

CREATING AND PERFORMING SCENARIOS FOR MOBILE SERVICES SUPPORTING MOBILE WORK IN EXPOSED PHYSICAL ENVIRONMENTS

Bente Skattør

*AgderUniversity College, Faculty of Engineering and Science, Grooseveien 36, N-4876
Grimstad NORWAY*

Abstract: Scenarios are widely used, explored and discussed in HCI. This paper addresses creating and performing scenarios in exposed physical environments, i.e. at construction sites. In this environment, little or no mobile ICT supports construction workers work. In an iterative design process with a user-centered approach, the project has created and explored ideas concerning actual use of mobile ICT supporting knowledge processes in exposed environment. The design process was based on three steps: workshops, shadowboxing (i.e. using dictaphones and mobile phones in real setting), and prototyping. By focusing and working with work incidents and related scenarios, we obtained the participation and involvement of the construction workers throughout the entire study. During shadowboxing, i.e. exploring by doing, the workers gained first-hand experiences and understanding (reflection-in-actions) of existing and future scenarios. This gave them a basis for mapping out when it was appropriate to use handhelds, and when it was not, and why.

Keywords: scenarios; mobile work; user-centered design; mobile services; reflection-in-action; knowledge processes, Contextual Design.

1. INTRODUCTION

Scenarios are frequently used when designing systems. There are already established approaches like scenario based design (Caroll 2000) and Contextual Design that support the use of information collected from observations to create scenarios (Beyer and Holtzblatt 1998). Often such approaches are used in further changes of existing systems, but they can also

be used in new application areas. One new, exciting area is the use of mobile ICT among mobile workers, or non-office workers, that normally do not depend on ICT to perform their work. Examples of such “non-office” workers are carpenters, electricians, installers, plumbers, ship surveyors, drivers, nurses and home-health carers. Many of the non-office workers have a work situation where they might be exposed to a hard physical work environment, e.g. rough climate, dust and noise.

The use of scenarios related to mobile services is an emerging field that has been applied in various settings. Bødker (1999) uses video to study the work at a combined district heating and power plant. She uses scenarios to support tensions between reflection and actions, between typical and critical, and between plus and minus situations. Binder (1999) suggests videotaping as a way for the electricians in an industrial setting to improvise scenarios with their own design of low-fi artefacts. Brandt and Grunnet (2000) use drama while they explore settings, scenarios and props in their studies of refrigeration technicians in supermarkets and families in their home. Iacucci and Kuutti (2002) create sessions using everyday life as a stage and the opportunity for participants to exercise reflection-in-action. Svanæs and Seland (2004) report workshops where end users were enabled to design mobile systems through scenario building, role playing and low-fidelity prototyping. Some of their workshops were related to nurses in hospitals. Garabet et al. (2002) elaborate on how performance art can be used to elicit information about device design and how art(ifacts) were used to spark behaviour and debate. Newcomb et al. (2003) use scenarios during design and usability testing of a mobile shopping application on a PDA in a shopping environment. Messeter et al. (2004) discuss the use of scenarios regarding implications for the design of mobile IT devices, focusing on coping with multiple social contexts and configuration and connectivity of mobile services.

There are, therefore, several examples of research related to scenarios in different mobile settings. Nonetheless, further research into, and the use of, scenarios in mobile settings are required to meet the challenges posed by this emerging field of mobile technology.

Even though blue-collar workers were some of the first to adopt mobile ICT (Churchill and Munro 2001) there has been a lack of research on blue-collar workers and design and use of mobile ICT (Brodie and Perry 2001). Some exceptions exist and probably the best known is the study by Luff and Heath (1998). This study might be an example of the importance of identifying mobile services that are appropriate to supporting mobile work. They discovered that the system hindered mobile collaboration because the wrong features of mobile work were chosen to be supported (Luff and Heath 1998).

