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Mobility and learning environments: Engaging people in design of their everyday environments

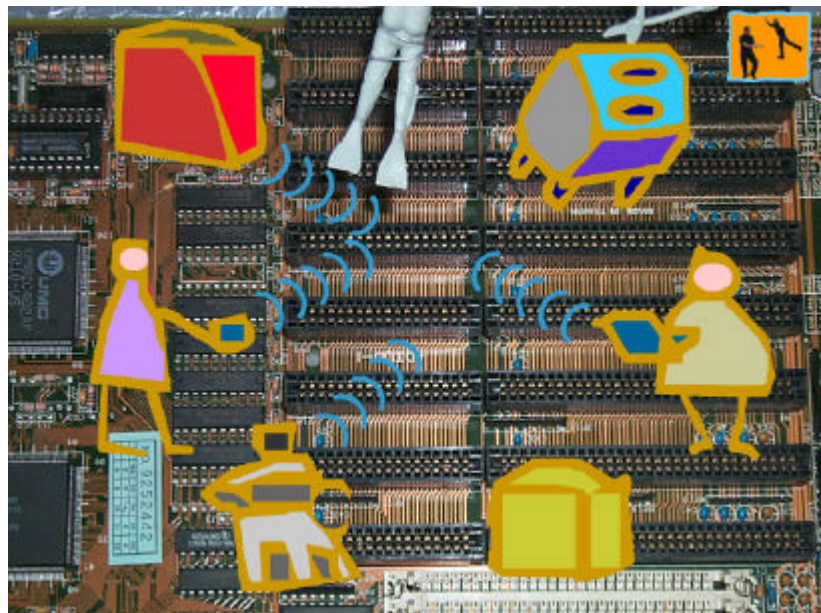Jönsson, Bodil; Svensk, Arne; Cuartielles, David; Malmborg, Lone; Schlaucher, Pierre

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Mobility and learning environments

engaging people in design of their everyday environments

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Contents

Introduction

This report documents activities during the first project period (1st August 2002 – 15th December 2002) of the Mobility and Learning Environments project.

Focus during this part of the project has been on establishing pilot-studies at the K3 user-site and at the Tryckolera user-site in order to apply and get experiences with methods for engaging users, apply and get experiences with current technology, and set up future study design.

The report is structured into five parts. Part one is an introduction to and critical discussion of cultural probes. We will relate this to the participatory design tradition and other methods for user engaging design. The question of to which extent and in which contexts and situations it's possible and appropriate to engage users is also raised and discussed here.

Part two reports from the two pilot studies that have been performed at K3 site – High Tech Hunters and K3 Nomads. The K3 site is described and the way cultural probes are appropriated in these two studies is discussed.

Part three will report from the study of the application of cultural probes that have been applied at the Tryckolera site. This part also contains a description of the Tryckolera workplace and pedagogical considerations behind this.

Part four discusses the experiences with current technologies for mobile learning with a special focus on digital pens, phones, PDA's and possible communication platforms.

Part five presents the conclusions we can draw from the first project period, and further on focuses on how research activities for the next period are planned to take place given the experiences and analysis achieved during the first project period. This part also contains a revised project plan.

1   Engaging users

In order to bridge the gap between development of technologically advanced and complex digital artefacts for communication and collaboration among people and a meaningful use of these artefacts it is necessary to engage users in the design process. Engaging users in the design process requires that users becomes active in this process but also that developers engage themselves in getting a better understanding of use contexts and –situations. Through abduction, this project will not only result in efforts to make two existing environments more user-friendly through micromobility but also in descriptions of the new eyeglasses through which we got sight of these possibilities.

In our research project proposal we proposed the following important issues regarding engaging users in the design process:

- How can we establish a design process engaging people in creating their mobile and digitally augmented environment?
- Studies of how to combine ethnographic approaches with the idea of cultural probes to support engagement in design processes
- Developing a more general methodological framework for engaging people in designing digitally augmented daily life environments.

In this first part of the project the aim was to perform pilot-studies at the K3-site and at the Tryckolera-site in order to apply at get experience with methods for engaging users, get experiences with current technology, and set up future study design.

1.1   The participatory design tradition

We set out from the participatory design (PD) approach, which has its roots in a Scandinavian IS development tradition. Bødker and Iversen (2002, p. 12) suggest an understanding of design and its relation to users and use, based on the following assumptions:

- When we design a computer artifact we design conditions for the whole use activity. In the mobility & learning project we refer to this assumption as *contextual design*
- Users and designers have different backgrounds and belong to different communities of practice. We refer to this assumption as *communities of practice*
- The users need to experience the future computer application in order to pose demands for it. We refer to this assumption as *experiencing future design*
- The practice of the users is the starting point for design. At the same time users need to be confronted with, and to experience new ideas in order to transcend their own practice. We refer to this assumption as *transcending practice*

In the following we will discuss our application of cultural probes in the perspective of these four assumptions and our labeling of these: contextual design, communities of practice, experiencing future design, and transcending practice.

