

The Power of Use Context: Designing where the Action is

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Mobile and pervasive computing expand the arena of "computer" use far beyond office and home environments. This makes it more difficult for designers to imagine use contexts and to design appropriate user interaction for instance for environments like industrial plants. This paper is concerned with bridging the gap between designers' imagination of and users' knowledge of use situations. It suggests field design sessions in use context as a way of organising design of user interaction. Designing in the environment of the product-to-be provides the design team with a number of advantages compared to traditional work in the design studio. The designers achieve direct physical experience of the circumstances and non-represented, non-abstracted introduction to the problems at hand. Through user collaboration on the spot designers gain insight into user's work practice and immediate feedback on design proposals. In the design of user interaction for complex computerised machinery we have found this approach highly successful.

In recent years there has been a growing interest in industry in understanding use and users to target products at specific needs and environments. There is an increasing acceptance of ethnographic methods of field study and a trend away from simulated user tasks in usability lab environments. In particular when designing new types of user interfaces for mobile and pervasive computing, the context of use has a significant impact on how people interact with technology and with each other. Traditional HCI methods developed for designing computer systems for stable office environments are hardly capable of dealing with these cases.

The approach we have taken in this work is to move design activities as close to the environment and the user as we can. That is, we are critical of and try to avoid abstracted experience. We also think that context and user are inextricably linked: One cannot understand the environment without the help of the user and one cannot understand the user's work practice and problems when outside his natural habitat. Therefore our design team actually moved out of our office space to work in use context, at least for short periods of time.

We will start with a review of the Contextual Design approach of [Beyer & Holtzblatt 1998] followed by a general discussion of the impact of the physical location on design practice. Then we will present two cases to support our claim that designing in use context is extremely valuable

when designing user interaction. The first case, set in a Boiler Room, focuses on the experience of actually designing in a use environment rather than in a design studio. The second case, set in a Power Plant, illustrates the advantages of collaborating with users on their home ground in field design sessions.

Use and context

With the term use context we strive to understand the material and social conditions for the user's work and interaction with products: The physical location and environment, the process system and its components, the tools, the organisational setting, the social culture etc. Interacting with the product is part of the user's work practice, by which we understand the competence and activities of the user. A dialectic relationship between work practice and context exists: One shapes the other and vice versa.

How do HCI approaches encompass the understanding of use context? The central methodology to discuss is the Contextual Design approach proposed by [Beyer & Holtzblatt 1998]. This methodology favours the notion of customer data: *"Contextual Design makes data gathered from customers the base criteria for deciding what the system should do and how it should be structured."*

Data are collected through interviews at the customer's workplace and organised into a set of models to describe work: A flow model, sequence model, artefact model, cultural model, and physical model. The models are abstract diagrams that represent aspects of work. To help understand customer interviews and see across a range of customers, Beyer & Holtzblatt recommend Interpretation Sessions where the team of investigators use post-it notes to structure and generalise findings.

Beyer & Holtzblatt consider the design process an inherently cognitive process: *"Design is a cognitive activity. It is thought work. It begins with a creative leap from customer data to the implications for design and from the implications to ideas for specific features."*

This focus on data and cognition suggests that all relevant impressions of use context and user work practice can be expressed and processed in words and diagrams. This emphasis relates to the nature of traditional computer systems that foremost support cognitive skills. In an industry world of plants, machines, components, and tools, however, the tangible and motoric activities are much more dominating, and the assumption that abstract data are sufficient to fuel design breaks down.

In this section we will argue that design activities should not be entirely based on data analysis in studio environments. It is paramount for the success of a project to include design activities that are staged in the use context. In this way designers get immediate access to both the physical environment and the work practices of the people who will use the product-to-be.

