NTNU
Norwegian University of
Science and Technology

Introducing New Technologies to Users in User-Centered Design Projects:
An Experimental Study

Tuva Foldøy Klingsheim
Benedicte Raae

Master of Science in Computer Science

Submission date:	June 2009
Supervisor:	Dag Svanæs, IDI
Co-supervisor:	Pieter Jelle Toussaint, IDI

Norwegian University of Science and Technology
Department of Computer and Information Science

Problem Description

Ubiquitous Computing technologies such as RFID and location tracking have been around for decades, but despite their widespread use it is not straightforward to design software systems with these technologies. One problem is the lack of knowledge and experience with the technologies, both among developers and users. The main hypothesis of this thesis is that hands-on experience with the technologies can make it easier to do user-centered design of such systems. To test this hypothesis, a set of UbiComp demonstrator will be developed and used in design workshops with doctors and nurses from StOlavs hospital Operating Theatre of the Future. The thesis will be done in cooperation with the COSTT research project.

Assignment given: 13. January 2009
Supervisor: Dag Svanæs, IDI

Department of Computer and Information Science, IDI

TDT4520 Program and Information Systems, Master Thesis
Spring 2009

Introducing New Technologies to Users in User-Centered Design Projects:
An Experimental Study

by

Benedicte Raae
&
Tuva Foldøy Klingsheim

Supervisors:
Dag Svanæs & Pieter Toussaint

Trondheim, June 2, 2009

Abstract

In user-centered design the users play an important role in the development process. The users are included in near every step of the process, but it is often a problem that they do not have the necessary overview of the technology intended used in the end system. They do not need to know all the technical details, but they do need to know what possibilities the technology makes available. To do this one needs to introduce the users to the technical possibilities, but how does one do this?

We had two suggestions as to how this could be done: (1) We proposed introducing the possibilities through abstract concepts not tied to the users' domain. The reason being that we did not want to lock the users to concrete ideas given by us, but let them use the abstract concepts to come up with ideas in their own domain. (2) We suggested giving the users hands-on experience with the concepts. Human knowledge is usually derived from experience, and we believe touching and trying out the possibilities of a technology would also be helpful in this kind of setting.

To test whether hands-on experience and abstract concepts are valuable in an introduction of new technologies we conducted an experiment involving two workshops. Both workshops got a theoretical presentation of the abstract concepts, while one workshop let the participants explore a demonstrator made by us giving them hands-on experience. These workshops were then analyzed both quantitatively and qualitatively.

The quantitative analysis showed that the workshop incorporating hands-on experience generated more unique ideas and also ideas in more categories than the other workshop. However due to low comparability between the groups due to factors such as prior experience with the technologies and current work situation, these findings are not statistically significant.

Through the qualitative analysis we see that hands-on experience can be valuable. For one participant in particular, the hands-on experience was very valuable. In addition we found that hands-on experience was valuable as a motivational exercise in a user-centered design process.

The abstract concepts were analyzed qualitatively, and these were not as valuable as hoped. The users found it hard to map the abstract concepts to

their domain. We now see the value of examples closer to the users' domain, but they should be kept as small building blocks for the users to combine themselves in order to solve larger problems.

We end this thesis with a suggested approach for introducing new technological possibilities. We still recommend using the abstract concepts, but taking care to exemplify them through many small and domain-specific examples. Hands-on experience is recommended if it is feasible to do this within the domain. We also recommend for time to mature and revisiting the participant after they've been back in their domain for a while.

Preface

This is Benedicte Raae and Tuva Foldøy Klingsheim's Master Thesis in Computer Science. It is a part of the specialization in Program and Information Systems. The work is done in the tenth and last semester of the Master of Technology, Computer Science program at NTNU, and takes up the full workload of the semester. The Master Thesis was done in collaboration between the two students and supervised by Dag Svanæs and Pieter Toussaint.

Dag Svanæs is a Professor at the Department of Computer and Information Science (IDI), and belongs to the research group of Design and Use of Information Systems. He proposed the Master Thesis, helped define it and oversaw our work.

Pieter Toussaint is an Associate Professor at IDI, and also belongs to Design and Use of Information Systems Group. He is the leader of the COSTT project where our thesis forms a part.

Trondheim, June 2, 2009.

Benedicte Raae and Tuva Foldøy Klingsheim

Contents

List of Figures

Chapter 1

Introduction

This chapter starts by explaining the motivation behind the project in Section 1.1. It then goes on to define the project in more detail through the research questions, see Section 1.2. An overview of the research to be done is given in 1.3 and the context of the project is explained in 1.4.

1.1 Motivation

As the title of our thesis suggests, we are looking into the introduction of new technologies in a user-centered design setting. In user-centered design one sets out to use the users' knowledge and experience within their domain to produce new or better information systems for the same users. It is important that the design process includes the users as fully empowered participants according to Muller[23].

In some cases the design of a new information system involves the use of new technologies, technologies the potential users may not even have heard of. How do you then get users to come up with scenarios and ideas that incorporates the possibilities than come with the new technologies; "In the beginning all you can understand is what you already have understood"[18], as Pelle Ehn states in his 1992 paper on Participatory Design. We will use the term User-Centered Design in a broad sense, covering also projects done in the spirit of the Scandinavian Participatory Design tradition[17]

"Users' thinking can be constrained by what they know"[27], limiting themselves to solutions based on the knowledge and experience they already have. On the other side, as Svanæs experienced when doing prototyping of new mobile devices with high-school students that did not get any introduction to the technologies, "...a lot of their wishes are not technologically feasible."[28]. Both these perspectives are in line with our own experiences when discussing technology with non-technical friends and family; there is often no mapping between what they believe is complicated and what is actually complicated from a technical side.

Our opinion is that the users do not need to know exactly how a computer systems will work, but they do need to know what is possible if they are to come up with plausible ideas. Muller says in his article on enhancing participation in the design process that one technique "is to insure that users have early exposure to the target implementation technology."[23]. This is what we want to look into through our master thesis: how does one best introduce new technological possibilities when doing user-centered design.

1.2 Project Definition

Our research concerns how one best introduces new technological possibilities to non-technical users. This is to enable them to incorporate the possibilities of the technology into ideas for likely uses in their lives. We have first defined our research problem.

Research Problem What is the best way of introducing new technologies to non-technical users when doing user-centered design?

We have devised three research questions related to the research problem. They are defined below.

RQ 1 What is the added value of giving users hands-on experience with new technological possibilities?

RQ 2 What is the added value of using abstract concept when introducing new technological possibilities?

Based on these two research questions, we will attempt to answer the last research question.

RQ 3 What recommendations would we make for introducing new technological possibilities?

1.3 Research

In order to answer our research questions we will conduct two workshops. Both workshops will get a theoretical presentation of the technological possibilities and end with an idea-generating phase. The participants in one workshop will be able to explore a demonstrator made by us, while the participants in the other will not. To answer our first research question we will compare the outcome of the idea generating phases, in terms of both volume of ideas as well a qualitative study of the process. The second research question will be answered primarily using a qualitative study. The last research question will base itself upon the answers to the two previous research questions, possibly suggesting a new method for introducing a new technology. A detailed research plan can be found in Chapter 3.2.

1.4 Project Context

The research will be done as a part of the *Co-operation Support Through Transparency* (COSTT) project at NSEP. NSEP being the The Norwegian Electronic Health Record Research Centre located close to St. Olavs University Hospital in Trondheim and organized under the the Norwegian University of Science and Technology. “The center is involved in different research projects regarding development, use and usefulness of electronic health record.” according to their webside[1].

The research could be conducted on any specialized workforce; we will use medical personnel from St. Olavs. The reason being that we saw the possibility of doing our research as a part of the COSTT project. The COSTT project already has a connection with St. Olavs and therefore access to personnel. In the project mandate[2] we find that the COSTT project wants to “develop technologies for inferring and identifying intentional healthcare acts and patient trajectories from logs and other torrents of activity data”. As a byproduct of our research we might be able to aid in the early-stage requirements gathering by collecting the ideas that come up when doing our workshops.

The demonstrator will be within the ubiquitous domain which fit the COSTT project, and that we also have some prior experience with from our specialization project “Introducing Ubicomp Technology to System Developers: The Value of Hands-On Experience”. For that project we used RFID technology supplied by Phidgets[7]. We will use this equipment again since we found Phidgets to be a developer-friendly prototyping hardware, and the equipment is readily available to us. COSTT has joined forces with Sonitor who has developed a system using ultrasound identification (USID) which can give a room or zone-based location of a tag. The equipment will be set up in NSEP’s usability lab and we will use Sonitor as well in our demonstrator.

[1] www.nsep.no
[2] personally communicated with Pieter Toussaint

1.5 Report Outline

Following is a short reader's guide to help give an overview of the chapters in this document.

Chapter 1 Introduction gives an introduction to the project by presenting the motivation, the project definition, an overview of the research to be done and putting the project into context.

Chapter 2 Pre-study introduces the research fields the project is based on.

Chapter 3 Research Method explains the research method we use for this project.

Chapter 4 Demonstrator: Functional Description describes how the demonstrator works and what features it encompasses.

Chapter 5 Demonstrator: Technical Description gives a technical overview of how the demonstrator is designed.

Chapter 6 Workshops describes the plan behind the workshops and what possibilities we want to get across.

Chapter 7 Results lists the ideas generated by the workshops, and gives background information on the users.

Chapter 8 Discussion of Method looks at the methods used and pinpoints some possible sources of error.

Chapter 9 Analysis counts and categorizes the results, and discusses some important factors when it comes to introducing new technological possibilities.

Chapter 10 Conclusion ends this paper by answering the research questions and mentioning possible future work.

Chapter 2

Pre-study

This chapter gives background information on the research done and is the theoretical base for the analysis and conclusion in Chapter 9 and 10.

We look at the research from the perspective of user-centered design, introduced in Section 2.1. Our first research question is concerned with hands-on experience and our research is dependent on the participants being creative. Experience as a part of a learning process is introduced in Section 2.2 and some important aspects of creativity is included in Section 2.3.

The demonstrator is based on the location technologies RFID and USID which are explained in Section 2.6. Location technologies are an important ingredient in context-aware systems as explained in Section 2.5.2, and context-awareness belongs to the larger field of ubiquitous computing introduced in Section 2.5.

Our results show a similarity to Bonnie Nardi's theories on abstract concepts in programming, and we've included an introduction to this in Section 2.4

2.1 User-Centered Design

As the title of our thesis reveals, we are looking into the introduction of new technologies in a user-centered design setting. We will therefore here give a short introduction to the field of user-centered design.

User-centered design is when users are central information sources, and according to Sharp, Rogers and Preece in [27] it "involves finding out a lot about the users and their tasks, and using this information to inform design." Whether the goal is to replace or update an established system or to develop a totally innovative product, the users' needs, requirements, aspirations, and expectations need to be discussed, refined, clarified, and probably rescoped (free from [27]). This can be done in several ways, they mention questionnaires, interviews, observations, focus groups and workshops. Users can also be an equal part of the design team in what is called Participatory Design (PD). The idea of PD appeared in the 1970s partly due to "the labor union movement pushing for workers to have democratic control over changes in their work", as Sharp, Rogers and Preece puts it.

The user contact that PD brings is beneficial to both the designer, the system and the users, as "users are experts in the work context and a design can only be effective within that context if these experts are allowed to contribute actively to the design. In addition, introduction of a new system is liable to change the work context and organizational processes, and will only be accepted if these changes are acceptable to the user."[10] Having the users involved in the design process can make them more positive to the introduction of the new tool.

In some cases the design of a new information system involves the use of new technologies, technologies the users may not even have heard of, and are not near knowing the possibilities nor limits in. A drawback of PD is that "Users' thinking can be constrained by what they know"[27], limiting them to seeing only combinations of what they have already experienced. In these cases one option is to bring the users up to speed in the fields they do not master.

In introducing new technologies, and in communication between users and designer in general, the vocabulary can be a problem. The two groups will necessarily have very different language sets; a designer does not know the workings of all domains (banking, retail, publishing, hospitals etc.), and the user does not know what programming is and how an information system works.

One of the difficulties in user-centered design is communicating in a way that all involved can relate to and fully understand. This involves a design language that all participants can make sense of, and as Pelle Ehn states in [18] this is difficult because the participants are from such widely different domains; "in the beginning all you can understand is what you already have understood".

Ehn continues to say that it is difficult to "create a design language game that makes sense to all participants". Continuing he states that "mock-ups become useful when they make sense to the participants in a specific design language game, not because they mirror "real things", but because of the interaction and reflection they support."

2.2 The Value of Experience

In this section we write about experience and learning. Experience both in the sense of hands-on experience and in the sense of prior experience. Our research question suggests hands-on experience as a tool in introducing a new technology.

The word *experience* is defined by the online Oxford English Dictionary[6] as “The actual observation of facts or events, considered as a source of knowledge.” Meaning, among other things, that an experience is something highly individual.

From the very first day we are born, we start developing. Jean Piaget (1896-1980), a Swiss psychologist especially known for his engagement in developmental psychology, suggests that there are four stages of development. At each stage, a child is “constantly creating and re-creating his own model of reality, achieving mental growth by integrating simpler concepts into higher-level concepts”[5]. Only in the final stage where we have reached adolescence is abstract reasoning developed. He highlights the importance of individual and subjective repetitive experiences in order to develop an understanding of the world and to move from stage to stage, desiring the educational system to adapt to this new thinking.

Another advocate for a change in the educational system, and the introducer of experiential education, was John Dewey. He was an ”American philosopher and educator who was one of the founders of the philosophical school of pragmatism, a pioneer in functional psychology, and a leader of the progressive movement in education in the United States.”[4] He based his theories of education on the idea that there is a close relationship between the processes of actual experience and education. He says that “education must therefore begin with experience, which has as its aim growth and the achievement of maturity.”[4]

The quality of the experience was dependent on several factors, the most important being continuity and interaction. The principle of *continuity* of experience basically says that every experience will affect a person to some extent. And because an experience will affect the person it will also necessarily affect future experiences. The principle of *interaction* builds on the notion of continuity stating that past experiences will interact with the current situation thus creating the current experience. This is what makes an experience individual and unique. Prior experiences are therefore very significant to future ideas.[16]

John Locke, an English 17th century philosopher, discusses amongst others the origin of ideas. In his 1690 *An Essay Concerning Human Understanding*[22] he explains that with “ideas” he means “term which [. . .] serves best to stand for whatsoever is the object of the understanding when a man thinks.” He exemplifies ideas as “whiteness, hardness, sweetness, thinking, motion, man, elephant, army, drunkenness, and others”. Locke is of the opinion that we come to this world with the mind as a “white paper” and “furnish” it from experience. He states that “in that[experience] all our knowledge is founded; and from it ultimately derives itself”.