Early practices of the Scandinavian PD tradition (Ehn 1988, Bødker et al. 1987, Bødker et al. 1993) often assumed that any touch of users' hands itself secured development of meaningful artifacts (Bødker & Iversen 2002). Now PD has reached a level of maturity that implies that a change in discourse must take place. Two constituting elements of a PD practice is suggested (ibid p. 11): First, the existence of a shared 'where-to' and 'why' artefact, and a conscious work with this artefact that helps to focus the direction of the participatory design. Second, professionalism based on an ongoing reflection and off-loop reflection among practitioners in the participatory design process. We agree in these proposals for a more mature and professional approach to participatory design. These proposals

will shape our methodological approach based on a combination of the idea of cultural probes and ethnomethodological studies.

1.1.1   Contextual design

Understanding use situations as opposed to understanding the digital artefact or technology itself is crucial when engaging users in the design process. A variety of methods for getting an understanding of use situations has been introduced in the PD tradition. Ethnomethodological approaches have introduced the idea of video-ethnography (Suchman & Trigg, 1991) as one way to understanding use situations. But what does it mean to understand a use situation when working with users? An early and useful framework for this was made by Kensing & Munk-Madsen (1993).
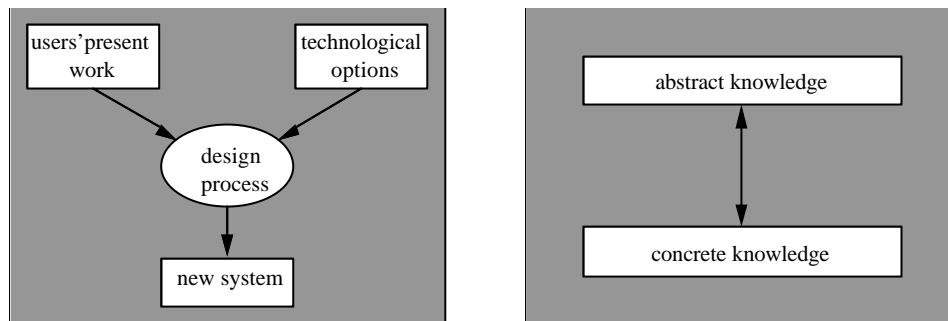
Figure 1:   Three areas of discourse and two levels of knowledge in the participatory design process (Kensing & Munk-Madsen, 1993)

They suggest that we consider three different areas of discourse: users' present work, technological options and the new system during the participatory design process. Further they suggest that we for all three areas of discourse make a distinction between abstract knowledge and concrete knowledge. Using e.g. video-ethnography is a way of getting concrete knowledge about users' present work, whereas setting up an organizational hierarchy is a way of getting abstract knowledge about users' present work. We can assume that users already have concrete knowledge about their present work, but not necessarily abstract knowledge. The ability to formalize or abstract structures of concrete situation is what is often referred to as tacit knowledge – we know how to do something, but we are not able to explain how. Like when we are bicycling. Designers usually do not have concrete knowledge about users' work, but are often offered formal – abstract – descriptions of users' work. In order to engage users in design of their own environments we believe that users and designers should have knowledge on both levels in this area of discourse. Users and designers can be considered two different communities of practice (CoP - see below).

1.1.2   Communities of practice

The concept of communities of practice has been coined by Lave & Wenger (1991). Originally it was used in the understanding of situated learning processes in organizations, but has also become quite influential in participatory design, as a way of understanding relations betweens different groups of users in a specific context (Wenger, 1999). According to Lesser and Storck (2001) a community of practice (CoP) is "a group whose members regularly engage in sharing and learning, based on their common interests. One might think of a community of practice as a group of people playing in a field defined by the domain of skills and techniques over which the members of the group interact. Being on the field provides members with a sense of identity—both in the individual sense and in a contextual sense, that is, how the individual relates to the community as a whole." It is useful to consider designers as one CoP with a certain set of skills and techniques, and different user groups as other CoP's with other sets of skills and techniques.

1.1.3   Experiencing the future

Experiencing the future is essential when it comes to letting users engage in design of digital artefacts and their contextual use. It is important that not only designers are competent and have experience in this area, but that users also get a 'touch and feel' of the digital artefact and its use-context. Mock-ups, prototyping, and use scenarios are well-known methods for this (see e.g. Kensing & Munk-Madsen, 1993). A more recent method in this area is video prototypes, where users and designers together direct and film short 'trick-video' simulating working designs (Madsen 2002). Another direction, which has been tried out in this project (see later chapter on High Tech Hunters), is experiencing the future by *playing with technology.* By letting users play with different digital building blocks (like a PDA, a mobile phone, a hand-scanner etc) difficulties, new usages, interesting combinations, anxieties etc. are revealed. In such a situation it is crucial to make the users feeling comfortable with the technology, by ensuring them that they cannot harm the device or cause any major problems by trying out – almost like when children fearless press all the keys and click everywhere with the mouse.