Design context and design practice

Our work is based on Schön's understanding of design as a reflective conversation with the situation:

"In a practitioner's reflective conversation with a situation that he treats as unique and uncertain, he functions as an agent/experient. Through his transactions with the situation, he shapes it and makes himself part of it. Hence, the sense he makes of the situation must include his own contribution to it. Yet he recognizes that the situation, having a life of its own distinct from his intentions, may foil his projects and reveal new meanings." [Schön 1983]

Schön challenges us to abandon the rational understanding of the use context being independent of the product, and therefore something that the designer can observe objectively from a distance. To design, we need to impose an order on the situation, while at the same time listening for the backtalk of the situation. This "order" is an understanding that grows out of framing and reframing the problem, rather than a theory to be formed once and for all. When designing user interfaces, the "situation" is the physical environment, in which the product-to-be will reside, as well as the context and work practices of the people that will relate to it.

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aking the point of Suchman that purposeful human actions are inevitably situated, shaped by the particular physical and social circumstances [Suchman 1987], we must accept that also the activity of designing is highly situated. Designing is shaped not only by the objectives (i.e. the product) and the plans that designers make, but also by the situations and contexts in which design happens.

From a case of re-designing the interior architecture of an industrial research lab, Horgen et.al. report: *"Efficient problem-solving, as experience indicated, did not happen in the conference room but at the machine or in the corridor outside the laboratory, where the right people could be gathered and the problem examined in the presence of the equipment under discussion. The design challenge, then, was either (1) bring the work into the conference room or (2) bring the conference into the middle of the work."* [Horgen et.al. 1998]

The first option of moving equipment into the conference room (or the design studio) may be possible in the case of systems of limited size, but to transfer a plant-size work environment and recreate the work context and work practices of people is not feasible.

Horgen et.al. introduce the term process architecture to describe a way of working with interior design that seeks *"to co-invent the workplace and work practice in a dynamically coherent way"* [Horgen et.al. 1998]. This challenges us to think of our endeavour into use context not simply as a change of scenery, but as a reframing of the way we work with design in general.

Design and architecture studios have a tradition of staging the workspace to support creative work, a tradition that is replicated in the studio facilities of design schools. But designing user interaction in locations too remote from the use context can put a designer on the wrong foot. Designing in an office or studio will influence decisions on what interface elements are acceptable for a product. So while working on an industrial machine for tough conditions, the clean, quiet and spacious environment the designer works in him- or herself biases the mindset. Also, the type of interfaces that surround the designer in the studio environment (calculators, video recorders, computers) is likely to influence choices. As a result, the designer may end up designing for perceptual-motoric conditions that match own environment, rather than that of the user. If one actually designs in the use environment, all of that changes.

Use context as a source of inspiration and backtalk

In the tradition of empathic design there have been attempts to recreate use environments in design studios. These typically serve as a playground for the team to act out scenarios with new design ideas. Burns et.al. for instance created a replica of a hairdresser's salon in their design studio in a project to experimenting with new computer applications. In a process they termed Informance Design, they playfully acted out situations, which they had previously observed in field studies of hairdressers at work, and tried to support and enrich these situations with new computer tools [Burns et.al. 1994]. They used the same installation as a stage to act out scenarios for colleague designers to obtain feedback on their ideas. Brandt and Grunnet have supported similar successful experiences with recreated use environments and drama in the design of user interaction [Brandt & Grunnet 2000].

In both cases the recreated use environment serves as a basis for the team to get a "bodily" understanding of the work practices of people and to build empathy with them. It also serves as a source of inspiration for new design ideas, and as a test bed for acting out scenarios with non-existing products. In short the build-ups are meant to recreate both the impact and the backtalk of real life use contexts. However, Brandt and Grunnet also describe how sets, scenarios, and props can serve to establish collaboration with users about design in use context.

Our position is that recreating use environments in the design studio, though inspiring and helpful, isn't sufficient. The industrial settings in which Danfoss components will be used, for instance, are too complex to imitate. While it may be possible to imitate a hairdresser's salon in a design studio, the gaps "boiler room to studio" and "power plant to studio" are too big. Designing complex industrial equipment for Danfoss is something quite different from designing a household object like a chair, a lamp or a video recorder, with which one has personal experience.