The ideas come from experience either through what Locke calls sensation or through reflection, which he states are “the only originals from whence all our ideas take their beginnings”. Sensation refers to what the senses convey into the mind from external material objects, while reflection is "that notice which the mind takes of its own operations, and the manner of them, by reason whereof there come to be ideas of these operations in the understanding".

So the individual experiences, the subjective experiences, are what is important in order to fill the "white paper"-mind with the ideas necessary.

Buchenau and Fulton Suri [14] also emphasize the importance of experience arguing in their 2000 paper on experience prototyping stating that "information becomes more vivid and engaging when it resonates with personal experience", adding that experience is very dynamic, complex and subjective. Continuing, they say "experience is, by its nature, subjective and [...] the best way to understand the experiential qualities of an interaction is to experience it subjectively". They emphasize the importance of personal experience, while not underestimating the significance of the interactions with other people, places and objects. They argue the only way to really understand and notice the subtle differences in various solutions or interactions is by actively experience them and "exploring by doing".

Hands-on experience is key to the learning-by-doing thought. We quote the Chinese philosopher Lao Tse who stated: "What I hear I forget. What I see I remember. What I do, I understand!", paraphrased from Buchenau and Fulton Suri [14]. *Hands-on* is in the online Oxford English Dictionary[6] defined as "involving direct participation in an activity [...], in order to gain practical experience of it; of experience, training, etc.: practical, rather than theoretical or second-hand."

We believe experience makes a person more comfortable with a technology and more likely to use it in an appropriate situation and see more possibilities with it. We can draw parallels to for example product design students who learn about and play with different materials in order to see more possibilities when faced with a project. The goal is for them to be more creative and more likely to use the most appropriate material in a given situation, as it is now familiar.

We end by quoting our supervisor Dag Svanæs, stating that "It is only through interaction that objects appear to us as immediately existing in the external world."[29]

2.3 Creativity

This section introduces creativity; what it is and how it is influenced. This is information that is relevant to our choices in setting up the workshop. We especially focus on creativity in groups because we will be using groups in our research rather than individuals.

Wikipedia[9] gives a rather good introduction to creativity, presenting it as "a mental and social process involving the generation of new ideas or concepts, or new associations of the creative mind between existing ideas or concepts." Continuing, Wikipedia states that it "is fueled by the process of either conscious or unconscious insight." In our case we want people to gain insight into new technologies, in this way enabling the combination of prior knowledge and new experience to stimulate their creativity.

Encyclopædia Britannica gives some of the individual characteristics that are common in creative people: independence, domain mastering, high intelligence, fluency, flexibility, originality and the combination of curiosity and problem seeking[3]. Paulus and Nijstad[26] add "personality, developmental experiences, culture, motivation, and cognitive skills" as factors underlying creative behavior in an individual.

As they point out in the intro to their book titled *Group Creativity: Innovation through Collaboration*, creativity *can* be a sole activity, however it does often involves several individual contributions combined. They state that "group ideation can in fact exceed individual ideation in both the quantity and the quality of ideas produced"[26].

There are several factors to consider when using groups for idea generation. When in a group, the members "tend to focus on ideas or knowledge that they have in common rather than unique information."[26] In addition to this, "it may be difficult to think of novel ideas when previously expressed ideas are very salient."[26] This problem of the premier ideas blocking future ideas, can be solved for example by doing brainstorming sessions with group members writing ideas rather than speaking.

The sharing of ideas is however important, and group members should be given time to do this. In this kind of brainstorming, it has been proven that guidelines and control increases the effectiveness of the group's idea generation. The guidelines can be enforced either by the group itself, or using a facilitator. A facilitator is usually a good solution, as there is always a risk that some individuals dominate the interaction process. In addition, a facilitator can guide and motivate the group.[26]

The group composition also plays an important role for the creativity. The felt ranks of members, their background, age, gender all make an impact. Looking at experience, we see that "prior experience can sometimes block or impede cognitive operations in memory, problem solving, and creative thinking and that similar cognitive processes are involved in all three domains. Such constraints can have profound effects on the creative ideas generated not only in individuals but in groups of people as well. "[26] That is, prior experiences can heavily influence current idea generation, as we've also touched upon with the theories of Dewey in the section on experience.

2.4 Abstract vs Domain-Specific

When looking at our results, we found that part of them could be due to the fact that we chose to give the concepts abstractly. In this section we introduce theory on end-user programming by Bonnie Nardi, which in part gives an explanation to some of our results.

Bonnie Nardi, in her book *A Small Matter of Programming*[24], explores the problems related to giving end users more computational power. She remarks that application development environments such as spreadsheets, statistical packages and CAD systems are successful and widely used, while the general programming languages fail to gain a substantial following of end users. What these environments have in common are task-specific operations that allow programming within a particular set of tasks. Nardi paraphrases Lewis and Olson's 1987 paper[21] stating that "users have difficulties both in learning the unfamiliar primitives themselves and then in learning how to assemble the primitives into functioning programs." Continuing, she says that "Programming with low-level primitives is difficult for end users because the primitives are unrelated to the tasks and concepts they understand." It can be difficult to use the building blocks given them when these are not within their domain. Spreadsheet environments such as Excel is made for mathematical purposes and the primitives, which in this case are mathematical functions, are well-known to the user. A general programming language seeks to create general rules to solve any problem, thus creating a system that demands more to learn and use. The concepts they do understand are those primitives which are within a domain they understand. There are different approaches to end user programming, Nardi discusses amongst others programming by example. This approach allow users to give concrete examples, directly manipulating items and text on the computer, which the system then tries to find a pattern in and creates a program. This is an approach that is explained by the argument that "people are good at thinking concretely but less good at abstractions such as those involved in programming."

A large part of the argumentation for end user programming is also the motivational aspects. End users have problems motivating themselves to spend a lot of their professional time on tasks not directly related to their main work tasks. As Nardi states: "end user systems should be task-specific because users do not want to learn or use unfamiliar low-level programming primitives and they prefer to work within the idiom of their domain tasks."

2.5 Ubiquitous Computing

As described in Section 1.1 our work is a part of the larger COSTT project and is located within the field of ubiquitous computing. This section gives a short introduction to the history of ubiquitous computing and introduce the concept of context awareness that is a field within broader field of ubiquitous computing.

2.5.1 History

The Ubiquitous Computing program was started at the Palo Alto Research Center's (PARC) Computer Science Laboratory. It was started by the late Mark Weiser who is considered to be the father of the field of ubiquitous computing, or Ubicomp as it has become known[13]. In Oxford English Dictonary[6] the word ubiquitous is defined as "Present or appearing everywhere; omnipresent: a) Of single persons or things, b) Of a kind or class of persons or things." This was the vision Mark Weiser had for computing in the 21st century - that we would be surrounded by "invisible" technology, making way for so-called "calm" computing. Weiser felt that the personal desktop computer demanded too much attention. He wanted technology to recede "into the background of our lives"[30], being integrated into everyday objects and activities.[32]

His inspiration came from the social scientists, philosophers and anthropologists at PARC. The anthropologists observed the way people *really* used technology, something which created an interest within the Human Computer Interaction (HCI) community of PARC. They wanted to find out how computers were embedded within the complex social framework of daily activity, and how they interplay with the rest of our densely woven physical environment, as Weiser put it in his 1999 paper [32] summarizing the history of Ubicomp at PARC.

The late 80s advances in graphical user interface research had given way to critique of traditional HCI. Weiser [32] summarized the problems with user interfaces at the time as being:

- Too complex and hard to use
- Too demanding of attention
- Too isolating from other people and activities
- Too dominating on desktops and lives.

To overcome these problems, Khedo explains in his 2006 paper [19] that one of the key concepts of ubiquitous computing became to empower technology to create a practical environment surrounding the user that merge physical and computational infrastructures into an integrated information oriented world.

Weiser [31] saw Ubicomp as the next natural step in the evolution of computing, as seen in Figure 2.1 He envisioned a world of Ubicomp, where users share many computational devices - almost without even being aware of it. This was in contrast to both the first era, which consisted of mainframes, where each computer had many users, and also his current era, the personal computing era, where each computer had a dedicated user.

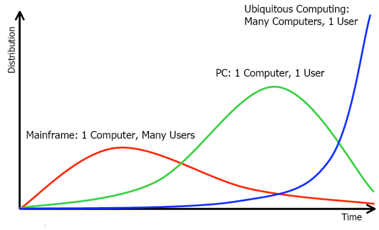

Figure 2.1: The evolution of computing, reproduced from [31].

He envisioned this world for the 21st century, and looking only at the hardware it seems close to being a reality. However, as Alsos and Svanæs [12] explained; "the current lack of network, software and user interface interoperability makes reality very far from Weiser's vision". Continuing, they say:

> we have the building blocks, but this kind of integration [that Weiser talked about] is still science fiction. There are a number of reasons why integration of devices and systems is difficult, ranging from organizational issues to lack of operating systems support for multi-device applications, and problems related to security and privacy.

As before mentioned, ubiquitous computing includes not being necessarily aware of a technology. Although at times practical, not being aware of a technology can also be frightening. Bell and Dourish convey in their 2007 paper [13] the feelings of Singaporeans, who live in a country of well developed computing including mobile handsets, pervasive Internet and smart sensors, expressing a concern about content surveillance and control. The Singaporeans are not alone to feel this way, this is said to be one of the reasons why Ubicomp has not been implemented in the way Weiser envisioned it - people are asking whether we really want the world to be that imbued with technology. Do we need the kind of convenience that is proposed?

One can also see it as a result of Weiser being such an enormous influence, not leaving room for other interpretations of what implemented Ubicomp could be. On the other hand, Bell and Dourish [13] argue that Ubicomp is already here, only that it took another form than what was envisioned. They claim that the Weiser seminal article's dominant theme is "the twin challenge of anticipating future trends and meeting future needs" leading to the fact that "by definition ubiquitous computing is not about the here and now."

Weiser, being a prominent figure in the field, wrote and co-wrote several articles and was cited in a quarter of all articles written in the field [13]. Therefore it is the view that he expressed in his 1991 article that still defines ubiquitous computing and its criteria for success.

2.5.2 Context-awareness and Location Aware Systems

Context awareness is an important field within ubiquitous computing. If we are to make systems that melt into the background and aid us in our daily lives we need systems that can sense what we are doing, and also guess what we intend to do in the future. To do these complex calculations the systems will need to constantly collect information about the world around us and maybe also the world within us. Here, we present the definition coined by Dey, Abowd and Salber in 2001[11]:

> Context: any information that can be used to characterize the situation of entities (i.e., whether a person, place, or object) that are considered relevant to the interaction between a user and an application, including the user and the application themselves. Context is typically the location, identity, and state of people, groups, and computational and physical objects.

Position and proximity information is by far the most used context data, both because it is an easy property of context to collect and because it is often a central and important part of a context-aware system. Positioning is the act of finding out where a person is in regards to some reference system. In Global Positioning System (GPS) one can calculate where on earth a GPS device is. Proximity information is slightly different, here the information would be about what other objects an object is close to. We use the term localization information for both in this paper.

For many car owners a life without their GPS system is unthinkable, and some of these system make decision based on more than merely the location of the car. Information about traffic jams and construction work are valuable when plotting a route for how the driver should get to work, but the location of the office and the car is the central piece of information in the system.

Proximity information is not necessarily about where you are in the world, but what you are near. For instance with contact-less payment cards the important thing is that the card is close to the reader, so that the card is identified and payment completed. In some cases it could be interesting to know the location of the reader. We can not however make sure the reader stays in place, and the only thing we can depend on is that the reader is close to the card.

This last example is not always an example of a bad property of proximity systems. For instance in a museum audio guide system the most important information is what artifact you are near so the right piece of audio can be played. If this system used a positioning system the artifacts could not be moved around the space without the system needing reconfiguration, with a proximity system the artifacts could be moved around at any time and the museums creativity would not be locked by the technology.

If we continue to use a museum as the example, there is another aspect more important for the user. How will he or she trigger the audio playback, when do we know that a person close to an artifact (determined either by position or proximity) *want* to hear the playback? Is the act of walking up to an artifact in itself an indication of a determined action form the users point of view?

This is were the concept of foreground and background activity come into place. Foreground activities as defined by Buxton[15] in 1995 are intentional activities that are in the fore of human consciousness. This is in contrast to background activities "...that take place in the periphery - "behind" those in the foreground". His prime example of the difference are being aware that the light in your kitchen goes on automatically when you enter it (background) or manually flicking the switch (foreground).

As an answer to the issue raised in the museum example, we can look to Svaneas[29] who writes:

> The important lesson from phenomenology is that what is foreground and what is background depends on our focus of attention and our intention and not on the physical action itself. By simply observing a user moving from one room to another, there is no way of telling if this is a foreground or a background activity.

2.6 Technologies

In order to explore the research questions we'll need to use some technologies to demonstrate the technological possibilities of localization systems. Since we'll be doing the workshops indoors we need some localization technologies that work indoors and there are many technologies that can do this; radio frequency identification (RFID), ultrasound identification (USID), infrared and bluetooth. In addition it is possible to triangulate using wireless access points to find the position of a device. We have found companies providing IPS utilizing all of these technologies, but the focus will be on the technologies that we'll be using in our demonstrator; USID and RFID. Section 1.4 explains the reason for choosing these technologies.

RFID has a long history of use and standards have emerged so that hardware form several manufacturers can be used interchangeably. USID on the other hand is slowly gaining ground and there are no industry standard.

Most of the information we have on USID is from the vendor that supplies the COSTT project; Sonitor.

2.6.1 RFID

An RFID system is made up of two components; a tag (more formally called a transponder) and a reader (which is sometimes called the interrogator). The data on the tag, in most cases only a unique id, is read when the tag is within the reader's range. The readers can have very different ranges, from a couple of centimeter up to about a hundred meters and makes RFID useful both as a foreground and background interaction technology.

In daily life most of us have experienced using RFID as a foreground activity, see Figure 2.2. It can be found in identification cards used to access building and rooms, and the cards used for the "bysykkel"-system[1]. The card only needs to be moved close to the reader to be read, no need for swiping or physical contact of any kind. RFID tags do not need to be in sight of the reader and works through the human body, clothing and non-metallic material. Therefore the "bysykkel"- cards do not need to be removed from a wallet or purse to be read, the user just moves the wallet or purse near the reader.