1.1.4   Transcending practice – engaging users with cultural probes

To transcend well-established practices and habits based on many years of experience, it is necessary to establish and use methods and means that allow viewing well-known situations and environments in a new way. Metaphorical design (Madsen 1994) and future workshops (Kensing & Madsen, 1991) are early attempts this approach to design. Cultural probes can be considered as another method based on the idea of transcending practice. Whereas the first-mentioned methods have their roots in the Scandinavian systems development tradition based on a socio-technical approach, the cultural probes method has it roots in an artistic, design-oriented approach.

Since the idea of using cultural probes was proposed by Gaver et al (1999) it has received substantial interest among the research community of interaction designers oriented towards conceptual design of interactive digital devices (Gaver & Dunne 1999, Crabtree et al 2002, Gaver and Martin 2000, Hemmings et al 2002). The applications of cultural probes have – as we see it – developed into two main directions, which we in the following will categorize as the *inspiration-direction and the information-direction.*

The pioneer version of cultural probes belongs to the first direction. It was developed at Royal College of Art, Computer Related Design by Bill Gaver and focused on how the use of cultural probes among participants could inspire the design process. This use of CP took its starting point in the profile of the research group who mainly consisted of academic-artistic group members, who worked on how to redesign three different community sites in Norway, Holland and Italy. The idea of these probes was to provoke inspirational responses from elderly living at these sites (Gaver & Dunne, 1999).

The information-direction of cultural probes has developed from the design research community oriented towards use of ethnographical methods in the design process. Pioneers in this usage of cultural probes have been the Cooperative Systems Engineering Group in the Department of Computing at Lancaster University, who has a long experience of the use of ethnography in design.

Another dimension of the appropriation of cultural probes can be seen as the *users-designers dimension.* When Gaver and Dunne (1999) talk about cultural probes as a means for provoking users in order to get inspiration for design, they talk about the designers' inspiration. But we believe that the 'friction' contained in the probes design can also work as a way of inspiring users to create new use situations and to look at their environment in a new way – with new glasses. The K3 nomads study (see chapter 2) is an example of users being inspired to change their way of looking at their daily environment.

Yet another dimension could be the *abstract-concrete dimension* as introduced by Kensing and Munk-Madsen (1993). If we apply this dimension we will see examples of cultural probes applied for both getting abstract as well as concrete knowledge about the participants working or living environment. The Tryckolera CP-study (chapter 3) contains several examples of how CP here helps to gain very concrete knowledge about the users' living environment. In the other end of the scale the K3 nomads CP-study gave us abstract knowledge about students' use patterns of the school facilities.
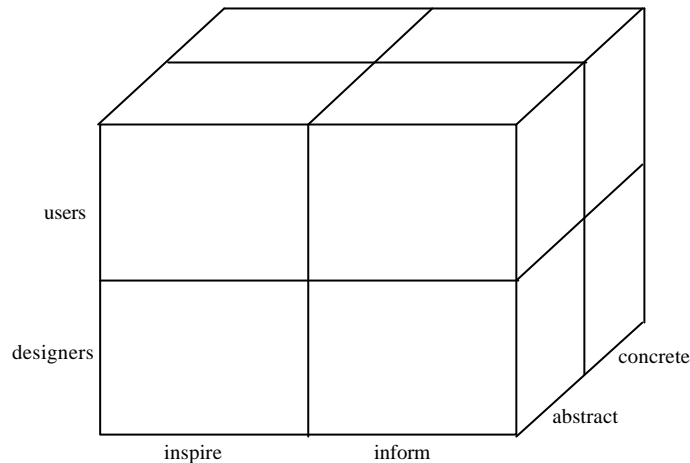
Figure 2:   Different appropriations of cultural probes based on relations between: users-designers, inspire-inform, abstract-concrete

When we in chapter 2 and 3 present our use of cultural probes at the two sites we will frame the uses by these three dimensions as a way of understanding the methodological challenges, strengths and weaknesses of using cultural probes in our settings.