To obtain participation and involvement among the construction workers this research has a user-centred approach. The exploration of their work and its constraints at the construction sites is grounded in an ethnographical approach with use of Contextual Design (Beyer and Holtzblatt 1998). Through the entire iterative design process we have focused on work incidents while creating and performing scenarios. The iterative process was based on workshops, shadowboxing (reflection-in-action) and prototyping.

This paper is organised as follows: Section 2 presents the research design including the research aims and the iterative design process. Section 3 reports on the results. Section 4 evaluates the design process by discussing the scenarios, and section 5 concludes the paper.

2. RESEARCH DESIGN

This research reports on experiences from an ongoing development and research project within industrialized residential construction in Norway. Within this type of manufacturing, ICT support project management and the design process of construction. However, little or no ICT supports the work carried out at the building sites. The physical work environment at the sites is characterised by variation in temperature, humidity, light, noise, dust and dirt. Today approximately 11% of workers in Norway work as craftsmen (Statistics Norway 2004) and workers within industrialized residential construction are part of this group.

This development and research project is in an early design phase and aims to develop mobile ICT to support the following three areas: 1) communication between the project team at the offices and the operation team at the building site, 2) knowledge processes at the building site, and 3) logistics at the building site. This paper reports experiences when designing mobile ICT supporting knowledge processes. The aims of this research were:

- To create ideas for the actual use of mobile ICT supporting knowledge processes like retrieval, storing, transferring and re-use.
- To test out and explore some of the emerging ideas and scenarios in their exposed physical environment.
- To design a prototype to support some of the emerging ideas for possible mobile services.

2.1 An Iterative Design Process

Knowing that the construction workers at the sites do not use mobile technology to support their work and acknowledging that they are the domain experts, this research adopted a user-centred approach in order to

obtain participation and involvement among the workers. The exploration of their work and its constraints at the construction sites is grounded in an ethnographical approach using Contextual Design (Beyer and Holtzblatt 1998). In order to reach the aims in the project and since we were going to study a novel field, we conducted an iterative design process based on *workshops*, *shadowboxing* (reflection-in-action) and *prototyping*. Through all the steps and iterations, we focused on work *incidents* and created and performed related scenarios. Figure 1 illustrates the iterative design process.

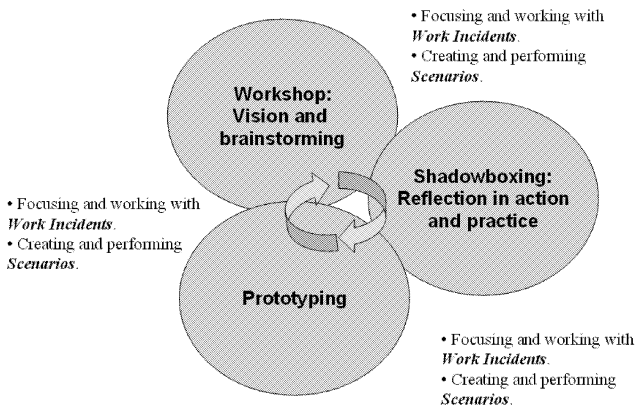


Figure 1. The iterative design process in this research project

The study was carried out over a period of six months by four full-time participants, three construction workers and one researcher. A mixture of qualitative techniques like observations, interviews, paper reviews (work process documents, checklists, and similar), taking pictures, video and recording voice was used. About twenty construction workers at the construction site were observed during work. Time spent with these workers varied from a few hours up to several days. The workers included professionals like carpenters, concrete workers, electricians, plumbers, bricklayers, painters, digger drivers and crane drivers. Twelve of these workers were also interviewed in depth. Furthermore, eight workers at the construction hut and the headquarters were interviewed. These workers cover occupations like gang leaders, project leaders, working managers, and architects.

Before describing the main steps in the iterative design process, the work incidents will be explained and exemplified.