If we extend the range of the reader RFID it can be used as a background interaction method, as long as a user or object has an RFID tag attached like the user to the right in Figure 2.2

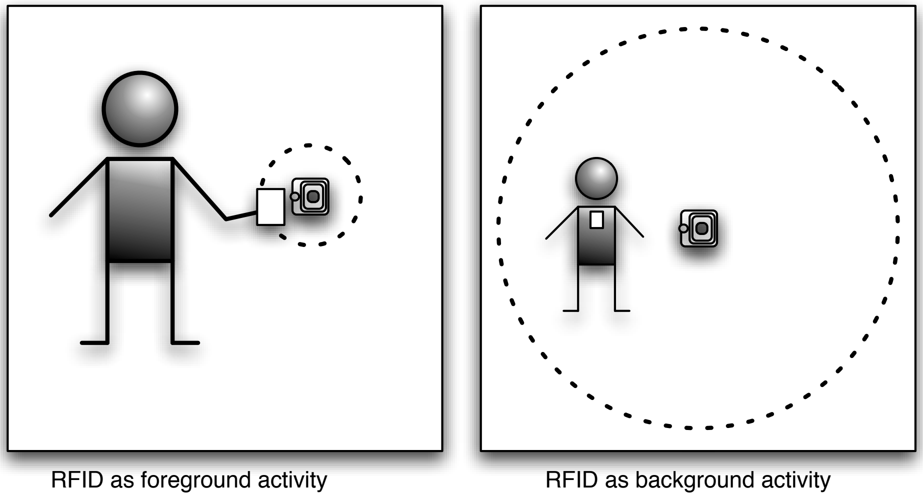

Figure 2.2: RFID as a foreground and background activity

RFID tags come in a multitude of shapes and sizes. They can be as

[1]A city wide system for borrowing bicycles where the identification of users are done by RFID cards, see http://www.adshel.no/

small as a pencil lead in diameter and only one-half inch in length for animal tracking, attached to a flexible sticker not even a millimeter thick for anti-theft, or they can be large heavy-duty rectangular boxes aimed to track containers or heavy machinery.

The start of RFID is considered to be World War II where the development of radar technology sparked the ideas of reflected-power communication. The pioneer in this field is considered Harry Stockman, who in his 1948 landmark paper "Communications by Means of Reflected Power", envisioned what we today call RFID. The early adopters started using it commercially in the 1970's and by the 19080's it had become mainstream, and with this the need for standards appeared. The first standards came in the 1990s when RFID become a part of everyday life and the 2000s have only continued expanding the field of RFID. It is now used to track millions of objects around the world.[20]

Hospital Example Chang-Gung Memorial Hospital (CGMH) in Keelung, Taiwan, implemented an RFID based patient management system in its operating rooms to improve patient safety. The introduction of the system helped verify and positively identify patients, gather real-time data, reduce risk of wrong-site and/or wrong-patient surgery, and ensure compliance with hospital patient safety procedures.[1]

2.6.2 USID

Ultrasound identification works by tags emitting ultrasound signals that are picked up by microphones placed around rooms. USID do not need line of sight between reader and tag, but in contrast to RFID, USID only works through material one can breath through. Depending on the situation this can be a positive or negative characteristic. It does constrain the signal to a room level guaranteeing room level accuracy, but the tag can not be covered by a heavy material, such as a bag or heavy duvet.

In addition to room level accuracy Sonitor can define zones within a room by placing microphones strategically. In addition they have started to produce microphones that only "hear" tags in a smaller area, this can be placed above for instance beds.

Sonitor tags produce tags that sends out signals at regular intervals, making it suitable for background interaction. Some tags however to do not emit signals when not moved, which is beneficial for object usually constantly send out a signal or only sends out a signal when moved. The latter is important because in USID the tags need their own power supply and the less they transmit the longer the battery will last, and some object lay still for most if its lifetime.

Hospital Example At Albert Einstein Healthcare Network in Philadelphia they use a tracking system from Patient Care Technology Systems, one of Sonitor's partners. They track patients, staff and equipment in their emergency unit leading to automatic updates on patient status amongst other things. According to [2] "...the hospital saw a 24% increase in ED volume and hospital admissions, but was still able to reduce the rate of patients walking out without treatment from over 5% to between 1% and 2%,...".

Chapter 3

Research Method

This chapter aims to explain the research design chosen. The first section gives background through explaining some related research topics, while the subsequent section gives our chosen research design. Our choices base themselves on Biony J. Oates' book *Researching Information Systems and Computing*[25], and if nothing else is explicitly stated, all quotes and facts derive from this book.

3.1 Related Research Topics

Experiments According to Oates an experiment "investigates cause and effect relationships, seeking to prove or disprove a causal link between a factor and an observed outcome", adding that it is in fact the only research method that can prove causal relationships. It is designed to prove or disprove a hypothesis.

There are several experimental designs, Oates lists some:

- One group pre- and post-tested
- Static group comparison
- Pre-test/post-test control group
- Solomon four-group design

In the experiment design called *static group comparison*, the researcher applies a treatment to one group and does nothing to the other group. When treatment is done, both groups will be measured. When using static group comparison the "differences in outcomes between the two groups could be explained by the treatment. However, if participants were not assigned randomly to the two groups, any difference might be caused by other factors than the treatment."

There are some limitations to experiments. The fact that they are usually performed in some sort of lab can cause participants to change their behavior as this is an unknown and abnormal setting for them. In addition to this, it is considered unethical to deceive the participants of the purpose of the experiment, sometimes leading the participants to behave differently in trying to “help” the researcher by doing it “right”.

Variables When doing an experiment it is important to control the variables. Only the factor that is being manipulated, should change. Other relevant factors, such as information given, participants, and group composition should be kept constant.

Controlling the additional variables is one of the most difficult aspects of experiments. When using groups, for example, it is important that the members are equally balanced; current and previous workplace, education, experience with the technology, gender, age and work status can all affect the group collaboration. It can be easy for one or a few people dominating discussions, especially if they have control, higher status, or other influence over the participants.

Measurement It is important to know beforehand what is to be measured and how to measure it, as well as the success and failure criteria. Oates says: “Good researchers would not [...] draw firm conclusions from experiments until they have been repeated many times by both themselves and other researchers.”

Validity The internal validity, whether the result is due to the hands-on experience and not to another factor, of the experiment can easily be threatened. Oates lists some threats to the internal validity:

- Differences between the experimental and control group. If the groups are different to start with, the difference measured might not be attributable to the manipulation of the experimental group.
- History. Unknown events between pre-test and post-test observations.
- Maturation. The participants change between tests.
- Instrumentation. Defect instruments causing faulty or inaccurate measurements.
- Experimental mortality. Not all participants stay in the experiment for the full length of it.
- Reactivity and experimenter effects. Participants are influenced by the appearance of the experimenter, for example the age, race or sex.

Oates also gives a list of threats to the external validity, the generalizeability, of an experiment:

- Over-reliance on special types of participants.
- Too few participants. This makes it impossible to show that a result is statistically significant.

- Non-representative participants. The participants are not typical for the population that statements will be made about.
- Non-representative test cases.

Interviewing Oates [25] introduces interviewing as a data gathering method that is advantageous when questions are complex, open-ended, sensitive or related to emotions, experience or feelings.

She defines three types of interview, the structured, the semi-structured and the unstructured. When the purpose of the interviews is discovery rather than checking, semi-structured or unstructured interviews are used, as structured interviews limit both the interviewee and interviewer to a pre-defined path. A *structured* interview has pre-defined and identical questions for all interviewees, this is basically like a questionnaire and does not leave room for improvisation in the course of the interview. *Semi-structured* interviews have room for changing the order of questions and go with new aspects that come up during the interview. There are however pre-planned questions and themes that the interviewer wants answered. In an *unstructured* interview there is only an introductory topic, allowing the interviewee talk freely.

Interviewing can be done individually or in groups. It is common in group interviews to have between three and six participants, as this allows for everyone to be heard while still getting the advantage of a group session. Using groups allow different people to interact with each other thus giving room for discussion in which new insights might arise because more varied responses can stimulate the group participants. However, in a group setting there is always a risk that the participants will only express the opinions that are "acceptable" within a group.

There are some things to remember when conducting interviews. The interviewee has to feel comfortable in order to be able to give the best input. This comfort-level can depend on several factors: the location of the interview, the impression of the interviewer, the level of preparation by the interviewer, the seating arrangement (all participants should be visible to each other) and the participant status (they should be of similar work status).

Prototyping A user test can be used as an experiment. In this case it is usually to test the performance of users with for example different user interfaces. There has to be a clear goal and the tasks for the participants should be thought of beforehand. It is also common to use a prototype.

A prototype or a mock-up can be everything from a cardboard "screen" to a fully functioning product, depending on the stage of design and the purpose of the user test. It can demonstrate the look, the structure, the idea behind, and other central points of a product.

Pelle Ehn [18] states in his 1992 paper about prototyping that "[Mock-ups] encourage "hands-on experience" hence user involvement beyond the detached reflection that traditional system description allow". A mock-up can show aspects of a product other than for example a specification, and allows users to try for themselves how it will work thereby making users more inspired and enthusiastic to convey opinions. Ehn does not eliminate the importance of detached reflection, he only encourages the use of mock-ups in order to gain even more knowledge.

Observation Generally, both focus groups and one-to-one interviews are quite laborious to transcribe. It is recommended to audio or video record sessions in order to be able to focus on the role as interviewer. However, in a group setting for example, the transcribing can be too time-consuming and it is advised to include a second researcher as a note taker in order to record the group interview.

Data analysis Research can end in two types of data: quantitative and qualitative. Quantitative data is all that is based on numbers. This incorporates all that is countable and that one can use statistical methods on in order to analyze and interpret. Experiments mainly produce some sort of quantitative data.

Qualitative data is non-numerical data, such as words, images and sounds. This data can be difficult to analyze as the interpretation can be different form one researcher to another. Oates states that "most qualitative data analysis involves abstracting from the research data the verbal, visual or aural themes and patterns that you think are important to your research topic", giving the researcher's identity, background, assumptions and beliefs a great significance. Conclusions from such data is therefore more tentative.

3.2 Research Design

In the following we will outline the research design for the research questions presented in Section 1.2. All three research questions will base themselves on the same experiment design. We give a thorough description of this design in relation to the first research question, explaining in the subsequent sections how the other research questions also find their answer using this design.

3.2.1 Research Question 1

What is the added value of giving users hands-on experience with new technological possibilities?

In order to correctly create an experiment, we have derived a hypothesis from this research question. Our hypothesis is that *a workshop with hands-*

on experience is more valuable for idea-generating than simply a theoretical presentation.

To test this we will use the research design called static group analysis. The "treatment" one of the groups will receive is hands-on experience with a demonstrator that we will construct. When the treatment has been given to one of the group, both groups will be measured. The measurement is done by counting and analyzing the ideas each group come up with. A higher number of ideas will signify a better method used to introduce the concepts.

In addition to this we will to a qualitative analysis of the workshops in order to find out if there is other value to hands-on experience as well.

Our project falls within the COSTT-project, and for their benefit, an additional goal is to get some new ideas and thoughts on how location technology can be used at the hospital.

Participant design We will be using two small groups with three participants in each. We have chosen group interviewing as our main data gathering method, and it is favorable to use small groups. We also have a limitation to the number of participants in that there is a limit to the number of people we can gather from St. Olavs University Hospital.

Our reason for using groups rather than individuals is in part because the technologies are focused on interaction and cooperation; it is therefore beneficial to let them interact with each other. The other reason is that we want the idea generation to be a discussion, letting the participants be inspired by each other. Due to the blocking effect hearing sound ideas[26], we should give participants some time alone first to gather their own initial ideas.

Variables There are variables within the experiment that are difficult to control; we do not choose the participants ourselves and rely on the participants chosen to be rather equal in current workplace, experience with technology and work status, which we consider to be the most important characteristics in our participants. Through random allocation of the participants to the groups we will ensure that the groups are relatively equal and that the members of each group are equally balanced.

We will ensure that information given will be the same through reviewing the video recording from the first workshop before doing the second workshop.

Validity In the previous section we listed some of the threats to the internal validity. The most relevant threats to our experiment are *differences between the experimental and control group* and *reactivity and experimenter effects*. We believe we are threatened by the experimenter effects depending on the participants we have. Some people might have problems admitting ignorance and asking questions to two such young girls, they might perceive this as showing weakness. The external validity can be threatened by *too few participants* and *non-representative participants*.

Observation We will both be facilitating the workshops and will therefore rely solely on video recordings of the sessions in order to fully focus on our roles. We will not do a full transcription, however giving a thorough description of the results of the workshop in Chapter 7.

3.2.2 Research Question 2

What is the added value of using abstract concept when introducing new technological possibilities?

We have chosen to present concepts of a new technology abstractly. Our theory is that abstract concepts will be inspiring and explanatory, yet not limiting the users in their thought processes and not blocking innovative ideas.

In order to answer our research question we will do a qualitative analysis of the data from the workshop. We are interested in finding out to what extent they are able to move directly from abstract concepts to domain-specific or concrete examples.

We will look at the video recordings from the workshop, analyzing the comments, actions and questions from the participants. Through this observation we aim to find the added value of using abstract concepts.

3.2.3 Research Question 3

What recommendations would we make for introducing new technological possibilities?

Our final research question will answered based on our observations and analysis of the two previous research questions. We will end up with some recommendations and perhaps a new suggested method for introducing technologies to users.

Chapter 4

Demonstrator: Functional Description

In this and the subsequent chapter we give a description of the demonstrator we will be using to give the participants in our experiment hands-on experience. It will demonstrate in an abstract way different concepts or location technology.

The abstract concepts, their purpose and how they will be shown to the participants in the workshops is explained in Chapter 6.

This is done by letting the participants move around in an area with installed location technologies. They will move through zones being detected through background or foreground activity, each detection giving some feedback.

The detection, which is described in Section 4.1, can be done automatically, as a *background* activity, when the participant is wearing an automatic detection tag, or as a *foreground* activity where the participants need to move another type of tag close to a reader on the wall in each zone. The feedback is provided through colored lightbulbs installed in each zone or by visualization on monitors located in the demonstration space, all explained in Section 4.2.