1.2 Terminological considerations in PD and usability

That this project has been carried out in two such essentially different environments as K3 and Tryckolera/Certec has resulted in vitalizing the methods discussions, both within and between the two locations. Since we have theoretical and methodological traditions that in some ways overlap and in others are different, we were inspired to compile some of the most relevant concepts for participant centering and participant engagement that were included in the interactive design that we were trying to implement. The list was quite extensive—so extensive that it, in and of itself, generates the thought that the different concepts / theories / methods are, perhaps, identical in the long run. If that is the case, it is only the original disciplines and contexts that differ and that resulted in different terminology. The consequence of this is that further on, it might be fruitful to unite what is central in what the different researchers have supplied and from that develop qualified guidelines. This work is in progress.

Through our methodological work and discussion we have selected some core concepts which are listed and described in table 1 below.

The design process can be more or less *user adjoining*, and the design results more or less *useable* and *useworthy*. None of these aspects have the character of either or; they should rather be analyzed and described by means of sliding scales. The aspects may be independent or dependent. It could be that there are context bound connections between them, for instance between the degree of adjacentness in the process and the degree of useworthiness of the results.

Concept/method/theory	Researchers, key sentences, special references
Affordance	What an every day phenomenon has to offer a person depends to a great extent on that person's wishes and abilities. (Norman, 1988)
Useworthy	Useworthiness in a phenomenon is determined by the wishes and abilities of the person using it. Useworthiness and usability are not synonyms. (Eftring, 1999)
Abduction (the logic for synthetic reasoning, a method to acquire new ideas)	In user-oriented design it is particularly important to be able to bring to light not only the different things that one sees using different kinds of mental eyeglasses, but also what it is that constitutes the actual glasses and the difference between them. (Alvesson & Sköldberg, 1994)
Distributed cognition	To place cognition in surroundings in the real world, often in the form of artifacts, is a widely propagated conscious and unconscious method. The possibilities it offers for people with cognitive limitations are under utilized. (Hutchins, 1996)
Tacit knowledge	Tacit knowledge does not only exist in individuals and groups of people—it can also be found built into environments and work places, in professions and traditions. It is often a counterpart to more explicit knowledge. (Rolf, 1991)
Phronesis	Aristotle. Along with episteme and techne, according to Aristotle, was the area of phronesis—that which dealt with "the human being and her actions". We experience that the user-personal design has a strong element of phronesis (Nussbaum, 1990).

Table 1:   Concepts related to methodological discussions about engaging users in design.

A decent assumption is that the greater the difference is between the designer's and the user's worlds of concepts, the greater is the need for a *user adjoining* design process, and the greater is the applicability of the sentence "You cannot know until you have tried". This is rather impressive when designing communication facilities for differently abled people. A communication artifact resulting from a design process is supposed to represent a *distributed cognition* not only to the designer but also to the differently abled user. This strengthens the need for adjacentness in the design process.

2   High-tech hunters and K3 Nomads

Two pilot cultural probes studies have been done with students at K3: The High-tech hunters (HTH) and the K3 Nomads (K3N). We are using the tribe metaphor to stress important characteristics of how the two user groups use, move around, and collaborate in their learning facilities and environments. The HTH study included 3 users who were equipped with a 'technological probe' for two weeks. The K3N included 9 users who got an 'SMS-probe' for one week.

2.1   Arts and Communication — K3

K3 is short for Arts and Communication (Konst, kultur och kommunikation) at Malmö University. It is a cross disciplinary 'faculty' with approximately 600 students and 50 staff members. Malmö University is a young university, established in 1998 in the industrial harbor area in Malmö. During and since its establishment K3 has focused on how to integrate digital technology, the physical environment, and the pedagogical approach as stated in Ehn (1998) and in a pedagogical manifest formulated as ten pedagogical principles (K3, 1998). Research studios as well as education programs are based on the ideas and visions of these manifests.

2.1.1   K3 — pedagogical directions, school profile, facts

As the pedagogical principles at universities starts to move away from the conventional classroom culture, towards a project and problem based learning (PBL) environment, new tools for communication and cooperation are needed. In PBL the process of learning is equally important as the result. Furthermore access to learning resources need to be much more flexible both in terms of *where* and *when* to access these since a PBL approach implies that learning most often takes place outside the lecture room, and beyond scheduled teaching hours. This has been strengthened by the fact that economic pressure at the universities has forced more students into the learning environment than originally planned for. A consequence of this is that students cannot have their own, permanent classrooms or 'studios'. Communication areas and areas for relaxing have to serve as complementary learning environments. We consider this very challenging and inspiring, and not necessarily a negative consequence of the growing number of students. A main question in this project is how to technologically augment a mobile, collaborative learning environment like the one at K3, Malmö University. At K3 interdisciplinary projects involving different educational programs are an important part of the teaching philosophy, as a part of the idea for the Digital Bauhaus (Ehn, 1998). As mentioned earlier the Digital Bauhaus aims to combine new communication technologies with softer values such as art, culture and design. This implies that learning resources often are multi-medial, i.e. can be text, graphics, sound, video, as well as physical models and materials.