Work incidents related to knowledge processes

In order to support knowledge processes with ICT it is important to structure the different knowledge types and the knowledge processes (Alavi and Leidner 2001; Fagrell et al. 1999; Kucza 2001). The preparatory work for this research was grounded in the work of Alavi and Leidner (2001). They report and discuss knowledge types like tacit knowledge (Polanyi 1966), explicit knowledge, individual knowledge, social knowledge, know-how, know-about, know-why, know-with and know-when (Alavi and Leidner 2001) and furthermore, they report on knowledge processes like retrieval, storing, transferring and re-use. In this study we decided to look for *work incidents* or situations that could exemplify knowledge processes at the construction sites. That was *incidents* that required some kind of action in order to proceed or to be solved. A *work incident* could be an experience, a quality problem, a question, a suggestion for improvement, a request, or an order. Possible *work incidents* could be related to normal working procedures or routines, related to complex activities or complex problems, related to lack of information and lack of quality of work. The knowledge processes were examined with respect to different levels like individuals, teams and construction projects. Table 1 presents two examples of such *work incidents*.

Table 1. Examples of work incidents

<p>Example no.1: Changing position of lay shafts in bathrooms. One or two apartments are often completed at an early stage in order to be used as showrooms for potential customers. This was also done in the case project. During assembly work in the bathroom in this apartment, some weak points in fasteners for the mirror were uncovered. At first, the assembly work was done according to the drawings. However, based on experiences gained while making minor adjustments to the mirror, the position of several of the lay shafts had to be changed. This experience or correction had to be registered and transferred to the more than 300 other bathrooms to be built.</p>
<p>Example no.2: Bad quality of pillars. Early in the project a participant discovered a lot of the pillars that arrived at the construction site were of poor quality. Many of the pillars were crooked, probably because they were made from rapid-growing trees. The carpenters spent a lot of time on grading and piling up the pillars. Between 40-70% of the pillars could be used. During the project a new type of pillars was tested out. These pillars were made of glued wood, and were then used in every case. Even though the new pillars were more expensive than the old type, money was saved because of less work.</p>

Workshops

On a weekly basis we had workshops at the construction hut lasting about 2 hours. At these workshops we had brainstorming sessions, worked with

our vision, discussed work incidents and other findings, and created and discussed scenarios using work incidents. One of the main steps in Contextual Design (Beyer and Holtzblatt 1998) is to envisage how new technology will address the user work practice by creating a high-level story (vision) of how the work will be changed and working out the details of this story at the level of the task. During the brainstorming sessions and while working with the vision, we used mock-ups as suggested in Contextual Design (Beyer and Holtzblatt 1998).

Shadowboxing: scenarios of reflection in action and practice

In order to create ideas and achieve insight into how, when and why mobile ICT can support work in mobile settings, the carpenters started to use dictaphones¹ as props during work. They had to pretend that the dictaphone was a real mobile application, i.e. perform future use of mobile services. Each time a *work incident* arose, they had to register it with the 'mobile' application, that is, make an audio-record. This exercise we called "Shadowboxing". After 6-7 weeks they started to use mobile phones (SonyEricsson P900) as props. With these mobile phones the workers took pictures and made audio-records and videos of the *work incidents*. This approach has strong similarities to what Buchenau et al. (2000) call 'Experience Prototyping'. The users 'experience it themselves', rather than witnessing a demonstration of someone else's experience. Furthermore, this approach stresses the importance of 'being there' for the understanding of the contextual factors, as Oulasvirta et al. (2003) do in their case studies in *bodystorming*, that is brainstorming conducted 'in wild'.

As with Bødker (1999), this research finds it important to create trial use situations as part of the design process, in order to stage users' hands-on experiences with the future. Also it is important to investigate ways in which users can feed back reflections over work and trial use that are directly anchored in the specifics of use in work situations to designers (Bødker 1999).