The demonstration space is divided into three distinct zones: one red, one green and one blue, see Figure 4.1. In each zone there is a lightbulb of the same color and a reader used by the non-automatic detection. In addition one might say there is a fourth zone, the upper left room in Figure 4.1. Moving into this space has the same effect as moving out of the whole demonstrator space, but will probably feel like a zone for the participants. One of the monitors is also located here. It could be regarded as a “control room”.

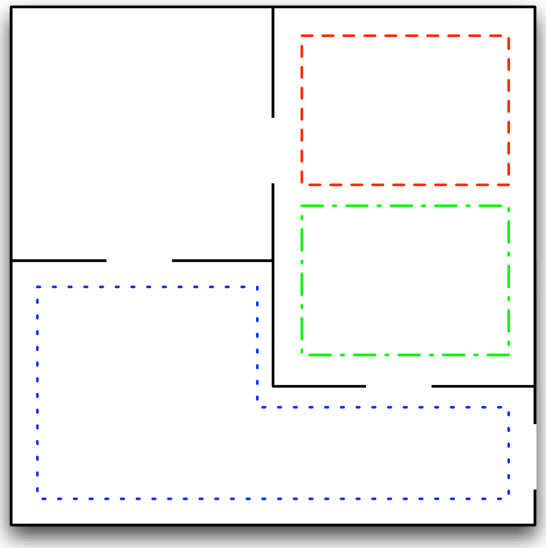

Figure 4.1: A simple representation of the zones

Figure 4.2: Pictures highlighting the automatic tag, green lightbulb and non-automatic reader (left), and the non-automatic tag and reader (right)

.

4.1 Detection

The participants are handed out a set of tags, one for the automatic detection and one for the non-automatic detection. In Figure 4.2 the person is holding a tag for automatic detection in the left picture and doing the action needed for non-automatic detection in the picture to the right. The last detection of either tag is regarded as the participant present location. In other words the system sees these two tags as one and the same, and use it to identify one participant. The tags in a tag-set should therefore not be shared between participants, and the tag-set is identified visually by having the same icon depicted on both tags.

If both detection systems are on, the automatic detection will overshadow the non-automatic system. It is not necessary for the participant to manually register his or hers presence in the zone when this is already done using automatic detection. It is however possible to turn the automatic detection system on and off during the demonstration. The participant can also choose to bring only the non-automatic systems tag into the demonstration space.

4.2 Feedback

The feedback we have devised can be divided into two distinct types: the localized feedback on a zone level and the feedback on the status of the whole demonstrator. For the first type we used the lightbulbs hanging in each zone and for the second type we used screens located in the demonstrator space. The back of one of the monitors is seen in Figure 4.2

Two screen-based outputs were made, one from the zones' perspective and one from the participants' perspective. The first is a simple mapping where the zones are displayed as colored sections. The participants are depicted by their icons in the colored section corresponding to the current zone of the participant, as shown in Figure 4.3.

The other screen-based output shows the location of participants from the participants' perspective, incorporating the history of the participants. It displays a participant's current zone in addition to the previously visited zones. The icon of the participant is shown at the top of the display, and each participant's column fills with colored stripes as he or she moves from zone to zone. The color of the present zone of the participant fills the remaining space in the column, see Figure 4.4). In the screenshot all the participants are outside the demonstrator space and therefore the columns are not fully colored.

The localized feedback uses, as stated, the colored lightbulbs hanging in each zone, as seen in Figure 4.2. In the demonstrators simplest version the lights will be -ON- whenever there is a participant in the zone, and -OFF-

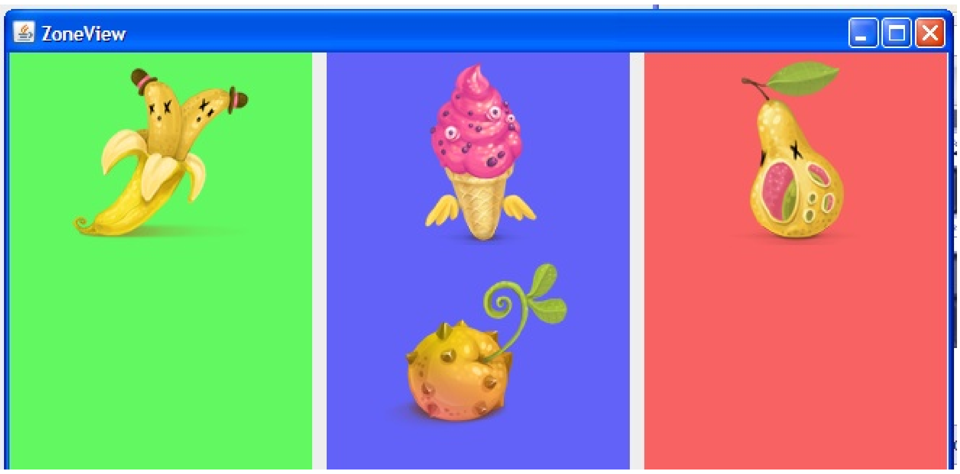

Figure 4.3: The ZoneView Screen

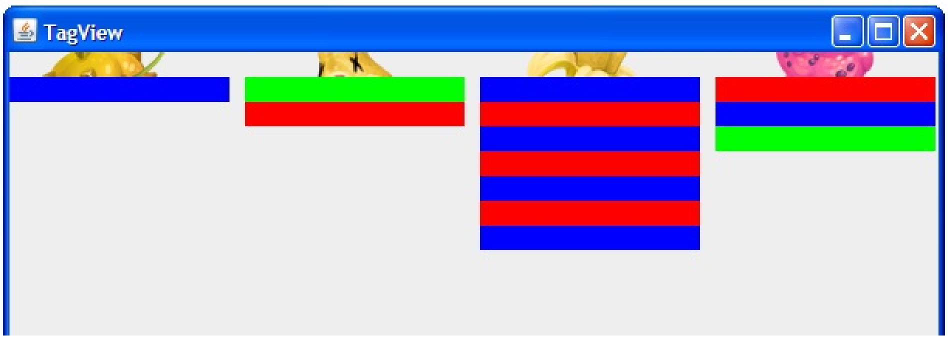

Figure 4.4: The TagView Screen

when there are no participants in the zone. More complicated conditions can be made and in our demonstrator we have the possibility to choose between three separate conditions for the light to be -ON-;

1. One or more participant(s) are located in the zone.
2. Two or more participants are located in the zone.
3. One or more *activated* participant(s) are located in the zone.

The second condition is much like the first, but the light will not turn on until there are at least two participants in the room.

The last condition brings in a concept that we have called participant activation. For a participant to be activated he or she has to let the non-automatic detection tag be read by the activation reader, and it can be deactivated again by the deactivation reader. For all feedbacks other than this last one, the concept of activation is irrelevant. For the last case there might be many people in the zone, but it takes an activated participant to turn the light on. Whether a participant is activated or deactivated is not visualized in any way, this has to be tested and experienced by the participant.

Chapter 5

Demonstrator: Technical Description

This chapter describes the technical sides of the demonstrator, and some of the technical choices we have made. An overview of the equipment used is given in Section 5.1 and we will briefly touch upon our experience with the different frameworks in Section 5.2. An overview of the software architecture will be given in Section 5.3.

5.1 Equipment

For the demonstration we used the usability lab at the Norwegian EHR Research Centre (NSEP). The Sonitor[8] ultrasound location system was set up at the lab for the larger COSTT project, and we were able to use this for the automatic detection of participants as described in Section 4.1. For the non-automatic detection, activation/deactivation of participants and the light-control module (also described in Section 4.1), we used components from Phidgets[7].

In this chapter we have chosen not to focus on the workings of RFID and USID, for more on these technologies we refer back to the pre-study, Section 2.6

As described in Section 4.1 we handle the integration between Sonitor and Phidget technology by letting the system perceive one tag from each technology as the same participant. How this is solved by software is described in more detail in Section 5.3.

An overview of the setup of the equipment is shown in Figure 5.1, and each component is described below.

PhidgetRFID An RFID reader from Phidget that can read EM 4102 protocol RFID tags.

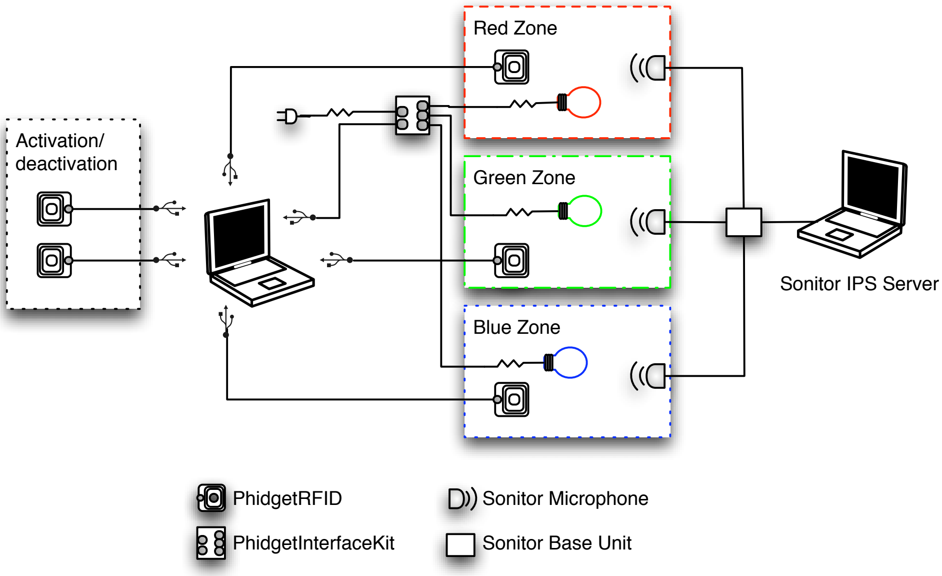

Figure 5.1: The setup of the equipment

PhidgetInterfaceKit A PhidgetInterfaceKit 0/0/4 that is able to power higher voltage outputs like our light bulbs.

Sonitor Microphone An ultrasound microphone that can hear (only) Sonitor tags.

Sonitor Base Unit Collects all signals from microphones and forwards in a comprehensible format to the server.

Sonitor IPS Server Collects the input from the microphone and figures out which Sonitor-zone the Sonitor tag is currently in.

5.1.1 The Lights

To operate the lights a PhidgetInterfaceKit 0/0/4 is used. Each lightbulb is connected to a separate relay on the interface kit, and the lights are turned on and off by the circuit opening and closing. The interface kit is connected both to an external power source, and to a computer via USB.

5.1.2 Activation/Deactivation

The activation/deactivation station, seen in Figure 5.1, is made by two PhidgetRFIDs, one for activation and one for deactivation. This makes activation/deactivation only work with the RFID tags, but will of course affect the tag-set, i.e. the participant. The PhidgetRFIDs can be connected to different computers, but in our case we connect them to the same computer.

5.1.3 The Zones

As seen in Figure 5.1 there is a red, green and blue zone and each zone has a PhidgetRFID for the non-automatic localization of participants. These readers can be connected to several computers, but are in our case connected to one (the same computer as for the activation/deactivation above). A participant will be regarded as located in the zone as long as the RFID tag is within detection range of the reader.

For the automatic localization of the participant the Sonitor system was installed, and microphones places around the demonstrator space. In Figure 5.1 we present is as if there is only one microphone in each zone. This is not always the case and for some zones in our system we combined two or more Sonitor-zones, meaning that there is more than one receiver in the zone. This is solved by software and is described in more detail in Section 5.3.

5.1.4 The computer(s)

Each USB device can be connected to a different computer and this is practical in the case of a large room or separate rooms. These computers will need to be connected by a TCP/IP network, so that the devices can communicate with the *main* computer, which is the one connected to the lights. This computer must be able to communicate with Sonitor Server in the same way. The computers do not need to be connected to the Internet, although it is not a problem if they are.

The computers need to have enough USB ports for the devices that are to be connected. If there is a need to use an RFID hub it is important to use one with an external power source. We have experienced that the PhidgetRFIDs become very unreliable when the power runs low per device. The readers do not give any indication that there is a problem, they only start to randomly not notice tags.

5.2 Frameworks

When developing the demonstrator we used hardware needing special frameworks that are not common to regular development projects. Here we will give a short introduction to each and give our general impression of them. The Phidget framework is described in Section 5.2.1 and Sonitor in Section 5.2.2.

5.2.1 Phidgets

In the demonstrator we used PhidgetRFID and PhidgetInterfaceKit 0/0/4 from Phidgets Inc., but we have played around with other components as well in another project. All of the phidgets we have tried worked easily out of the box, and they could be tested with the Phidget21Management program for the Windows operating system. Phidget21Management is a graphical user interface and is included when you download the Phidget framework for Windows. Frameworks[1] for all the major operating systems exist and are available in most programming languages.

The framework is simple to install. Follow the directions and everything needed for testing and development is installed. Remember to make a note of where the libraries are installed, so you can easily reference them when developing.

We found it very encouraging to use and play with the phidgets. The framework was easy to get an overview of, and using it in the development of the demonstrator was painless. The hardware is really plug-and-play, one plugs in the USB cable and it works - just as promised. The available framework downloads include example files and these are recommended to play with for a quick introduction.

5.2.2 Sonitor

The physical implementation of the technology was done by a company representative, and Sonitor-zones where set up in an administrative interface by the people at NSEP. The zones can be changed, but the microphones are firmly attached to the ceiling so it is not as prototype-friendly as the Phidgets. Sonitor is however not meant for prototyping, but is a technical solution already implemented in hospitals.

It is possible to divide one room into several zones, as described in Section 2.6.2, but this was not working as promised. When leaving a tag in one place in the largest room consisting of supposedly three distinct Sonitor-zones the position changed throughout the night. The special microphone designed to "hear" smaller areas worked and we were able to divide the top right room into two separate zones, the red and green zones, as can be seen in Figure 4.1.

Andreas Dypvik Landmark at NSEP looked at the example client and modified it to filter out other messages than tag detections, and this is the client we ended up modifying slightly so it calls the methods in our core system when tags are detected. Sonitor has its own textbased protocol, which is not based on xml. We found it hard to get an instant overview of this, but were able to make the necessary changes what we needed in the code Andreas gave us.

[1] Downloadable from `http://www.phidgets.com/downloads_sections.php`.

5.3 Software Architecture

From the start we needed to make a modular system, since we did not know exactly which location technologies we wanted to use and what concepts we wanted to demonstrate. The end system consists of a core system as explained in Section 5.3.1, that any location technology (see Section 5.3.2) can connect to, and where one can make any feedback (see Section 5.3.3) based on the movement of participants or object.