2.1.2   K3 — the physical layout and architecture

In order to understand how the K3 environment could be augmented and transformed into a mobile, collaborative learning environment the physical layout and architecture should be explained (see figure 3-6). The total area is approximately 5000 m^2. The overall architectural idea has been to put all 'function'-area along the outer walls of the building.

In the left part of the ground floor (figure 3) are mainly research studios. In the right part of the ground floor are mainly labs, project rooms for students that can be booked for shorter or longer periods of time.

Second floor (figure 4) primarily contains lecture rooms and project rooms.

The basement (figure 5) primarily contains computer labs, lecture rooms, and video- and sound editing facilities.

Figure 3:　K3 ground floor
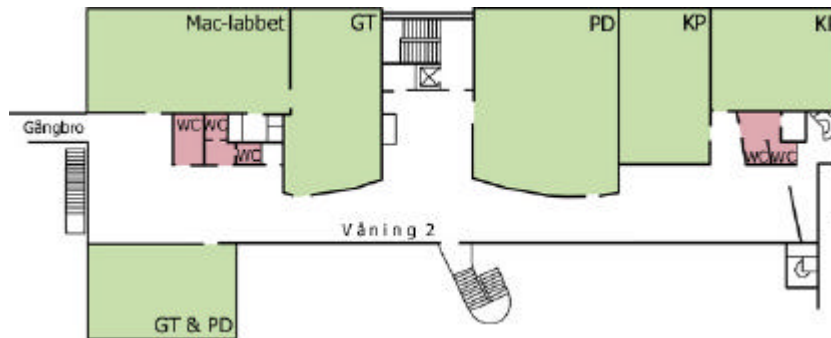
Figure 4:　K3 second floor

Figure 5:　K3 basement

The most interesting parts of the building in our respect are the 'white' areas – what architects normally refer to as communication areas – between the function spaces. Compared to usual work places we have a substantial amount of

communication areas which are equipped with café-tables and -chairs, sofas, coffee-tables, 'computer islands', a wide stairway (which can also be used for sitting on), notice boards and open wall areas for exhibitions etc as the photos from students' project activities on figure 6 show.

An important question that we ask ourselves is what it means to be working in a group, and how such collaborative learning situations in an open, mobile environment can be augmented by digital artefacts?

Figure 6:   Students working in the 'white' areas

The K3-students move freely both in closed augmented spaces like the university facilities, a student corridor, and a library; or through a non-augmented spaces like the city center, a cafe, etc. The mobility outside the augmented spaces is constrained in terms of connectivity to digital resources, which we in the following define as 'communication constraints'.

2.1.3   Hotspot and collaborative displays - an early design idea

Once in the augmented space, it is obvious that the availability of the different indoor spaces is what will define the workspaces for the project groups. We also consider the 'white space' a so-called potential 'HotSpot' - an open usability lab where different technologies could be tried out in a prototypical way both in user-centered and product-centered analysis. The administration of such spaces has evolved in a similar way at many universities around the world. In these open areas, both a social and work-related interaction takes place. Such spaces differ from the more closed project rooms because of an obvious lack of intimacy, loud background noise, etc. There is a constant change of the group working locations, and students move among groups for joining different projects, which makes it very difficult to set up a physical space, that can be personalized by the group-members. This raises another interesting question: How can we support the project-groups with personalized spaces, which can quickly change between different project settings?

In an earlier scenario (Nyström, 2001), we created a concept of a movable projection wall, where different devices could get connected simultaneously, giving non-prioritized access to the display, where the project members could interact freely using their own devices. We envision such a wall to be used both for limiting and augmenting the workspace. In this way, by virtually storing the project display configuration, the configuration can be changed easily by detecting which kind of workgroup is present and close to the screens. Such a concept is feasible today using existing technologies: high frequency ultrasound signals for the direct interaction with the screen, low frequency ultrasound for the group-members positioning, projection walls and sound speakers; all integrated by an adequate software design and communication platform. An important part of our project activities during 2003 will be to create prototypical designs and study whether such

a setting would be useful in a collaborative learning situation, and if it would provide the group with enough intimacy and other qualities as described above.

2.1.4   First experiences with technological infrastructure and facilities

Today K3 has an ordinary LAN, and access to computers from all labs and studios. The open space has – so far – one computer 'island' with four basic computers mainly for reading and sending emails and for searching for information. Everybody (staff and students) at K3 have an account and profile stored on a central server, which contains the individual documents, mail catalogue, access rights, web area etc. This means that everybody can access his or her files from any computer connected to the network, just by logging into the personal account.