Since construction workers do a physical work and are continuously using their hands, it is of interest how and when they use the dictaphone or the mobile phone to record their work incidents. We were challenged to identify appropriate times of interactions where the mobile application could offer assistance to the user while working. By exploring by doing, the hope

¹ The dictaphones have different types of size and shape. Also, they are different as to how functions are used (differences in menus) and different in functionality richness. Three types of dictaphones (Apacer Audio Steno BP300 MP3 Player 256MB, MP3 Spiller - Asono Beatsound 256MB, MP3 Spiller - Asono 50f 256 MB) were used.

was that this could provide first-hand understanding and experience of existing and future scenarios.



Figure 2. Tom uses the P900 to record a work incident.

Prototyping

According to Contextual Design we used User Environment Design and paper prototyping (Beyer and Holtzblatt 1998). In order to visualise our ideas we made a prototype for handling the work incidents, e.g. registering, updating, follow-up and reporting. According to our vision the prototype covered mobile services for handhelds at the construction site and an application for stationary PCs at a construction hut or an office. The prototyping was done in three iterations.

3. RESULTS

3.1 The Vital Importance of Work Incidents

The work incidents were mainly discovered by the participants during work or by observing other construction workers. It became evident that the *work incidents* were of vital importance.

Documenting and working with the *work incidents* gave us deep insight into situations and problems at the construction site. Also, trying to solve the

work incidents generated scenarios in a naturally way. The group created scenarios by thinking of possible new solutions while discussing situations like: How did the incident arise? How could it be communicated and registered? How could it be solved, and who could participate in solving it? What could we learn from the incident? Moreover, talking with other workers that were not members of the project about *work incidents* gave further insight and inspiration for new scenarios.

Working with the work incidents and their related scenarios certainly contributed to the engagement and involvement of the members through the whole project. This was of vital importance and came to light every time we solved a *work incident* in the project. Through this, the members felt that they were contributing with improvements both on the spot and for the future. Furthermore, since the *work incidents* were based on their personal experience, the creation of scenarios became more vivid and engaging.

The first two workshops when we brainstormed on a possible vision, the carpenters did not contribute a lot. However, as soon as we started to work and solve *work incidents* and tried to 'place' these into the vision, this changed. Now they were the experts and were overwhelming with ideas and suggestions. During this process the users invented and told stories. Furthermore, as we started to use mock-ups with simple illustrations, i.e. in this case stick figures men, they became engaged in the process. The workshops revealed open-ended (Bødker 1999) and wide-ranging scenarios on a conceptual level. However, as the process proceeded, the scenarios became more and more detailed. It appears that this was connected with the use of the *work incidents*. The further we went into detail in order to solve the work incidents, the more detailed the scenarios became.

Fore each of the three iterations of prototyping we used a number of the *work incidents* and their related scenarios as test cases for the prototype. This was very useful and made us focus on concrete and real issues, problems and processes. Furthermore, this made it possible to validate whether the prototype was able to handle the workers daily *work incidents*.

3.2 Shadowboxing was a Very Fruitful Activity

We have found that shadowboxing, i.e. using a dictaphone or a mobile phone as props in order to register the work incidents, was a very fruitful activity. Setting the stage for 'context of practices' and 'reflection-in-action' (Schön 1983) enforced ideas about possible use. And, by exploring by doing, the users gained first-hand experiences and understanding of existing and future scenarios. This gave the workers a basis for mapping out when it was appropriate to use handhelds, and when it was not, and why. A great many

experiences were revealed during this activity. Table 2 contains three of these.

Table 2. Examples of when it was appropriate to use handhelds, when it was not, and why

Example 1: In general, the workers found the use of handhelds was strongly related to what kind of work incident they were handling. For instance, very seldom it was useful to register the work incident at a very early stage when it was related to experiences or knowledge processes. Frequently, they had to do some trial-and-error work before they actually could register or describe the work incident. However, when the work incident was related to logistics, they saw the possibility to reduce the time used in searching for materials. Instead of going around the site to look or ask other workers, they could use the handheld for locating them. Based on the location given by the handheld, they then could go and fetch the materials, or order the materials directly by using the handheld if the materials were out of stock.