5.3.1 Core System

The core system is centered around the concept of `TrackableOjects` and `Zones`, as seen in Figure 5.2. A `TrackableObject` could be any physical object, but in the way we use the demonstrator the `TrackableObjects` are synonymous to participants. The core system's main focus is to keep track of the `TrackableObjects`' locations at all times. This is solved by letting the `TrackableObject` store this information by containing a list of all the `Zones` it has visited, with the last `Zone` in the list being its current location.

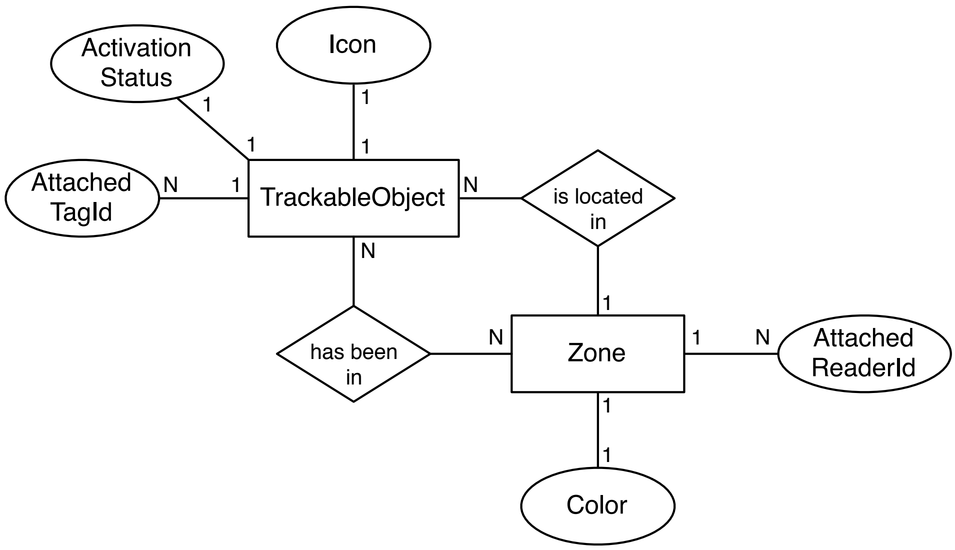

Figure 5.2: The core system's entities

We choose to use the `TrackableObject` as the main component since the focus of the demonstrator is the physical objects and their location, in our case the participants. This choice makes it very easy to get the status of a `TrackableObject`, one only needs to ask for the list of `Zones`. The same is not true for a `Zone` where the system has to run through all the `TrackableObjects` to get the complete picture. This is not a large problem however; in a prototyping environment there will always be a limited number of TrackableObjects.

In addition to the list of Zones the TrackableObject contains information about its activation status, its icon and its attached tags. The attached tags are explained in more detail in Section 5.3.2.

The Zones are much simpler, a Zone only has information about its color and what reader ids point to it. More about the reader ids in Section 5.3.2.

To keep the system lightweight and easy to deploy there is no persistence layer; the zones and an initial set of TrackableObjects are set in the configuration file. There is support for adding new Zones and TrackableObjects runtime in the system, but for the working demonstrator only new TrackableObjects are added when introduced through one of the location technologies.

The core system consists of an interface for the location technologies, as explained in Section 5.3.2, and an interface for the feedbacks made, as explained in Section 5.3.3.

5.3.2 Location Technologies

Any location system can be used with the core system, as long as an adapter is made to call the core system's location technology interface (described later in this section). We used the Sonitor system and PhidgetRFID components as location technologies and they were easily adapted to the interface. The Sonitor system came with an example client that was modified to call the core system's interface. The PhidgetRFID came with example code that was used to make an adaptor calling our core system.

The integration between the different technologies are solved by using several ids to address a Zone or a TrackableObject. One or more tags from different technologies are used to identify a TrackableObject, so we let the id of each tag point to the same TrackableObject. By doing this the location technologies do not need to know anything about what TrackableObject a tag is representing, this is handled by the Core System.

The principle is the same for Zones. In the case of PhidgetRFID we use the id of the reader to identify a zone; one could choose to have many readers in a Zone. In the case of Sonitor the system works differently; Sonitor centralizes the information from its receivers and figures out what Sonitor-zone the tag is in, we use the Sonitor-zones' ids.

The setup of ids is done through the configuration file. This makes a dynamic system where the demonstrator space can be changed to suit different needs by changing the ideas around. Color of the Zone and icon of the TrackableObject can also be changed in the configuration file.

Our demonstrator was set up as in Figure 5.3 and the configuration file then includes the information:

```
numberOfZones: 3
zone0: RED ZONE, sonitora, rfidx
```

```
zone0.color: 255, 0, 0
zone1: GREEN ZONE, sonitorb, rfidy
zone1.color: 0, 255, 0
zone2: BLUE ZONE, sonitorc, sonitord, rfidz
zone2.color: 0, 0, 255
```

This will give us a red, green and blue zone with one PhidgetRFID reader and one (or more) Sonitor-zone(s) for each `Zone`.

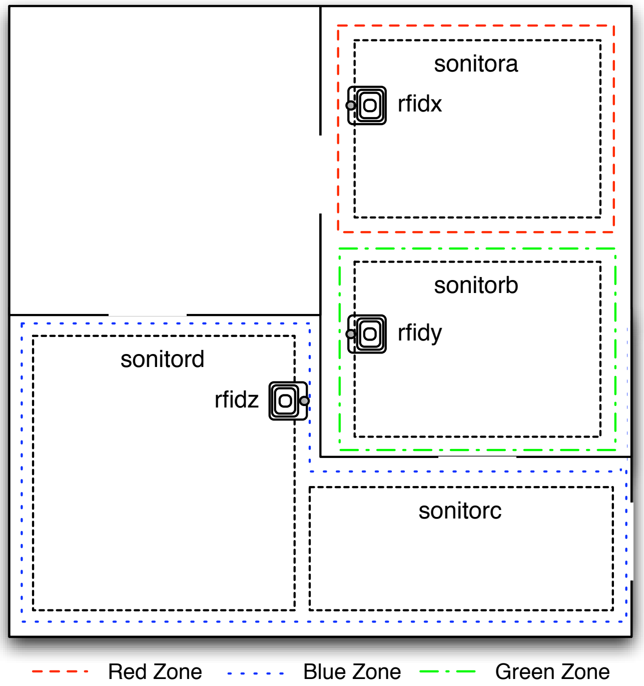

Figure 5.3: The demonstrator space as we set it up.

The core system interface used by the location technologies consists of the methods below. If we continue with the demonstrator space as set up in Figure 5.3 the Sonitor client would call `tagGained` with the id of the tag and `readerId` equal to the Sonitor-zone the tag is in, for instance "sonitorc". The tag will then be registered as in the blue-zone.

tagGained(String tagId, String readerId) The tag with id `tagId` was detected by the reader with id `readerId`.

tagLost(String tagId, String readerId) The tag with id `tagIs` is no longer in reader with id `readerId`.

tagActivated(String tagId) The tag with id was activated

tagDeactivated(String tagId) The tag with id was deactivated

The last two methods are used for the activation or deactivation of `TrackableObjects` described in the last part of Section 4.2.

5.3.3 Feedbacks

Feedbacks are made by subscribing to events fired by the `TrackableObjects`, and the events are:

trackableObjectAdded(TrackableObject object) A new `TrackableObject` was added to the system.

trackableObjectMoved(TrackableObject object) The `TrackableObject` object has moved to a new `Zone`.

One can get more information by asking the `TrackableObject`. Information available includes Sonitor zone names and RFID reader id, shown in Figure 5.2. Using this information we made the feedbacks described in Section 4.2.

Chapter 6

Workshops

This chapter explains how we planned to execute the workshops, detailing the sequence of events and how it allows us to test our hypothesis. The first section gives an overview of the workshops, while the next few sections give more depth to some parts. In Section 6.3 we discuss the importance of participant selection.

6.1 Procedure

We have made a structure we will use for both workshops since it is important that the two workshops are as equal as possible. Tuva will lead both workshops to make them as similar as possible, while Benedicte will be there as a technical assistant in the first workshop.

Introduction The introduction is both of ourselves and the workshop itinerary, letting the participants at ease about the reason for, way through and goal of their presence.

Questions The first step of the workshop will be to map the participants current knowledge and experience with location technologies. Previous use and thoughts is a part of the characterization of the participants as explained in 6.3, which is an important variable in our experiment and therefore essential to map out.

Presentation/Demonstration Here we will present the technological possibilities and concept we have decided to introduce to the participants, as explained in 6.2. Workshop 1 will get a theoretical presentation and the participants will explore the demonstrator, while Workshop 2 will only get a theoretical presentation.

Post-it session After the presentation post-it notes will be handed out. This is a simple and informal opportunity for the participants to draft down their initial thoughts and ideas for themselves. As mentioned in the creativity section of the pre-study, Section 2.3, people are prone to be caught up in the first ideas they hear and are then not able to think past this to other ideas. The plan is therefore to give them 5-10 minutes to write down their thoughts on post-its before presenting them to the rest of the group. This will also help them remember their ideas during discussion.

Discussion As a result of the post-it session we hope to get a fruitful discussion based on the initial ideas. We will give each participant the opportunity to present each post-it note and attach it to the board to keep it visible. By discussing the initial ideas the concepts will mature, and hopefully bring about new and more complex scenarios or ideas.

The goal is to have the discussion end up with several situations or scenarios where the technologies at hand could be used.

Brainstorming: "This involves all participants in the design pooling ideas. This is informal and relatively unstructured although the process tends to involve 'on-the-fly' structuring of the ideas as they materialize. All information is recorded without judgment. The session provides a range of ideas from which to work. These can be filtered using other techniques."[10]

Closing Finally we plan to summarize the discussion, making sure we have thoroughly gone through all the post-it notes and giving the participants a chance to add any last-minute comments on these or other ideas.

6.2 Presentation and Demonstrator

We decided to base the presentation of the technical possibilities around four abstract concepts that we have named presence, tracking, trajectory and state changing. We have chosen to present the concepts in an abstract manner because we believe this will expand the participants' creativity. We hope they will be able to combine the different concepts with more ease this way. The alternative would be to have the concepts shown in a domain-specific way, where each concept would be shown in a hospital setting. This could be limiting, making it difficult for the participants to see other uses of a concept than the one we demonstrate. Another advantage of making the demonstrator abstract is that it can be reused in other domains without any changes.

The concepts each correspond to a setup of the demonstrator. The points we make using the demonstrator will also be presented to the group that does not get hands-on experience with the demonstrator.

In addition to these concepts we will focus on two more themes. We want the difference between background and foreground interaction methods to be clearly understood. The participants should also understand that we and/or they decide what to do with all the location data; the premisses are not se by the system.

We will be presenting some examples of uses when explaining the concepts, these will not be expressed during the workshops. The examples we present are ideas that we think they could come up with through the interaction with the demonstrator.

Background vs. Foreground These interaction methods are explained in Section 2.5.2, and both of these methodss are interesting in a hospital setting. In some cases it is important with a foreground activity; sometimes it can be necessary for personnel to deliberately register their presence to initiate something. This would be true in the case of sensitive data being displayed on a screen, one would want to make sure nobody else could see the screen. Other cases call for background interaction; it would be counterproductive to ask doctors to explicitly dock in at every room so that nurses would know where to find them when needed. A better choice would be for them to be automatically and passively tracked.

These interaction methods will be introduced theoretically early in the presentation by explaining the difference between the tags (RFID and USID), and how this corresponds to background and foreground interaction. It will also be exemplified through all the concepts, since they will be explained and explored using both RFID and USID. It will be especially emphasized in the first concept: presence.

The concepts The set-ups of the demonstrator is used to exemplify the different concepts. The demonstrator is explained in Chapter 4. The drawing used here are the same we used in the workshops to exemplify the concepts. Both workshops saw these since they were a part of the theoretical presentation.

1. **Presence** This setup is meant to show how the technologies can represent the presence of something or someone. We have chosen to exemplify presence by hanging a lightbulb in each zone that will turn on when a participant is present (either actively using an RFID-tag or passively through the signals of a USID-tag), see Figure 6.1. The light will turn off again whenever they move away from the zone.

   In a hospital setting one could see the possibility of a patient screen changing or some room setting changing according to who is present.

Figure 6.1: Presence Example

2. **Tracking** In this setup we will show how these technologies can track people or equipment. How this tracking information can be used we will not give example of other that displaying where the participants are in the demonstrator space with the ZoneView. How this would be done look with the RFID-tag is shown in Figure 6.2.

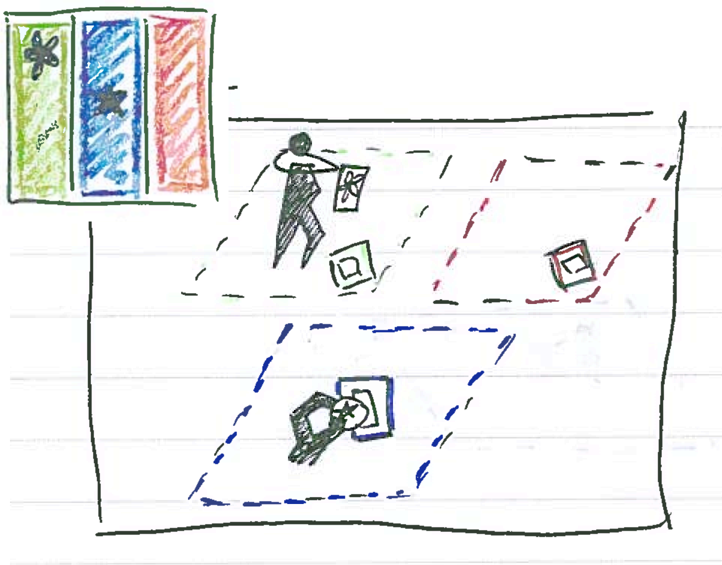

Figure 6.2: Tracking Example

This could ease the workflow of several hospital wards, one could imagine shortening the time for personnel looking for equipment or other personnel.

