency of the task performance. However, we think that the efficiency and safety of a task is also influenced by the assets that make up the joy and challenge in one's work. Maybe listening to the radio during an operation is very important to the mental well being of some of the staff and therefore an important working condition.

Designers of medical equipment have to be aware of the future impact changed technologies have on the process of intensive care nursing. Design requirements concerning next generation intensive care equipment should therefore address the essential values of work as well. We found that cultural probes and generative tools applied within focus group sessions indeed revealed signals for (future) design guidelines, including examples of valuable working conditions. Furthermore, they revealed opportunities concerning the application of context awareness in next generation intensive care equipment.

We demonstrated the use of various participative techniques and applied three methods to analyze this data. The usefulness and benefit of this approach should be further explored but our preliminary findings are promising. Next step in our research is the application of the newly found preliminary guidelines and innovative solutions in scenarios and storyboards envisioning the process of intensive care nursing after implementation of context-aware technology (step C in table 1). As part of an ongoing process to test and further refine our guidelines the iterated scenarios and storyboards will be regularly presented and discussed during interview sessions with intensive care nurses. Once these storyboards and scenarios have evolved to a satisfactory level working prototypes will be introduced (step D in table 1).

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