Example 2: They learned from experience that the use of pictures or video from a mobile phone was more suitable than the audio-record when the work incident was complex or detailed. They found it easier to explain the situation with the use of a picture.

Example 3: Many of the work procedures in residential construction are well-defined through certain sequential building processes. For instance, first the concrete has to set, then come the ground beams, then the pillar for the walls, then the electricity work, then the plumbing, then the insulation procedure, then the planking or plaster, then the painting and so on. But since many types of professionals and workers are involved at different times for different periods, the management of planning, informing, coordinating, and following up progress is a complex and challenging activity. Today, the gangers have the operational management for this out at the sites. Since the sites are often large and hard have an overview of, the gangers cannot easily reach the workers, and visa-versa. Consequently, the participants see possibilities to support the building progress. They can use a handheld to report on progress, progress problems, or even better, before they get into problems.

Since the study lasted for months, each participant was alone most of the time while shadowboxing at the construction site. This gave them time to consider and evaluate their own thoughts and ideas, what Schön (1993) calls reflection-in-action, i.e. thinking about what we are doing. However, when two or more were together, the shadowboxing was expressed verbally and intertwined with discussion. This exercise of exploration and evaluation provided confirmation or rejection of the scenarios based on real experiences.

Kuutti et al. recognise a successful creative process in the performance where there are at least two things happening. Firstly, there is performing and interaction with the physical reality, by which participants take action in the physical world and change it during symbolizing activities (Kuutti et al. 2002). In this study we find this to be fulfilled during shadowboxing. The dictaphones and the mobile phones were used in their real settings and symbolized new activities, or even in all probability, they have some of the mobile services needed at the construction sites (i.e. audio-recording, video, picture and registration of texts). Secondly, the participants interpret symbolizing actions in the changed environment, and aim at a shared

interpretation in a collaborative way (Kuutti et al. 2002). This was achieved when two or more were together at the site performing shadowboxing and expressing scenarios verbally. These interpreting scenes were intertwined with discussions, confirmations or rejections.

3.3 Mobile Technology in Exposed Environment

During the project the participants experienced many other aspects that might be of relevance for designing mobile technology in this kind of environment. Table 3 lists three such aspects.

Table 3. Aspects relevant for designing mobile technology in exposed environments.

Aspects	Description and comments
Handhelds as work-wear	Due to the natural setting at the construction site, the handhelds must withstand variation in temperature, humidity, light, noise, dust and dirt. In addition they must withstand tough usage by the workers, and to some degree be shock-proof. The handhelds have to be wearable, or more precisely, they have to become a part of the work-wear. Even though the project was not carried out during winter months, neither the dictaphones nor the mobile phone tolerated this usage and environment. None of them were robust enough.
Noise disturbance	Example 1: Because of noise the workers had a tendency to raise their voice while doing audio-recording. The consequence was bad audio-quality. Example 2: During video-recording with the mobile phone, some technical problems occurred. The participants tried to fix this, without success. To solve the problem they had to look for a quiet place. They could not concentrate enough to solve the problem in the noisy environment.
Culture	Example 1: In the beginning the construction workers had problems with audio-recording at the construction site. They complained about the poor sound quality of the dictaphones, and they had to record at home or in the car. However, based on further investigation, it came to light that this was not the case. In fact, they really felt uncomfortable when making audio-records at the site. They did not want other workers to see them in that situation, even when they were alone on a section at the construction site. However, there was a breaking-in period and after five-six weeks, they got used to using the dictaphones on site. Example 2: Even though the participants got used to the dictaphones, i.e. using it during their daily work, they still felt uncomfortable using them or the mobile phones in a particular setting. This became very evident when participants visited other places at the site to register an 'old' work incident, for instance taking a video instead of an audio-record, while some other workers not familiar with the work incident were present. The participants then felt like total strangers. This feeling in this particular setting lasted for the rest of the project.