With the growing interest in ethnographically inspired fieldwork, user centred design groups tend to spend more time with users in their worlds. They leave the traditional usability labs, trying to understand contexts and work practices, and what impact they may have on the design of future products. There is an increasing acceptance now that the understanding one achieves by being with users cannot be easily represented in text or diagrams and transferred to somebody who hasn't been there. Out of these experiences grew the urge to move on one step beyond studying and actually go and sit in a use environment while designing.

The Boiler Room Case

The boiler room is a part of the house one is seldom in. Because it doesn't form part of everyday life it is hard to imagine. Also, because it is so complex and because equipment has been added over time, it is hard to imagine what it is like by means of a diagrammatic representation. The diagram suggests order; unfortunately, the real boiler room is nothing like the tidy diagram. To the untrained eye, the heating system seems like a tangled mess of intertwined, non-colour coded piping.

In a recent design project on future domestic heating controls we borrowed a boiler room for staging team design events. The product in focus was a weather compensator: an electronic device that controls the heating in accordance with the outdoor temperature. In particular we were interested in improving the procedures that the heating installer must go through to order, mount, connect, and adjust the product. The team was a multidisciplinary group of five members (engineers, industrial designer, interaction designers). The boiler room was a cramped, hot and dusty basement cubicle with poor lighting and with pipes running along all four walls. For a start we tried to make sense of the many pipes and devices: Pumps, valves, thermometers, sensors, cables etc. The heating systems expert of the team guided this part.

Next we moved chairs into the room to run an Interaction Relabelling session [Djajadiningrat et.al. 2000]. Interaction relabelling is a creativity method in which the functionality of the product to be designed is mapped on an object that is foreign to the environment. This helps designers to break away from the prototypical interaction style for the product to be designed. In our case, we wanted to move away from interacting with a display and keypad, which is so typical for electronic devices, towards tangible interaction. Therefore we used objects, which invited rich actions: A stamp and ink cushion, a soft children's toy, and a hole puncher. Together we tried to imagine, explain and act out how each of these objects would be operated if it were the electronic weather compensator. During the interaction relabelling session we not only mapped existing functions to the relabelling objects, they also came up with new functions. One of the team members remarked in surprise: "We're mapping affordances of this (hole punch) onto functions that don't



The design team in the boiler room running an Interaction Relabelling session. The hole punch is used to break away from the present interaction style

yet exist". Clearly, the rich action possibilities of the relabelling objects allowed us to "think outside the box". Instead of wondering how we could possibly interact with the numerous required functions through a conventional display and keypad, we suddenly found ourselves adding desirable functionality.

Later on, after a brainstorming session at the whiteboards of the design studio, we returned to the boiler room to exploit ideas about the installation situation.

Sitting in front of the complex piping work, we realised that one of the major challenges was to map the physical/spatial systems understanding of the installers onto the abstract control model of the electronic control device. The usual way of doing this today is through engineering diagrams depicted in the installation guide, but from previous user studies we knew that these did not make all that much sense to the installers. While discussing this, one designer stood up and started labelling the components with adhesive post-it notes. Another designer spontaneously tried to act the role of an installer using the labels to create communicative links between devices and the controller. This led to a series of scenarios, which explored different directions and combinations. Each of us contributed with ideas and produced props of foam and cardboard on the spot.

The team work pattern that emerged was one of intense acting and discussing (Would this work?) interrupted by pauses of silent pondering (Is it feasible? What is missing?). Within an hour we had a range of proposals, so we videotaped the most promising ones to check consistency and to document for a later presentation to design colleagues. All in all we spent about 4 hours in the boiler room interrupted only by occasional gasps for fresh air and by the brainstorming session in the study.

Boiler Room: What did we learn?