Our vision is to give access to these resources anywhere at K3, and in a way allowing for a more collaborative way of working. One issue of this project is to create a communication platform which allows users anywhere and anytime to access their personal digital resources from a wide area of difficult hardware platforms ranging from conventional desktop computers to small handheld devices.

In terms of creating a *communication platform* we have so far tested out a few technologies (for a technical analysis of these, see chapter 4):

- One W-LAN base station has been set up in the open space on the ground floor. Everybody with a W-LAN equipped portable computing device and a K3 account can have network access when sitting in the open space on the ground floor (it even covers some of the labs and studios). This gives access to any of the personal, digital resources (email, fileservers, web access…).
- Experiments have been made with mobile access to resources even outside reach of the W-LAN. For this the Anoto-pen and a GPRS-enabled mobile phone were used. Phone and pen communicate via Bluetooth, and the phone communicates to a central server via GPRS. This 'kit' allows for extreme mobility. First of all connection can be made anywhere. This Anoto concept allows the user to produce a handwritten object and mail it through a GPRS-based service. It is even possible to receive small handwritten notes, and SMS's via the phone. In an ideal setting students should be able to communicate directly to the Bluetooth access-points placed in the K3 environment (see next bullet), but even at public places which are frequently used for students work. The GPRS-based solution is – to put it very frankly – too expensive compared to a student budget.
- Finally we have set up a couple of Bluetooth access-points, which allow different Bluetooth enabled devices to communicate with the access-point which in turn is connected (through usual LAN) to a central server. Unfortunately either the pen or the phone is able to communicate with these access-points, but our aim is to gain experience and insight and hopefully be able to establish direct communication from Bluetooth enabled devices to the Bluetooth access-points. We have attended a development course in the Anoto technology – as part of the collaboration we established this industrial partner. At this occasion we learned about the possibilities on how to use the pen and paper, which helped us to understand the technical limitations of the technology, and the still non-explored applications.

In terms of creating a *display concept* that allows for more *collaborative activities*, we have not tried out any commercial digital solutions yet. We have worked on a conceptual level with mock-ups and scenarios:

- In an earlier pilot project we developed a conceptual design for a collaborative solution, and tested out this in a series of scenarios and workshops. This concept consisted of a big display where members of a group could submit the content of their PDA to a shared display. The vertical displays could also be used

- as room dividers hanging from the ceiling, or even as displays for exhibiting students' artwork, when they are not used for group work (Nyström 2001).
- Other discussions have touched upon the possibility of shared table (horizontal) displays, which can be used as input as well as display (output) device. In an exam project supervised by one of the mobility and learning project members a *tag and track table* was designed, in order to support collaboration between people in creative activities, by allowing a tactile interaction with design material in a collaborative setting. This table was implemented by combining back projection and video-recognition of different colored tags attached to design material (Eden et al. 2002).

The issue of designing or configuring and existing display for a collaborative mobile learning environment is a main challenge during 2003. We believe that one of the major obstacles for creating a collaborative learning environment is overcoming the small individual working spaces and displays.

2.2 The High-tech hunters

This cultural probes study took place during a two-week period October – November 2002.

2.2.1 Aim of probing

We had several purposes of setting up this CP study. First, it was our initial experience with cultural probes. Second, we considered it an interesting way of getting non-experts' experience with and opinions about the mobile technologies we considered to integrate into our design of mobile learning environments. Third, we hoped to get informed about aspects of students' learning environments that we would not be able to study by more conventional methods like e.g. video-ethnography. More specifically we wanted to:

- analyze how students working within a PBL environment develop a project in a constrained period of time
- study a case where the digital pen technology is used both for communication, collaboration and documentation
- analyze migrational policies of students within the micro-space of the school, the one at their homes, and the city

2.2.2 Recruiting and selection of participants

In this first version of the pilot study with application of cultural probes *we* selected the participants, because we wanted a collaborating group, and because we wanted students not only working with text based learning resources. Three MVD (material and virtual design) students were chosen: one female and to male students. At the time for the probing study inter-disciplinary workshops were going on at K3. The three students all participated in a workshop about construction of mobile sculptures. Furthermore one of the workshop teachers is also a member of the research group, which made it easier to follow parts of the CP process as it went along.

2.2.3 Probe design

The probe design was oriented towards recording traces of the students' work and life as well as towards provoking them to think differently about their own working environment. Each probe consisted of the following items:

- a chatpen and a mobile phone with an Anoto sketch book, and post-its for short emails and SSM's
- a ruler 30 cm long
- 8 pens in different colors
- 5 sets of round stickers in different colors

- scissors
- maps of Malmö in A3 and the city-center zoomed in A4
- clips
- tesa-film
- a racket or a frisbee
- a polaroid camera and two films (24 pictures in total)
- a folder for storing the different maps
- a folder for objects collected in the process
- a bag for carrying the whole set around the city
- a rubber spider for collecting their fears
- an empty CD for storing the digital material that they produce
- a CD with music for inspiration

The three sets were almost identical. The three CDs with music contained completely different styles of music, and they got different toys each. The sets had a general color for distinguishing them from each other: white, red, and blue. The aim of these differences was to make the sets more personalized.