Table 3 illustrates the importance of social and cultural aspects in the design and use of mobile technology. We fully agree with Visciola (2003) when she states that social issues are one of the important emerging research issues in research on wireless applications.

3.4 Aspects of the Scenarios

In the following important aspects during the exploration of the creating and performing of scenarios are highlighted:

Open-ended scenarios: In this research we have tried to facilitate open-ended scenarios (Bødker 1999) in order to give broad and conceptual answers. We found this to be the case in the beginning of the process when we worked with the vision and new ideas of mobile services. As the project proceeded, the users tended to work with more detailed scenarios related to *work incidents*, e.g. *closed* scenarios (Bødker).

Memorable and inspiring scenarios: According to the study of Oulasvirta (2003) bodystorming sessions make scenarios both memorable and inspiring. This was also the case in this research. The shadowboxing (i.e. bodystorming) with real work incidents and their related scenarios was thought to be inspiring by the participants. Furthermore, during the workshops' brainstorming sessions of possible scenarios based on the shadowboxing, it became clear that the work incidents and scenarios were felt to be memorable.

Roles of performance: Iacucci et al. (2002) emphasize three roles of performance in the design of interactive systems: exploring, communication, and testing. This research contains examples of all these roles. The exploring was performed while shadowboxing on the site. Further, the *work incidents* and their related scenarios were communicated in the project between all participants in all steps. And finally, the testing of the scenarios and our vision/concept was done during the prototyping iterations.

3.5 Problematic areas

Knowledge processes: One of the aims of the research was to create ideas for the actual use of mobile ICT supporting *knowledge processes*. Very early in the project we experienced that it was very hard to gather only *work incidents* related to knowledge processes. Most of the incidents were not an 'obvious case'. Frequently we spent a lot of time discussing whether the *work incidents* were within our scope, or not. So, after a while, we decided to register all *work incidents* that we discovered.

We ended up with 55 highly diverse work incidents. In order to separate *work incidents* related to knowledge processes from the other processes, further analysis and categorisations were necessary. The documentation was extended to include categories like seriousness, frequency, different classifications of causes, classification of production area, professions, and costs. Through this comprehensive analysis and categorising of the *incidents*, we found that about 30% were related to suggestions for improving the

building processes that were based on work experiences, about 26 % were related to quality problems (often caused by lack of knowledge or information), and about 17 % were related to communication between the projecting team and the operation team. The remaining, were related to other categories like logistics, project management and health and safety.

As we have gained a deeper insight into *work incidents* and scenarios related to knowledge processes, we are aware of much that we do not yet understand. Further research has to be done in order to understand and structure knowledge processes and knowledge types. However, we have gathered an overwhelming amount of complex information. All the *work incidents* are stored in the database of the prototype, including videos, pictures and voice. Thus we can see the beginning of a database containing information about knowledge and experiences. Also, we see possibilities of mobile services supporting discontinuities (i.e. *work incidents*), thus bridging the gap between intention and action (Gershman et al. 1999).

Documentation: During the discussions of scenarios at the workshops and the shadowboxing we were not able to document all the scenarios. We realise that we should have used audio recording or video during these discussions. Moreover, much of the process of documentation, especially the diary/log of the work incidents was very time consuming.

4. DISCUSSION

Despite the difficulties related to knowledge processes, we venture to say that the iterative design process was very helpful in order to achieve the research aims. The project has created and explored ideas relating to the actual use of mobile ICT to support knowledge processes in workers' exposed physical environment. Also a prototype was designed.

This study has illustrated the vital importance of real *work incidents* and the creating and performing of related scenarios. Hence, it could be of relevance to evaluate the iterative design process by evaluating and discussing the scenarios in this study. Just as Svanæs and Seland (2004) evaluate their workshops with respect to objectivity, reliability, validity and transferability we also evaluate the scenarios in the same way:

Objectivity: To what extent do the scenarios and the ideas originate from the users, and not from the facilitators or developers? In this project all the work incidents were discovered by the construction workers or through observation of them. At the beginning of the project the researcher had to help the users in how to create scenarios. However, after a few sessions, the construction workers were able to create the scenarios themselves. They were the experts and they knew it.