The experience of being there in the use environment while working with new ideas was remarkable and challenging. First, understanding the functions of the complex heating system and its usability problems is much easier if one can see the equipment with own eyes, rather than trying to understand it through a diagram or somebody else's explanation. Second, the environment serves as a source of inspiration for generating ideas and new interaction patterns. Artefacts of the domain are within easy reach; one can physically interact with handles and feel the available space. Context provides both inspiration and an immediate feedback on ideas: This is what Schön refers to as backtalk. The design artefacts we brought along (relabelling objects, post-its, props, mobile phones, video camera) introduced a kind of tension, which instigated and supported design thinking. They allowed us to reshape the environment to imagine the future.

In the boiler room a designer acts out an improvised scenario, in which a mobile phone is used to control the components of the heating system



We also learned how important it is to establish a team working rhythm that alternates between intense periods of creative, bodily activity and breaks of silent reflection. All in all the experience of working there sufficiently compensated for the absence of spacious design desks, meeting tables, whiteboards, natural light – at least for the duration of the session.

Use context as a space for co-designing with users

In the Boiler Room case, we did not have a real heating installer present. We had a very knowledgeable engineer, but still, the “installer’s experience” was conveyed, not direct. Now that we had established the importance of designing in the physical environment of use, the next step for us was to engage users in our field design sessions to better understand work practice and context. How could we combine the experience of working there on location with collaborating with users? Would they let us? Would they engage in our design quest?

In the Scandinavian tradition of user collaborative design, user workshops are the most important format for organising design activities with users [Greenbaum & Kyng, 1991]. When running such design workshops in our meeting space or even in a boardroom at the user setting, there is the risk, however, that outside their natural habitat users feel uncomfortable about communicating their problems to “expert” designers. Our experience – as expressed in the former two sections - shows that users tend to be much more motivated and creative, when we as designers visit them in their actual working environment. With this as a challenge we set out to involve ourselves with users on their home ground.

The Power Plant Case

A power plant is even more alien to most designers than a boiler room. It is even more difficult to imagine it and to empathize with the users. In this case we were concerned with the re-design of a frequency converter: A device that controls the speed of electric motors. Frequency converters are used for a wide variety of applications within the process industry. The type of interaction design problems we had observed in field studies were concerned with setting up the parameter values for the specific application, testing and experimenting with the settings to improve the performance of the overall process, and troubleshooting efficiently if problems occur. To gain a better understanding of the applications and to identify opportunities for improvements, we organized field design sessions in four different companies that use frequency converters: A power plant, a brewery, a conveyor belt manufacturer, and a manufacturer of packaging equipment. Here we will use the session in the power plant to discuss our experiences.



A pair of designers working on camping chairs in the heating & power plant. The frequency converter in focus is mounted on the pillar to the left.

The plant is a district heating and power plant that burns refuse to generate electricity and heat for the district heating networks. It has about 10 employees. The people who install and operate the frequency converters are electricians and process operators. In this case we had a good relationship with John, an electrician at the plant. He had been involved in another design project with Danfoss three years previously. So he was tuned in to the kind of things, which would be of interest to us, and he accepted our 3-5 year time perspective. In this project we were a team of four: two interaction engineers (Jesper and Jacob), an industrial designer (Tom), and a design anthropologist (Werner).

Two days before the planned field design session, Werner visited the power plant. The electrician gave a 1-hour guided tour showing him the different locations of frequency converters in use. Back in the office, Werner edited a short video sequence and prepared an application collage to inform the rest of us of what to expect, and to clarify characteristics of typical applications in use: Drives for pumps, ash conveyors, chimney fan, chemical dosage pumps etc. When we arrived at the plant early in the morning of the field design day, John gave us a quick tour to show us the different applications of frequency converters. Compared to the boiler room, the plant was spacious and clean, albeit noisy (gas turbines) and smelly (garbage combustion) in some areas.