3. **Trajectory** This setup is meant to show that it is possible to remember

the history of tags or people. Again we will only have a simple representation showing which zones each tag has been in using TagView. A persons trajectory through three zones and the corresponding screen is shown in 6.3

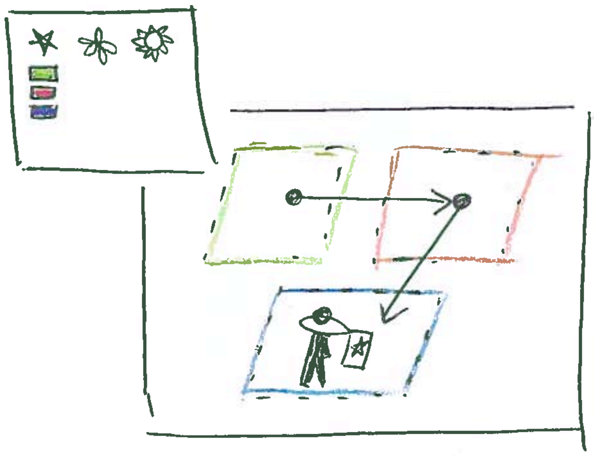

Figure 6.3: Trajectory Example

By remembering where personnel, patients or equipment have been one could plan better in the future, or a nurse can make sure that he or she has visited the patients assigned to her or him.

4. **State Changing** To exemplify that the tags are not static entities, a variation of the first concept, presence, was used. The participants had to "activate" their tag ("themselves") at the activation/deactivation station to be allowed to turn on the light in the zone.

   There are different roles in the hospitals and some actions should in many cases only be allowed by specific personnel, or only allowed after another action. For instance a doctor should not be allowed into the operating theater if he is not scheduled for the operation or if he has not scrubbed in.

Again, it is also important for us to get the participants to understand that we and/or them decide what the localization data is used for. To do this we explained that the only thing actually going into the system is the ID of the tag and the ID of the reader in the zone, and that this information can be coupled with any other data or rules created by us and/or them. We plan to explain this several times during the presentation, to ensure their understanding.

One way we will show this is using a version of presence where there has to be two or more people in the zone for the light to be on. It is exactly like the first concept but shows that the rules can be changed easily.

In the end we will have a set-up where all of the concepts will be shown at the same time. This is to show that they can be used interchangeably. We will have tracking and trajectory shown on the screen, simple presence in one zone, presence of two or more in the second, and state changing in the last zone.

6.3 Participants

The participants will be personnel working at the Operating Room of the Future (FOR). Our supervisors will be recruiting people through the COSTT project and there will be six people in total - three for each group. We would like this to be evenly distributed with one doctor and two nurses in each group as this will make the composition in terms of ranks and roles as comparable as possible. Using group comparison leaves a large part of the results depending on the participants as mentioned in the previous chapter on research method.

When comparing participants several factors play an important role. Current and previous workplace, education, experience with the technology and work status will all affect the group collaboration and the type of ideas our participant will come up with. The participants will all work at the same unit, so they will probably have experienced some of the same types of problems that localization technologies can solve at FOR. They will also have experience from previous units, a difference that can be useful for creativity purposes. However, this can be a source of error if this is not evenly distributed in the two groups. Even so we do believe their present work situation will be more prominent on their minds.

We do not believe the participants will have any significant experience with location technologies, however any elaborate previous experience with this or other technologies can make it difficult to find the source of their ideas. This is why we ask for background knowledge in the beginning of the workshop.

Chapter 7

Results

This chapter will summarize the results of the workshops. The participants, their background and the ideas they came up with will be presented. Quotes have been included and these are our translations of their statements in Norwegian. The ideas are organized by when they were though of, since ideas were not only generated when asked for during the post it session.

Four participants were recruited by our supervisors, two through the COSTT project's collaboration with FOR and two from the research staff at NSEP. The original plan was to have six participants from FOR or other units at the hospital. This did not happen, but we stuck to the original plan of six participants and recruited two medical students to fill the space.

7.1 Workshop 1

The presentation in Workshop 1 included hands-on experience with the demonstrator. The time spent before going into the idea generating phase was 40 minutes, and three possible uses had already been brought up by the participants. The participants then spent 35 minutes on the post-it session and the following discussion. During this time additional 12 possible uses were mentioned and discussed, some going back to the ideas from the presentation part of the workshop.

7.1.1 Participants

We had three participants for the first workshop, all with experience from St. Olavs University Hospital: an experienced male doctor, an experienced female nurse and a young female medical student. We've chosen to anonymize them and will be calling them Doctor 1, Nurse 1 and Student 1, respectively. Doctor 1 has an administrative role in addition to his position as doctor at

FOR. He is involved in and interested in the COSTT-project and the introduction of location technologies at the hospital. Nurse 1 also has an administrative role in addition to her position as a nurse at FOR. Student 1 is in her third year of medical school. She spends time weekly at miscellaneous clinical wards at the hospital, since the medical school in Trondheim focuses on practical learning.

7.1.2 Background

We asked what they knew of location technologies, mentioning GPS, ultrasound, wifi-triangulation and cellphone tracking. Student 1 immediately said "I don't know anything", later changing her answer to say that she *had* heard of GPS, however not in the hospital context when we asked explicitly. Doctor 1 stated that most people are "starting to get a sort of relation to the usual GPS-technology", however continuing to say that he thought using this kind of technology to track things inside hospitals is still a rather distant thought. He also said that he thought this kind of technology has its mission in the bigger picture, especially when focusing on improvements in logistics this type of tool would be important. And in that sense he thinks "it is important to create an understanding for this from the very start for the users who will meet it." Nurse 1 had heard that it was possible to attach chips on equipment and such at hospitals for logistical purposes. She knew of GPS use, but not in hospitals.

7.1.3 Uses mentioned during hands-on

These are the ideas mention or thought out loud when the participant were allowed to explore the demonstrator. Some pictures from the participants exploration is seen in Figure 7.1.

House arrest Student 1 asked if this could be used for imprisonment as well. Imprisonment in the way of not allowing people outside a specific zone, and that some kind of action is taken if that happens.

Cleaning personnel Nurse 1 did not want to walk and check if a specific operation room is ready, since these are not co-located and the distances might be substantial. She would like to "see" (where she was) if all cleaning personnel has left the specific operation room, since this indicated that the room was ready. This idea came after us mentioning identification of groups and asking if the flower icon could be cleaning personnel.

Equipment location For Doctor 1 this is one of the major advantages of the Sonitor equipment. He has visited Rikshospitalet University Hospital in Oslo and seen how they track their equipment. This is especially useful for the movable equipment that are low in volume. At Rikshospitalet they knew where the equipment was at all times and could locate it.

Figure 7.1: Left: Looking at the screen to see their location. Middle: Doctor 1 at activation station. Right: Trying out the RFID-reader.

7.1.4 Initial written post-it ideas

When the presentation and demonstration was over the participants were asked to write down ideas on post-its and the ideas below is what they came up with. A picture from the post-it session can be seen in 7.2

Figure 7.2: Picture from post-it session.

Parking flow Doctor 1 mentioned there is a problem finding parking spots for visiting patients. They show up early and still they miss their appointment due to parking problems. Doctor 1 refers to a visit to Yonsei University Hospital in Seoul, South Korea, where he was amazed at their system. He explained that when given an appointment at the policlinic for an examination or control, you were also given a tag. When you came to the hospital's parking garage on the day of your appointment, you could swipe this tag and it would assign you a parking space. When you have parked, the doctor is notified of you arrival and this gives the doctor time to prepare. From the parking garage the patient is in addition guided electronically to the correct floor and the correct office through the use of the tag. The tag was also linked to the patient's cellphone. Doctor 1 was amazed of how well this system worked, and how he would have liked to have something similar, in smaler scale for St. Olavs.

Equipment tracking This was the suggestion of Doctor 1 from the hands-on session that he wrote on a post-it for this part of the workshop. When asked, Nurse 1 explained that they use a lot of time to search for units that there are few of.

Register hospital clothes in/out Student 1 explained that the system for loaning hospital clothes is now that you use your ID card to open the closet. She wasn't sure, but thought that there must some loss of hospital clothes, so if each piece of clothing you grabbed with you was registered, you could be given notice once a month or year telling you what you've collected.

Patient cards Nurse 1 thought of giving an RFID-card to the patients. They could then register when they were in a room, for example the x-ray room, and find out how much time you need to calculate for them to be done.

Sterile/ non-sterile equipment Nurse 1 said that they sometimes were missing (sterile) equipment for an operation and then had to wait to operate until there is available equipment. She was not entirely sure how this was to be done, suggested attaching tags to the carts the equipment is transfered in (as she doubted the tags could handle the heat when sterilized) so she could locate them.

Logistics - trace workflow Doctor 1 explained that they've already started to some videotape operations in order to see the workflow (use of time and work methods) in different contexts, and felt that this technology that he had seen would be a good supplement.

Personnel Tracking This is a repeat and expansion of what Nurse 1 mentioned during the demonstration. She mentions workflow and location of people in general. Nurse 1 has also worked on the project where they videotaped as mentioned above.

Medicine flow Doctor 1 is here thinking of the flow of medicines from the medicine room and out to patients. Sometimes, rarely, medicine is lost on this en route due to disloyal personnel. He compares this to retail where groceries are tracked in to the store and all the way out again, and they have full control of the stock. He doesn't have a clear view of how one would trace for example a morphine pill - however he was confident there would be a solution to this.

7.1.5 Ideas from discussion

A discussion followed the initial post it sessions, and the ideas that came up during this discussion are presented here.

Patient care Student 1 has worked at nursing homes and said that patient care can be very hectic. If all the caretakers would register where they'd been, one could see which floors were not done and caretakers on floors that were quickly done could go help out those who were slow.

Danger of infection Doctor 1 brought up the case of equipment used directly in the patient and how this could be a source of infection. He suggested the equipment be linked to the last treated patient, giving a treatment history one could go back to if a patient was later found to be infected.

Equipment Stock Student 1 started thinking along the lines of what Doctor 1 said about medicine flow, suggesting that equipment closets (with gloves and such) could keep track of their inventory, giving notice if stock is getting close to empty.

The line at X-ray Doctor 1 starts to complain about how there is always at least a two week line for X-rays, without him really understanding why. He doesn't suggest how location technology is supposed to help this, but he probably means that this is also a part of the logistics improvement.

7.1.6 Supplementary comments

When asked whether they found the technologies interesting, Doctor 1 immediately responded, “Absolutely! We have an extreme potential for improvement. It is all about logistics.” Nurse 1 supplemented with “It's not that people work too slow, it's that they don't work smart enough". When asked whether they found it useful to test the technologies, Nurse 1 responded, "It does illustrate better how the technology can work, it gives a clearer picture". Doctor 1 commented that they were given a more pedagogical explanation which gives more understanding, and make "you try to be a little creative". Nurse 1 continued by saying "when she gets back to work she might think; that would be smart", she believes she'll see more possibilities.

7.2 Workshop 2

The participants in Workshop 2 only got the theoretical presentation and this lasted 10 minutes, and the following idea generating phase lasted for 20 minutes. 15 ideas were mentioned in total, eight from the initial post-its and seven more in the discussion. Some ideas are overlapping and many are based on other ideas.

7.2.1 Participants

In this workshop we had three participants with some connection to St. Olav's hospital; a female nurse, a male doctor and a male medical student. We will hereafter call them Nurse 2, Doctor 2 and Student 2, respectively. Nurse 2 had the most experience with 5 years working as a nurse. She is currently doing her ph.D. at NSEP where we had also had our workshop. Doctor 2 is a recent graduate from medical school and is currently doing research on the COSTT project. Student 2 is a last-year student working twice a week at the hospital waiting to start his internship.

7.2.2 Background

When asked if they'd heard of location technologies they simply replied "no". When probed to find out if they'd heard of for example GPS, they had both heard of it and also nodded that they had used and knew how it worked.

Nurse 2 later said, during discussion, in connection to a discussion on ethics that she had read a story in the media about nursing home patients and tracking of them, concluding that "people know about the technology in connection to tracking" and emphasizing the importance of the ethical issues.

7.2.3 Initial written post-it ideas

When the presentation was over, the participants were given time to themselves to write down on post-it notes the things they thought of. Pictures from the post-it session can be seen in 7.3

Figure 7.3: Picture from post-it session.

Locate patient Claiming he starts with the simple cases, Doctor 2 suggests location of patients, explaining that it is sometimes a problem knowing where a patient is.

Locate colleague Doctor 2 also suggests finding where a colleague is at the moment together with above.

Estimated location of colleague Doctor 2 suggests looking at current location and history of a colleague to estimate where one could find the colleague in x minutes. For example if he has been to the policlinic and is now in the operating room, he'll probably be in his office afterwards.

Location of equipment Doctor 2 here means the expensive and mobile equipment that is not always in its proper location. It would be useful to be able to see where it is when it is not located in its proper place.

Room status Doctor 2 mentions that room coordination could be done easier. One could look at the sum of people in a room and the time they have spent there. He exemplifies by saying that if a doctor and a patient has been in a room for an hour they're likely to soon be done, compared to if they've only been there 10 minutes. In addition, an empty room is most likely available.

Location of personnel Nurse 2 suggests location of both a specific person and also personnel in the same group. She says this will ease the need to search the halls in order to find the correct person, although when given more thought she does show some skepticism towards her own idea saying that it will be difficult to get nurses to wear it, and also that she doesn't really find it necessary because "everyone" carries cellphones anyways so this is usually not a problem. She does mention that it might be useful if the doctors where tracked, especially the doctor on call who might be operating.

Location of equipment Nurse 2 has also written down the location of equipment there is few of in a ward, giving the examples of blood pressure and blood sugar devices.

Patient care After confirmation that "the system" can report whether someone has not been registered in a room over a certain period of time, Student 2 suggests that is could tell when a patient needs to be visited. He explained that some seriously ill patients need attention at given time intervals, for example two hours. This system could register when someone was in the room, and give notice if no-one has been to see the patient within the interval.

7.2.4 Ideas from discussion

Below we present the ideas that came up during the discussion following the initial post-it session.

Patient tracking Student 2 mentioned that personnel in the geriatric ward already had started to think of the possibilities of tracking some of the elder patients who suffer from senile dementia for example. He explained that some of the patients had a tendency to wander, and that this could give an alternative to locate them.

House arrest Student 2 comes up with this idea, somewhat similar to Student 1 idea and for him it was closely related to the previous idea. He mentioned that there are patient who are not competent to consent and who are now tied down or locked in because you can not control them. He suggested that they could rather be tracked and so a silent alarm could give notice if a patient wandered of.