Reliability: Are the scenarios accurate in their description of the situations being studied? Since the scenarios most often emerged from real work incidents they certainly are in-situ and are highly relevant to the situation being studied. The scenarios created during the workshops were further elaborated and verified during shadowboxing, i.e. grounded in real settings. At the end of the project a cost analysis of the work incidents was done which revealed that most of the work incidents were costly to handle or solve. This supports the facts that the work incidents are relevant and important.

Validity (internal): Are the scenarios describing the important aspects of the situations related to the purpose of the research? The scenarios describe the actual use of mobile ICT supporting knowledge processes at the construction sites. However, we had to extend the scope to other types of processes and work incidents. The research also gave insight in such a way that the workers could map out when it was appropriate to use handhelds, when it was not, and why. Furthermore, we tested the validity of the prototype by using work incidents and scenarios, i.e. we visualised whether the ideas and design could handle the work incidents.

Transferability: Are the scenarios typical of the situations being studied, i.e. can the conclusion drawn from analysing the scenarios be generalized? Shortly after the fieldwork was finished, its results and experiences were presented to a group of managers in a large global construction company. This company builds (large) buildings, residences, roads, bridges, tunnels and so on. They found it both relevant and interesting and are now a partner in the main development and research project. This could indicate that the scenarios are of relevance for other construction sectors.

Another, and maybe more interesting, question is whether the scenarios could be generalized to other kinds of mobile work in exposed physical environments. Some of the conceptual scenarios might be, e.g. a handheld that makes it possible to register *work incidents* and transfer information into a database, and the handling of the *work incidents*. The scenarios that are detailed we find not appropriate to generalize. In all probability they are too specific for the construction sector, and some even too specific for industrialized residential construction. However, we see transferability of the scenarios within the different professions at the construction site, like carpenters, concrete workers, electricians, plumbers, bricklayers, painters, digger drivers and crane drivers.

However, what we find appropriate to generalize to other kinds of mobile work in exposed physical environments is the steps in this user centered design process to create the scenarios. Especially using *work incidents* and their related scenarios during shadowboxing might be relevant in other industry or sectors.

5. CONCLUSION

This research has resulted in a diversity of experience through creating and performing scenarios in mobile work in exposed physical environments, i.e. industrialized residential construction. In an iterative design process based on workshops, shadowboxing (i.e. using dictaphones and mobile phones as prompts at the site) and prototyping, the project has created and explored ideas for the actual use of mobile ICT supporting knowledge processes. This paper has described shadowboxing as a very fruitful activity. Through exploring by doing, the users gained first-hand experience and understanding (reflection-in-action) of existing and future scenarios. This gave the workers a basis for mapping out when it was appropriate to use handhelds, when it was not, and why.

Moreover the research has successfully promoted the participation of users in an innovative design process. By focussing on work incidents, elaborating and working with the incidents at all the stages, we obtained participation and involvement among the construction workers through the entire design process. The use of work incidents and related scenarios was of vital importance. This paper has highlighted and discussed important aspects of the scenarios.

ACKNOWLEDGMENTS

I would like to thank all the workers participants for generously giving their time and effort during the project. Specifically, I wish to thank and credit Tom Ø. Hansen and Kris Sigurjonsson whose attitudes and inventions have inspired the fieldwork through the whole period.