The amount of information John communicated to us about each of the frequency converters depended on the time gone by since he had last operated it and to what extent he had been involved in the commissioning process. One application, which John explained to us in detail, was the chimney fan drive. It started out as an experiment two years previously and went through a number of alternative control strategies before it became a permanent installation. At another location he actually had made re-arrangements in his work plan to be able to show us a specific frequency converter set-up task. He wanted to connect a remote potentiometer to the frequency converter. This should make it possible for a truck driver, who transports ash refuse, to stand by his truck and manually control the speed of the conveyor two floors up. Today the driver uses a walkie-talkie to communicate with an operator, who is standing by the frequency converter control panel.

When the tour was over, John invited us for morning coffee and rolls, and we had a general talk about work at the plant. We then asked for some time by ourselves and decided to split into two teams, each working at a location in the plant. One team worked on the chimney fan frequency converter, focusing on the possibilities for carrying out experiments to optimise parameter settings. The other team sat near the ash conveyor application and worked on ways of improving the set-up task introduced by John. Both teams "camped" close to the specific locations, sitting on camping chairs, wearing the compulsory hardhats. We started sketching

ideas and creating quick foam mock-ups, both to reify our understanding of the situation and problems, and to explore new interaction opportunities. About one hour later, we presented our ideas to the electrician, and asked for his feedback. Some of the ideas he liked, some he didn't. A few of them he found hard to relate to at all. The mock-ups at the ash conveyor initiated a particularly rich dialogue about how to complete his set-up task with the present product (which wasn't easy), and how this could be improved in future designs.

After the 4-hour field design session, we returned to our design studio for a reflection session on our experiences of that morning. We felt overloaded with impressions, and it was a relief to get observations and ideas down on paper, and to share understandings of what happened. For our project, the outcome of this field design session was (1) a thorough understanding of two real life frequency converter applications, (2) a record of present interaction problems, and (3) the recognition of a number of design opportunities.

Power Plant: What did we learn?

It was reassuring to find that we experienced the same benefits of designing-in-context as in the Boiler Room case: The inspiration drawn from the environment, the backtalk of the physical presence of the equipment. But in addition we got more: We got a user's explanation of the system, and this was quite different from an engineering interpretation. It was more concrete and easier to grasp for us non-experts.

We got close to actual work practices of the user. He directed us towards use situations with specific problems that he was presently struggling with, or which had previously occupied his mind. This forced us to reconsider our pre-assumptions of what users might need. The basic ethnographic preamble *"You must build your argument on what is there, and not on what you brought along"* (Frederik Barth in Sperschneider, 2000) seemed highly applicable to us.

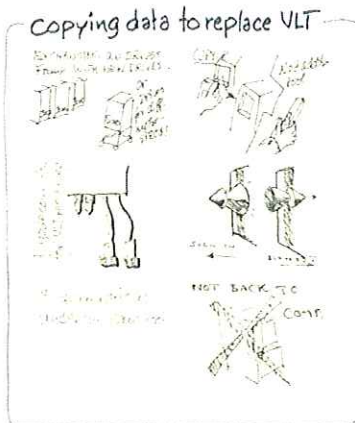
And, we got immediate feedback on our assumptions and ideas. The user was very motivated and creatively involved whenever we got close to things that mattered in his daily work. Sometimes we struck a dead end: When some of our ideas didn't draw any reactions at all from the user, it was likely that our understanding of the problem as such was lacking. In this way the ideas served to check our understanding of the situation at hand. This was very much "learning through designing": Did we attack relevant problems?

The following three field design sessions varied in different ways. The number of users varied from two to five, and in one session we got an impression of the social interaction between several electricians. On two occasions we had not met the users previously, which meant that the



A coarse interface mock-up created by the designers on the spot initiates a design dialogue with the plant electrician.