Estimate when colleague/patient/room is available Student 2 elaborates on some of the ideas by Doctor 2 given in the initial round of post-its. He explained that it can sometimes be frustrating not knowing which of the doctors to call, not knowing which of them had the most time. As it worked now he just called around hoping someone would answer. If he knew where they were and what they were doing and for how long they had been doing that he could more easily find the proper doctor to call on or even just place himself strategically.

Contagion/ Infection tracking Doctor 2 says that someone, in worst case health personnel, carrying a contagious disease often does not know this themselves. If you tracked who where in contact with each other, then you could find out who had been in contact with these patients or health workers and in that way make sure you treat the most exposed and also maybe limit the number of people to treat.

Patient Status Student 2 elaborates on the first thoughts of locating patients. He would like to know what treatment a patients has had done or what posts a patient has been to.

Bed tracking Following a discussion on tracking patients Nurse 2 suggests tracking the beds instead. That way when operating staff calls to say that they're ready in a half hour, they can track the bed to see how far it has come and then meet the patient in the hallway.

Planning Student 2 explains that he would save time by not having to walk back and forth between the wards he works at. If he knew that a patient needing his time at ward he is currently in (coming back from x-ray for instance) then he could wait there and do the check up needed before going back to his other ward. Today he experiences being called back to one ward shortly after arriving at the other ward he works at.

7.2.5 Supplementary comments

In the informal chat following the workshop, the participants shared that they found the technology and the possibilities interesting and could definitely see how this could be useful in the hospital.

During the discussion, Nurse 2 explained that health personnel already feel pressured on time, and would feel very uncomfortable being tracked because this could make them feel that spending time in the break room would endanger them of cuts in personnel.

Patiens have buttons to push if they need personnel and lay in bed most of the time, so Nurse 1 does not really see the use in tracking patients. She does however say that she understand the use in tracking personnel, but she is skeptical to whether the personnel would be comfortable with being tracked.

Nurse 2 suggests situation based tracking, in this was people do not need to be tracked all the time - only in situation were it is critical.

Chapter 8

Discussion of Method

This chapter is a discussion of the method we chose. It gives our thoughts on some possible sources of error based on the execution of the workshops.

8.1 Group Composition

There were two important aspects when it came to the group composition; how the groups functioned in themselves and how comparable they were. The groups were not as comparable as we anticipated and we did experience some issues regarding the different experience levels within Group 1.

Doctor 1 had significantly more real-life experience with applications of technology than we had anticipated. He had visited both Rikshospitalet University Hospital and Yonsei University Hospital, both with implemented location technology solutions, and therefore knew of many uses for the technology we were presenting. In addition it appeared he has a vested interest in the COSTT project and he quickly assumed a role of authority, giving a statement about how this type of technology has its mission in the bigger picture. This could have had a negative impact on the other participants in feeling free to voice their opinions and ideas. It also makes it hard to tell which were inspired by our presentation and demonstration, and which were due to his previous experiences.

In Group 2 the doctor is a researcher and a part of the COSTT project and had prior insight into the field we are exploring. He himself said: “I'm slightly prejudiced” when Nurse 2 commented on his rapid production of post-its. This gives us some of the same problems as with Doctor 1, that we do not know where to accredit his ideas, however in Doctor 2's case it is not due to experience but to the reading of theoretical articles.

The two groups are hard to compare with regards to current work situation, which we regarded as one of the most important comparison factors. In Group 1 there was a doctor and a nurse from FOR who work in the hospital every day, while in Group 2 both the doctor and nurse work as researchers at NSEP. In addition, the two participants from FOR have administrative roles with more insight and interest in the optimization of workflow and the need to make improvements in the hospital. The two groups have not been exposed to the same situations, problems or issues, nor to the same extent. The medical students were more comparable, both working at the hospital sporadically. However, we can not compare single participants.

8.2 Research Method

We chose to do a static group comparison. We still feel that this would be a good method to test our hypothesis. It does, however, call for comparable participants randomly assigned to each group. As above explained, we feel that they were not fully comparable. Had we known this prior to the workshops, we might have chosen a different method.

It could have been a good idea to have sent out initial questions on background before starting the workshops. Then we could have chosen to do identical workshops for both groups with a pre- and post-measurement research design. For example give all the participants a theoretical presentation, then a discussion and idea gathering, before a round of demonstration and hands-on experience finishing with a new round of discussion and idea gathering. Then we could assume that all the ideas they had from previous experience would appear after the presentation, and any new ideas after the demonstration could be directly contributed to the hands-on experience. Of course, this method would also have had its possible sources of error, but could have fitted our set of participants better.

8.3 Execution of Workshops

Looking back at the video recordings we realize that both workshops were slightly rushed. This caused the first presentation to end up more technical than planned and this in effect made the second one too technical as well since it had to be comparable to the first. Before going into more detail on that, we have some smaller concerns with seating arrangement and the expectations we expressed to the participants in the introduction. Both groups experienced these flaws and in that regard they do not affect our ability to compare the results.

Seating The room was set with one of us as the presenter and workshop facilitator at a small whiteboard and the participants in a half circle around her so that all could see each other, as recommended by literature. We feel, however, that it would have been profitable and fostered a more creative environment if the participants would have been seated around a table. This would have made it more of a group session and less like a teacher/student setting. When watching the videos we also noticed that the participants are moving around in their chairs, a sign that they are not completely comfortable. Especially Doctor 1, the oldest participant, moved a lot during the presentation.

Expectations In the introduction to the workshop we mention that one purpose for the workshop is to gather ideas for the use of the technologies we are to present. Nonetheless we see in retrospect that this was not clearly enough understood by the participants. It could have been easier for the participants to see new possibilities if they had focused on idea generation throughout the presentation.

Too rushed and technical In retrospect we realize that time probably plays an important role in digesting the concepts, and it is unfortunate that we let the workshops become rushed. One participant in the second workshop even expressed it saying: "You speak very fast and informative!" when the presentation was over. This was also true when doing the practical demonstration, we were too afraid of letting the participants be "bored.". The moments we perceived as boredom could have given the participants a chance to contemplate the concepts and thus helped generate novel ideas. When looking at the video we have also considered that the discussion facilitator's attempt of encouragement might be perceived as impatience, and this could have lead the participants to keep ideas to themselves as to let the discussion move forward faster.

The plan was to focus on the concepts we had chosen and not put too much emphasis on the technology in itself. However, the presentation became more and more focused on the technical details of the demonstrator. Unfortunately this level of detail cluttered the presentation of the abstract concepts and may have made them less comprehensible. This might have had an effect on the participants ability to combine concepts.

Both of these issues were mostly an effect of being inexperienced in holding workshops. We have done similar things throughout our education and for our specialization project, but for all of these the participants have been acquaintances. With external participants from a larger research project, we became more nervous than anticipated. We rushed the workshops partly due to nervousness, but also of fright of wasting "important" people's time. Both of these factors impacted the technological focus, as technical people we feel more comfortable talking about the technical side of things and easily find this more worthy of people's time.

Lesson Learned Looking back we see that we should have had a proper pilot test, as is common. It could have been helpful going through the workshop with some friends, and even more so with our supervisors. This could have helped us gain more confidence in our arrangement and given a clearer focus on our plan, making us less nervous. It could also have exposed the first two issues mentioned, seating and expectations, letting us change it for the "real" workshops. In addition it could have helped getting input from someone skilled in workshops or teaching, or as an extreme case use someone with more experience to actually hold the workshops.

8.4 Our Role

Planning for the workshops, we made sure we knew what we had to say, and what we needed to ask them. However, we did not think thoroughly enough through what our role would be, and what we were *not* going to say. This resulted in us both being somewhat opinionated and in a small way participating in the discussion, rather that simply being facilitators and interviewers. It is also unfortunate that both of us were involved in the first workshop, this is a source of error as the second workshop only has one of us present. We do not feel that our involvement in the discussion played a significant role, as our comments are more of the encouraging, summarizing and repeating type. We tried to structure their ideas and repeat them back – however sometimes slightly "enhancing" their ideas. It would have been better for the sake of the experiment if we kept to the planned information. The way it is now, this is an experiment variable that we did not have full control over. We should have let them structure and elaborate their own ideas, which we are confident they would have done if given some time.

Our role in the workshop should have been as interviewers and facilitators, and we should have refrained from leading questions, hinting and elaborating on their ideas. The participants should not be colored by our thoughts and ideas from reading articles on the subject.

8.5 The Demonstrator

There were some concerns regarding the Sonitor ultrasound technology that had an impact on the way the concepts were exemplified through the demonstrator. The Sonitor zone detection was not as accurate as we anticipated. When standing in one zone the tag would be detected as moving back and forth between zones. We discovered that the tags should be held horizontally to get the best result. In addition the tags sent out signals only every five seconds. In five seconds a participant could have moved quickly through all the zones. This caused us to instruct the users to hold the tags horizontally and hold in a button that make the tags send signals once every second. Because of this we could not attach the RFID tags to the Sonitor ultrasound tags and the integration between the technologies was not as seamless as we had intended. The Sonitor ultrasound technology did not feel as smooth as it should have been for the participants.

This led to a non-optimal demonstration of the interchangeability of background and foreground interaction, which in turn could have led the participants away from combining these two types of interaction. It could have been useful to have had a set-up were the two worked separately at the same time. This could easily have been done, for example with a set-up where a participant's icon appears on screen when he or she walks into the zone, but the lights having to be actively turned on by touching the RFID tag to the reader.

Chapter 9

Analysis

In this chapter we will do a mostly qualitative analysis of the results from the workshops in Chapter 7 in view of the discussion presented in Chapter 8. The ideas generated in the workshops will be revisited in Section 9.1. We will try to organize and categorize the ideas for analytical purposes. Furthermore we look at the research questions from Chapter 1, discussion the value of hands-on experience in Section 9.2, and evaluating our choice of introducing the technological possibilities through abstracts concepts in Section 9.3.

9.1 Findings

In Tables 9.1 and 9.2 we have extracted all the separate ideas from the more loosely narrated results in Chapter 7. The ideas have been reformulated into a common "vocabulary" to better get an overview of the ideas, and to make comparison and categorizing easier.

The word *know*, or conjugations, is in cursive. In most cases the participant just wanted the location information visualized or in some way made available to them; then they would just "know", meaning they would interpret this information themselves. *Calculate* is also in cursive, and is similar to *know*. It seems the participants in these cases were more aware of doing interpretations. Sometimes they hinted for the system to display *calculated* information, like estimated time to completion for a patient at x-ray.

We have also tried to group the ideas into more general categories or themes of ideas in Table 9.3. Locate and status is used several times. The locate-categories contain ideas that are based solely on an object's current location. The ideas combining more types of information, usually to calculate the status of an object, is filed under the status-categories. The status-ideas are often based on an object's history of where, and for how long, in a combination, either with a user's own experience or with some rules defined in a system.

None of the participants came up with ideas using presence to initiate an action, except Doctor 1 who had seen a system at Yonsei University Hospital that notified doctors when patient logged in with some sort of RFID-like tag in the parking garage. The students in each group were able to see the reverse possibility; initiating an action if someone is no longer present in a zone. Student 2 suggested this in a hospital setting for keeping track of people with dementia or those now needing to be tied down.

Both groups also talked about workflow in general and how tracking "everything" would enhance this. This was especially true for Workshop 1 (W1) where there were two people who were familiar with current workflow recording and analysis at FOR, but it did come up in Workshop 2 (W2) as well. In W1 the starting point for discussion was the need to optimize workflow as seen from the administration side. Interestingly the starting point for a large part of the discussion in W2 was ethics and many of the ideas came about to convince Nurse 2 that tracking people's movements can be justified in solving important problems.

Unique ideas from Workshop 1

1. Guide patients from parking to appointment by checking in at stations with RFID tag.
2. Notify doctors of patient arrivals by patient checking in when parking; doctor can then prepare before patient arrives.
3. Find equipment by *knowing* where it is.
4. Home-imprisonment. (Not a hospital case)
5. Remind medical students to return equipment from lockers by registering who took what.
6. *Calculate* completion time for patients on different post based on how long they have been there.
7. *Know* if the equipment needed for surgery is available and sterile.
8. *Know* if operation room is ready based on the cleaning personnel having left the room.
9. *Know* where medicine is lost, based on where and who it has been with on its way to the patient.
10. Help people at other floors in nursing homes by *knowing* which floors are done and which still could need some help.
11. Find source of infection by *knowing* what equipment has been use on an infected patient.
12. Automatically get notified when supplies are low in equipment (gloves etc) lockers.
13. Find personnel when needed in different situations by *knowing* where they are.

Table 9.1: Summary of ideas from workshop 1

Unique ideas from Workshop 2

a. Find patient when needed by *knowing* where they are; could be used with senile dementia that are prone to wander.
b. Find colleague when needed by *knowing* where they are.
c. *Calculate* where a colleague will be in the future, based on past history; can then catch him/her on his/her way somewhere and minimize effect of disruption.
d. Find equipment when needed by *knowing* where they are.
e. *Calculate* room status based on the people in the room and their time there; an empty room will mostly be likely be available.
f. *Know* who has been in contact with an infected person to find the source of the infection and/or who to treat.
g. Automatically notify personnel when a patient has not been seen to in a given time interval (some patients are put on watch).
h. Automatically set off silent alarm when patient (who would otherwise be tied down) leave the allowed premises.
i. *Calculate* status on patients based on where they are and when they are done; the doctor can then plan accordingly.

Table 9.2: Summary of ideas from workshop 2

Category	W1	W2	Concepts
Locate Equipment	3	d	Tracking
Locate Colleague	13	b	Tracking
Locate Patient		a	Tracking
Patient Status	2, 6	i, g	Tracking, Trajectory
Room Status	8	e	Tracking, Trajectory
Personnel Status	10	c	Tracking, Trajectory
Equipment Status	7		Tracking, Trajectory
Infection Tracing	11	f	Tracking, Trajectory
Stock Control	5, 9, 12		Tracking, Trajectory
Guide Patients	1		Tracking, Trajectory, Presence
Imprisonment	4	h	(Anti-) Presence

Table 9.3: Comparison of the result

9.2 The Value of Hands-On Experience

This section will explore our first research question:

What is the value of giving users hands-on experience with new technological possibilities?

If we look at the Tables 9.1 and 9.2 we see that W1, who had hands-on experience, came up with 13 unique ideas, while W2 came up with 9 unique ideas. Looking at Table 9.3, which presents the categories of ideas, we see that W1 is also stronger in terms of generating ideas in multiple categories. W1 has ideas in 11 categories and W2 in eight categories. Seven of the categories are overlapping between the workshops.