2.2.4   Probe process

Before starting the probing process the project and the idea of cultural probes were presented for the group. The three MVD (Material and Virtual Design) students were working in a two weeks long probing period where their task was to design a mobile sculpture. They are used to work with design tasks in groups. They discuss about three-dimensional forms using both sketches and models made of paper and other materials. Looking for inspiration they like to change the room they're working in. When approached asking about the possibility of working with cultural probes they showed a lot of interest. The group consisted of four members, but we provided probes just for three of them. The reason was basically that we had only three pen-phone sets, and we wanted to analyze how they could make use of such a technology combined with other "traditional" tools.

The test group agreed with us to document their working process, their inspirations, and prototypes. The only thing that we demanded from them was that they had to use the maps in the form of a diary, tracing where they worked and how they did it directly on the maps

After two weeks we collected all the material that they produced for a further analysis, as described in the following paragraph.

2.2.5   Analysis of collected probe material

In the following we are analyzing not only the material that we collected, but also the kind of impressions that we got from the students that participated in the experiment. We also analyze the feedback we got regarding the method itself, since this is important during this part of our project. In the HTH study the use of cultural probes was mainly *informative* about concrete knowledge on a) users *current work* and b) the *technological options*. But we also got concrete knowledge about c) the users' *visions of future design*.

We got useful information about the limitations of the technology when trying to use it in several every-day situations. It was informative because the users reported about their own visions for technology, and linked the non-technical probes (maps, markers, etc.) to the technical ones, proposing the use of maps with Anoto patterns for getting digital versions of their way through the city, what would help them to link their ideas to the place where they came up in an easy way. This showed that the users could go much further from what we ever expected at the beginning.

On the other hand, it was also *inspiring* since it revealed users' visions about how standard mobile devices could be used in new settings.

On a methodological level this study has inspired us a lot on how to design CP, how to handle information to users in creative ways, and how to gather information of very private character in a non-intrusive way.

We are still analyzing part of the material that we got back from the students, because we would like to compare the results with the ones that we got from the second case that will be presented later in the next section (2.3 K3 Nomads).

During this CP study, we had three interviews with the three participants, which gave us an idea of the kind of problems derived from complex technical probes like the Anoto pens. This made it easier for us to see how much each one of the students had been working with the use of the technology, and how they had been tracing their activities in the city, the school, or their homes. In a way, we were very lucky in the experiment, because the three participants had very different styles of studying.

USER 1: THE ENTHUSIAST

Our first user has been working as web-designer for the last seven years, and works using a notebook for documenting all her work. Once the notebook is filled up with notes, she transcribes those to the computer, and scans the pictures. The whole process is very time consuming, but she likes to follow it, because every idea as very valuable in her later work.

She is very positive about the process of mapping activities; she attaches her memories to places, and likes the idea of being able of remembering how things happen in time. Her documentation has been done in a very careful way, taking care of the different events along the day. She hadn't thought about such a system before, but she plans to use it in the future.

When it comes to the technological probe, she is very enthusiastic about the possibilities that the normal use of the pen brings to her. It would save her a lot of time, since everything can be stored directly into the computer, and she automatically would get a file-structure of her sketches or notes since these are given a 'subject' and a date stamp, which she can sort by or search among afterwards. Of course there are drawbacks, she tried to use the pen during a normal lecture situation, where she had to take lots of notes, but after one hour she had to stop, because the size and balance of the pen made it hard to use.