Post-it notes with observations and ideas from the team reflection session



collaboration was rather formal. Also, the time we had for ourselves to condense the input from the guided tour into design varied greatly. During one session, two supervisors representing the users participated in the design process. This changed our team design rhythm dramatically, because of the lack of both a common design language and a social relationship.

We learned that in particular three preconditions are of uttermost importance to make the collaboration with users in their work environment a success:

Establish a social relationship with users

If people are to share their problems with you and are to criticize the products you help design they need to trust you. We had met John before and therefore he felt reasonably comfortable. Comfortable enough to share his problems and criticisms. Our experience with other sessions tells us this is important: people who had not met us before were more reserved. The lack of a social relationship is hard to catch up with. Therefore the preparatory visit is very important. A second issue about relationships is to talk to the right people: That you're talking to a person in the work environment doesn't mean he's the right one to speak to. If he's not the actual user, the account that you get is still generalised.

Establish a common design language

To collaborate, we need to share a language about design. Throughout the sessions we extended our use of mock-ups. For us the mock-ups served as a model of our understanding - we learned through designing. For the users it served as a model for how to improve their work practice. Both to exemplify ideas but also to make a clear contrast of how things are done today, and how we could see it be done in the future.

Create a co-design atmosphere

Rather than asking users to evaluate ideas, we find it important to create an open atmosphere where criticism and new ideas are sought. When we returned with ideas and mock-ups to the users after our team design session, we experienced the difficult transition from being a guest to being an agent of change. In one session we started consciously to question each other's ideas among ourselves - just to show that ideas weren't "holy", everyone was allowed to criticize and suggest improvements. This helped: The users got less shy and started commenting. On the other hand, it became clear to us that in a field design session like this, time for ourselves in the team was as important as the design discussions with the users: time to sit and think, sketch, concentrate.

Design-in-context is a balance

From our experience with Process Architecture we know that rearranging the physical space for design work has a bearing on our design practice as well. Therefore it should come as no surprise that moving the design activity out into the use context causes us to re-address some quite fundamental questions relating to design practice. In our team reflection sessions, a number of dilemmas kept attracting focus as we tried to evaluate and improve our field design sessions. It seems to us that it is of paramount importance to find the right balance between the following conflicting design positions:

Designing products vs. studying use

The mock-ups produced in haste on location partly serve the purpose of learning more about use by provoking the users to react (did we attack relevant problems?), partly serve to document potential ideas for later elaboration.

Introduce contrast vs. build on what is there

The artefacts of the work context are extremely important as source of inspiration and learning, but we need to introduce 'alien' objects (computer artefacts for instance) to instigate design thinking.

Team design vs. co-design with users

The interaction with users is very valuable, but the team also needs time by itself to reflect and concentrate on expanding ideas.

Action vs. reflection

The pressure of accomplishing something visible within the short time-frame encourages one to work frantically. It is hard, but necessary, to take time to simply sit back and reflect on what you have seen.

Perspectives

The main conclusion from our work is that product design is situated just as product use. The field design sessions organised in use context and in collaboration with users provide us as designers with a chance of first-hand experience of the use environment and with rapid feedback on early design sketches.

There is a second motivation for taking design out into use context too, though. In an industrial corporation like Danfoss, with highly specialized departments, the contact to customers and users is taken care of by sales agencies, marketing departments, and application specialists. There is no immediate opportunity for R&D members to meet with users face to face and learn about their work and views on the product. We see our field design sessions also as an attempt in the direction of develop-

ing the organization towards customer orientation and user centeredness.
Horgen et.al:

"Workplace-making in this sense becomes a powerful means of organizational intervention, capable of enabling the organization at large to enhance its capacity for change". [Horgen et.al. 1998]

The field design session is part of an ongoing strive to improve collaboration with users. First we moved usability testing out to the users, then we moved out in the field to observe and analyse. Now the time has come to move design too. But there is still much to learn about when and how to co-analyse, co-evaluate and co-design with users in their context.

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