The numbers by themselves indicate that hands-on experience is valuable in terms of ideas generated, with W1 having four more unique ideas and three more categories than W2. In view of our discussion, in particular the incomparability of the groups, we do not put much emphasis on these results.

On the other hand we cannot dismiss the value of hands-on experience with the demonstrator. One idea clearly demonstrates the value of hands-on experience. After walking around the demonstrator and intensely looking at the screen, Nurse 1 asked if the flowers (referring to the icons used in the demonstration) could represent cleaning personnel. If that was possible she could know if an operating room was ready by "seeing" that the cleaning personnel had left the room and in this way saving herself the walk. We feel the combination of holding her tag, seeing the icon on the tag, seeing "her" icon on the screen and seeing the other icons moving around was important for her ability to utilize the theory presented; clearly showing the value of hands-on experience in her case.

An aspect of her revelation can also be the time she had to reflect and contemplate on the theoretical concepts presented, by spending time exploring the demonstrator. Is this reflection time an aspect inherent in hands-on experience or can one mimic this in a theoretical presentation?

Nurse 1 also applauded the demonstrator, stating at the end of the workshop that it made her "see possibilities" and gave a "clearer picture [of the technology]". Both Student 1 and Doctor 1 agreed the workshop (including hands-on) could be beneficial when getting back to work and Student 1 stated: "then [while working] maybe one thinks that here is a possibility for something". All three participant seemed eager to go back to work and look for possible uses. This leads us to believe hands-on experience to be a valuable and important factor for motivating users in a user-centered design setting.

9.3 The Value of Abstract Concepts

This section will explore our second research question:

What is the value of using abstract concept when introducing new technological possibilities?

We chose to present the concepts of the technical possibilities in an abstract way. We did not want to limit the participants' creativity and so deliberately chose not to make a domain specific presentation of the concepts. The choice was based on theory of creativity presented in the pre-study; users can be caught up in the first sound ideas they hear. We feared that concrete examples of use would make it hard to see beyond these uses to other and more novel uses.

After seeing the results and looking at the theories of Bonnie Nardi on end-user programming[24], we see that the abstract concepts can just as easily have been limiting them. Nardi explains how users find it difficult to understand and put together unknown and abstract primitives of general programming languages. This relates to our observations; the abstract concepts presented were the unfamiliar primitives in our setting, and the subjects had problems putting these building blocks together.

If we classify the ideas in Tables 9.1 and 9.2 after what concept they belong to we find that only three ideas can be classified as presence ideas; 2, 4 and h. It seems however these ideas were not inspired by our presence-concept. S1 gets the idea when trying out trajectory; S1 after having an idea of using location information to locate senile patients that have wandered off and D1 copied an idea he had seen at another hospital. The remaining ideas are evenly divided between the concepts of tracking and trajectory.

In retrospect we see that the examples are of uneven abstraction. Some of the first ideas were on tracking people which was a direct mapping to make since we had been tracking them; people. Both tracking and trajectory were exemplified through visualization (on a screen or drawn on a whiteboard). We see that most of the ideas generated are based on just making the information available to the user, as described in Section 9.1 when explaining our use of *know* and *calculate* in Table 9.1 and 9.2.

The most abstract concept, presence, was not as easily mapped to their hospital domain. The use of a light turning on/off as an example was supposed to show that one can get an automatic reaction to an object's presence in a room (background activity), or that one get the that reaction by explicitly making ones presence known (foreground activity). However it seems the light was too abstract to be mapped to other reactions like alarms or screens automatically switching on/off.

All of these findings are supported by Nardi's findings. It was easier for the participants to use the "building blocks" closest to their domain, finding many uses for information gathered and visualized, or in some other way made available to them. We now believe one should make many small examples showing a larger range of more concrete possibilities. An important part of this would be to show an example that includes rule-based behavior (the system side). In the hospital case having an alarm go off if the person has not been in the sterilization zone first, showing that it is possible to connect trajectory to for instance presence automatically by the system.

The notion of using domain-specific examples is also somewhat supported by the earlier mentioned fact that the subject D1 of the first workshop had visited both Rikshospitalet and Yonsei University Hospitals, both hospitals that uses modern technologies such as location technology. His previous knowledge and experience with location technologies in hospitals made him able to see similar situations in his own environment at St. Olavs. On the other hand, his ideas were not very creative and most of the ideas were more or less examples from the other hospitals he had visited. So in that manner, his experience with the technologies did limited him somewhat in coming up with new and not fully experienced examples.

Chapter 10

Conclusion

This chapter concludes our work. We sum up the analysis of Chapter 9 by giving our response to the research questions below. Finally we give our thoughts on further work and research on this topic in Section 10.1.

RQ 1: What is the added value of giving users hands-on experience with new technological possibilities?

The quantitative analysis of the workshops showed that the workshop incorporating hands-on experience generated more unique ideas and also ideas in more categories than the other workshop (13 vs 9 ideas and 10 vs 8 categories). However due to low comparability between the groups due to factors such as prior experience with the technologies and current work situation, these findings are not statistically significant.

However, in a user-centered design setting we see the value of hands-on experience with a new technology, especially as a motivator for the users going into a system design process using technology they have no prior experience with. People also have different needs when learning something new and we saw that for one participant the hands-on experience was very helpful; we cannot say we saw that it was negative for the others and therefore we still feel it is a good idea.

RQ 2 What is the added value of using abstract concept when introducing new technological possibilities?

The abstract concept were not as easily mapped to the user's domain as we had anticipated. We did however experience that using concepts, in a way building blocks, was very helpful for generating ideas. The concepts they managed to map into their domain generated many useful ideas, but the users were not as creative as we had expected.

We believe that exemplifying the concepts with many small examples close to the user's domain would be a good way to go; showing them a large range of possibilities, but not locking their ideas to one larger solution. We see some comparison with regular prototyping, if the product seems finished users will not give as much feedback as when the product seems unfinished. If the users get a large example of a system utilizing all the concepts, they might not be able to or not dare to break it into building blocks and reassemble them in a different way.

RQ 3 What recommendations would we make for introducing new technological possibilities?

Given the above observations, we introduce a suggested method for introducing new technologies to non-technical users in a user-centered design process.

1. Presentation of concepts chosen to cover the new technological possibilities.
2. Presentation of many simple and domain-specific examples, preferably through hands-on experience.
3. Individual brainstorming/ idea generation
4. Discussion of ideas, further elaboration
5. Let participants have time to let thoughts mature while being back in relevant situations.
6. Recap of the concepts, examples and a discussion of ideas that may have emerged in Step 5.

Steps 1 and 2 of the method are the main recommendations following the results of our research, and fit well into an early stage of the user-centered design process as a way to introduce technologies and help motivate users.

We used a post-it session and a following group discussion to generate ideas, but our suggested approach is not depended on this. Step 3 and 4 can be replaced with another method for idea generation or scenario building, or a different session all together if requirements gathering is not the purpose of the workshop. We saw for instance an interesting discussion on ethics being started after the introduction in Workshop 2; this could for instance be the purpose of an introduction of technological possibilities.

Step 6 is a follow-up to the work done in 3 and 4, so this would also be changed accordingly. If a hands-on demonstrator is made we believe it would be useful to have it available for point 6 as well. The idea of point 5 and 6 fit well into a user-centered design setting where the users are recommended to be a part of the whole process. Going back to step 6 at regular intervals throughout the whole process could be beneficial to remind people of what the basic concepts were. Some might have gotten lost when larger and more complex ideas have emerged.

Using groups worked well for our workshops, giving fruitful discussions in both cases; we thus keep both the group and workshop form in our suggestion.

In addition we feel that hands-on experience is valuable, but it is possible to use the method described by explaining the examples. If a hands-on demonstrator is used it is valuable to have it available all through the sessions, so the participants can point to and maybe demonstrate their ideas later on. This leads hands-on to first be a separate activity included in the presentation, before being a part of the workshop space.

10.1 Future Work

It would be interesting to evaluate our suggested approach in order to find out whether it would be a better solution. It could also yield new improvements leading to the best way of introducing a new technology to users. Especially some work on what level of abstraction is perceived as abstract by users.

Due to the fact that this experiment was not too conclusive, it would also be interesting to repeat the experiment we have here performed to see if this would give a different result. One could test the effect of a hands-on demonstrator by doing different examples of different types of presentations, but always letting one group get hands-on experience. One could also see if our conclusion of the need to bring the examples closer to the users' domain is valid.

Future work could be done on participants from other domains, leading to some insight if what we have found true for health workers can more generally be applied to other non-technical user groups.

Bibliography

[1] Precision dynamics corporation and hp provide chang gung memorial hospital with rfid system for patient management. HP News, January 2007. http://www.hp.com/hpinfo/newsroom/press/2007/070104a.html?jumpid=reg_R1002_USEN. [Cited on page 16]

[2] Asset tracking helps hospital improve patient care, last accessed May 2009. http://www.assetmgmtnews.com/content/view/581/6/. [Cited on page 17]

[3] Encyclopædia britannica online "creativity", last accessed May 2009. http://search.eb.com/eb/article-9026811. [Cited on page 9]

[4] Encyclopædia britannica online "dewey, john", last accessed May 2009. http://search.eb.com/eb/article-9030186. [Cited on page 7]

[5] Encyclopædia britannica online "piaget, jean", last accessed May 2009. http://search.eb.com/eb/article-9059885. [Cited on page 7]

[6] Oxford english dictionary online, last accessed May 2009. http://dictionary.oed.com/. [Cited on pages 7, 8 and 11]

[7] Phidgets - products for usb sensing and control, last accessed May 2009. http://www.phidgets.com/. [Cited on pages 3 and 31]

[8] Sonitor - high definition ultrasound indoor positioning systems, last accessed May 2009. http://www.sonitor.no. [Cited on page 31]

[9] Wikipedia "creativity", last accessed May 2009. http://en.wikipedia.org/wiki/Creativity. [Cited on page 8]

[10] G. D. Abowd A. J. Dix, J. E. Finlay and R. Beale. *Human-Computer Interaction*. Prentice Hall Europe, 2nd edition, 1998. [Cited on pages 6 and 40]

[11] G. D. Abowd A. K. Dey and D. Salber. A conceptual framework and a toolkit for supporting the rapid prototyping of context-aware applications. *Human-Computer Interaction*, 16:97–166, 2001. [Cited on page 13]

[12] Ole Andreas Alsos and Dag Svanæs. Interaction techniques for using handhelds and pcs together in a clinical setting. In *NordiCHI '06: Proceedings of the 4th Nordic conference on Human-computer interaction*, pages 125–134, New York, NY, USA, 2006. ACM. [Cited on page 12]

[13] Genevieve Bell and Paul Dourish. Yesterday's tomorrows: notes on ubiquitous computing's dominant vision. *Personal Ubiquitous Computing*, 11(2), 2007. [Cited on pages 11, 12 and 13]

[14] Marion Buchenau and Jane Fulton Suri. Experience prototyping. In *DIS '00: Proceedings of the 3rd conference on Designing interactive systems*, pages 424–433, New York, NY, USA, 2000. ACM. [Cited on page 8]

[15] Bill Buxton. Integrating the periphery and context: A new taxonomy of telematics. In *Proceedings of Graphics Interface '95*, 1995. [Cited on page 14]

[16] John Dewey. *Experience and Education : The 60th Anniversary Edition*. Kappa Delta Pi, 1998. First edition published 1938. [Cited on page 7]

[17] Pelle Ehn. Scandinavian design: on participation and skill. *D. Schuler and A. Namioka, editors, Participatory design: principles and practices*, pages 41–78, 1993. [Cited on page 1]

[18] Pelle Ehn and Morten Kyng. Cardboard computers: mocking-it-up or hands-on the future. *J. M. Greenbaum, M. Kyng, editors, Design at work: cooperative design of computer systems*, 1992. [Cited on pages 1, 6 and 22]

[19] Kavi Kumar Khedo. Context-aware systems for mobile and ubiquitous networks. In *ICNICONSMCL '06: Proceedings of the International Conference on Networking, International Conference on Systems and International Conference on Mobile Communications and Learning Technologies*, page 123, Washington, DC, USA, 2006. IEEE Computer Society. [Cited on page 11]

[20] Jeremy Landt. The history of rfid. *IEEE Potentials*, 24(4), 2005. [Cited on page 16]

[21] G. Lewis and G. Olson. Can principles of cognition lower the barriers to programming? *Empirical Studies of Programmers: Second Workshop*, pages 248–263, 1987. [Cited on page 10]

[22] John Locke. *An Essay Concerning Human Understanding*. 1690. [Cited on page 7]

[23] Michael J. Muller. Pictive—an exploration in participatory design. In *CHI '91: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 225–231, New York, NY, USA, 1991. ACM. [Cited on pages 1 and 2]

[24] Bonnie A. Nardi. *A Small Matter of Programming*. The MIT Press, 1993. [Cited on pages 10 and 66]

[25] Briony J. Oates. *Researching Information Systems and Computing*. SAGE Publications Ltd, 2006. [Cited on pages 19 and 21]

[26] Paul B. Paulus and Bernard A. Nijstad. *Group Creativity : Innovation through Collaboration*. Oxford University Press, Inc., 2003. [Cited on pages 9 and 23]

[27] Jenny Preece, Yvonne Rogers, and Helen Sharp. *Interaction Design: beyond human-computer interaction*. John Wiley & Sons, Ltd., 2006. [Cited on pages 1, 5 and 6]

[28] Dag Svanaes and Gry Seland. Putting the users center stage: role playing and low-fi prototyping enable end users to design mobile systems. In *CHI '04: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 479–486, New York, NY, USA, 2004. ACM. [Cited on page 1]

[29] Dag Svanæs. Context-aware technology: A phenomenological perspective. *Human-Computer Interaction*, 16(2), 2001. [Cited on pages 8 and 14]

[30] M. Weiser. The computer for the 21st century. *Scientific American*, 265(3), September 1991. [Cited on page 11]

[31] M. Weiser and J. S. Brown. The coming age of calm technology. *Xerox PARC*, October 1996. This paper is a revised version of: Weiser and Brown. "Designing Calm Technology", PowerGrid Journal 1.01, July 1996. [Cited on pages ix, 11 and 12]

[32] M. Weiser, R. Gold, and J. S. Brown. The origins of ubiquitous computing research at parc in the late 1980s. *IBM System Journal*, 38(4), 1999. [Cited on page 11]