References

- Alavi, Maryam, and Dorothy E. Leidner. 2001. Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues. *MIS Quarterly* 25 (1):107-136.
- Beyer , Hugu and Karen Holtzblatt 1998. *Contextual Design - Defining Customer-Centered Systems*, Morgan Kaufman Publishers, ISBN: 1558604111
- Binder, T. (1999) Setting the Stage for Improvised Video Scenarios, ext. Abstracts CHI'99, (pp230-231)
- Brandt, E., Grunnet, C. (2000) Evoking the future: drama and props in user centred design, In: Cherkasky, T., Greenbaum, J., Mambrey, P. (Editors), *Proceedings Participatory Design Conference*, New York, CPSR, 11– 20
- Buchenau, M., Fulton Suri, J. (2000) Experience prototyping. *Proceedings DIS2000, Designing Interactive Systems*, New York City, USA, ACM Press, 424–433

- Bødker, S. (1999) Scenarios—setting the stage for reflection and action in user-centered design. Proceedings Hawaii International Conference on System Science.
- Carroll, J. (2000) Making Use: Scenario-Based Design of Human-Computer Interactions. MIT Press
- Fagrell, Henrik, Fredrik Ljungberg, Magnus Bergquist, and Steinar Kristoffersen. 1999. Exploring Support for Knowledge Management in Mobile Work. Paper read at The European Conference on Computer Supported Cooperative Work (ESCW'99), at Copenhagen, Denmark.
- Iacucci, G., Iacucci, C., Kuutti, K. (2002) Imagining and experiencing in design, the role of performances Proceedings of the second Nordic conference on Human-computer interaction, October 2002, 167-176
- Iacucci, G. Kuutti, K. (2002) Everyday Life as a Stage in Creating and Performing Scenarios for Wireless Devices. Personal and Ubiquitous Computing, 6:299-306.
- Garabet, A., Mann, S., Fung, J. (2002) Exploring Design through Wearable Computing Art(ifacts). Extended Abstracts CHI 2002, Minneapolis, Minnesota, ACM Press, 634-635
- Gershman, Anatole V., Joseph F. McCarthy, and Andrew E. Fano (1999). Situated computing: Bridging the gap between intention and action. Paper read at The Third International Symposium on Wearable Computers, at San Francisco, USA.
- Kuczka, T. 2001. Knowledge Management Process Model: Technical Research Centre of Finland, VTT Publications.
- Kuutti, K., Iacucci, G., Iacucci, C. (2002) Acting to Know: Improving Creativity in the Design of Mobile Services by Using Performance. Proceedings on conference Creativity & cognition, 2002 October 14-16, ACM Press, 95-102
- Luff, P., Heath, C. (1998). Mobility in Collaboration. Paper read at Proceedings of the 1998 ACM conference on Computer supported cooperative work, at Seattle, Washington, United States.
- Newcomb, E., Pashley, T., Stasko, J. (2003) Mobile Computing in the Retail Arena, Proc. CHI 2003, April 5-10, 2003, Ft. Lauderdale, Florida, USA.
- Messeter, J., Brandt, E., Hasle, J., Johansson, M. (2004) Contextualizing Mobile IT. DIS2004, August 1-4, 2004, Cambridge, Massachusetts, USA. 27-36.
- Oulasvirta, A., Kurvinen, E., Kankainen, T. (2003) Understanding contexts by being there: Case studies in bodystorming. Personal Ubiquitous Computing Vol. 7, 125-134.
- Polanyi, Michael. 1966. The Tacit Dimension. London, UK: Routledge and Keegan Paul.
- Schön, D. (1983) The Reflective Practitioner. How Professionals Think in Action. MPG Books Ltd, Great Britain, ISBN1857423194.
- Statistics Norway (2004) Employment divided in professions and gender. Yearly average 2002-2004. <http://www.ssb.no/emner/06/01/yrkeaku/tab-2005-02-02-02.html>
- Svanæs, Dag., Seland, Gry. (2004) Putting the Users Center Stage: Role Playing and Low-fi Prototyping Enable End Users to Design Mobile Systems. CHI 2004, April 24-29, Vienna, Austria (pp 479-486)
- Visciola M. (2003) "Reflections on the User Centered Design Perspective in Research on Wireless Applications. Ubiquity, An ACM IT Magazine and Forum, Volume 4, Issue 8, April 16-22, 2003