USER 2: THE BETA-TESTER

This user is a former engineering student, very methodic in his way of working. He has moved to the city recently and therefore doesn't know that much about the city. He constantly asks questions about the process and even thinks about the use of CP in his own design process. The computer is an every-day tool in his working method, e.g. if he is going to build a prototype, he first works in paper, then jumps to the 3D modeling, and finally starts to treat the materials.
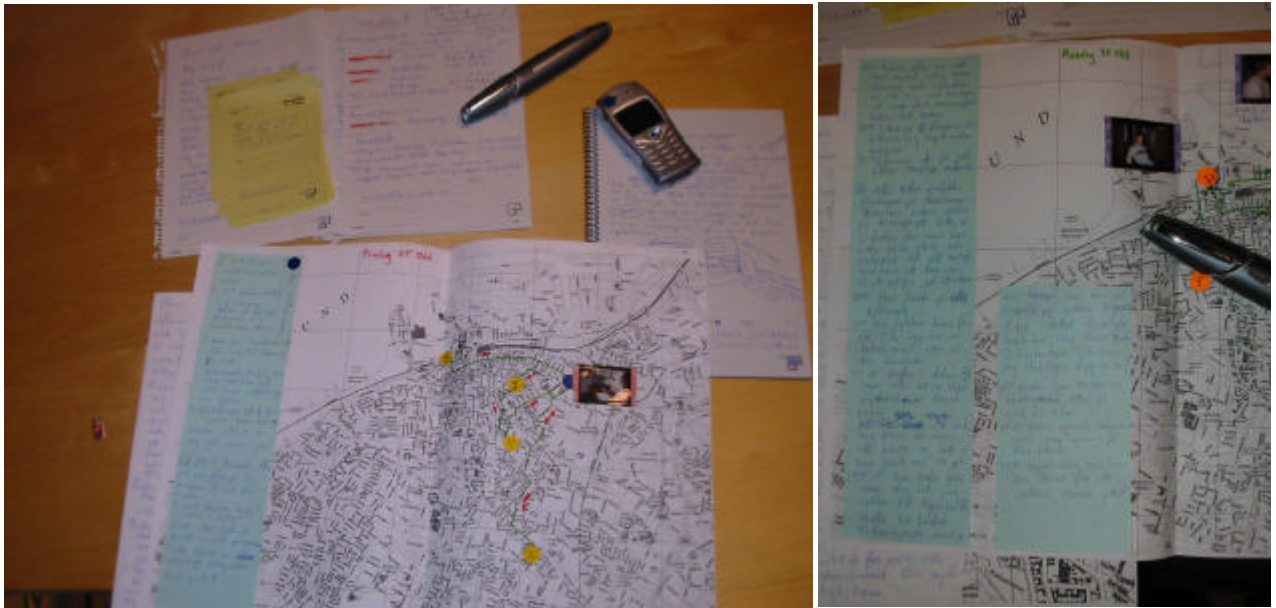
At the beginning he created many expectations for having access to the technological probes; especially for the chance to use the Anoto technology. He has a PDA that he uses constantly, so it is a chance for him to see which one of the artefacts that fits him the best or if they can supplement eachother. He had lots of problems with getting the technology to work, because the equipment arrived with some defect when we got it. That, together with the fact that he couldn't use the pen exactly as he had expected, makes him dislike the technology for his own purposes. He proposes lots of ideas of how he would like to use it; therefore we decided to call him "the beta-tester". He played the role that beta-testers do in software development, analyzing if the system is doing what it should and thinking about possible improvements. In his analysis of the pen, he used terms like "it is only one-way, it is not possible to receive information". Then, on a further analysis about the use of graphical capabilities on SMS, he said: "the graphics for SMS are not really working, if you go into details it's just blurry … it's a pen for ideas, sketch ideas, but not details". About the personalization of the device: "if you own one, it is more useful, because you get used to it". The cost of the materials where commented, too: "the paper is too expensive, I use lots of it". He would like to have OCR capabilities, and the pen connected directly to the computer, he thinks that would make the work easier, and that he would like to have "live-feedback" on the display. On the other hand, using the pen as it is today, he reflected about the real use: "why should it be sent to myself? I should send it to someone else, since I have the copy in my notebook". Furthermore, he thought that it would be too dangerous to carry the pen around, it's price makes hard to buy a new one, in case of loosing it.

He liked the idea of using the maps, because it helped him to get to know the environment (since it was new to him). But he thought that it was a lot of work to sit down and filter the kind of things done during the day for writing about them in the map. He thinks, as the first user, that it is important for their creative process to have access to the "physical" representation of the creative process. Inspiration happens in a certain place under certain circumstances, for going back to a certain idea, many times we have to trigger our memory with objects that were present in the place where the idea happened.

USER 3: THE SKEPTICAL

This user is a Malmö-citizen, where he was devoted to the production of music before starting to study at K3. He is one "old-school" kind of artist that works

physically with the materials. From the beginning he didn't show that much interest in using digital technology like the pen for his everyday processes. His opinion in this way is very valuable, as skeptical to technology.

Concerning the working process he talked about the fact that the length of the experiment was too short to make the process become natural to him. Many of the things needed to be reprocessed afterwards, once at home in the evening, after the whole day working, what made it time consuming.

The technology was interesting to him, but only at a certain extent. He talked about the use of the tools, but he thinks that it was too expensive to feel confident enough of carrying it around in the city.

2.2.6   Discussion of CP-study and consequences for future CP-design

In the following we discuss the analysis of the HTH cultural probes study and relate it to our methodological considerations and framework.

INFORMING ABOUT K3-STUDENTS OR INSPIRING DESIGN?

Our first reflection about this experiment is that, a CP-study needs to be prepared carefully, taking care of the details that we want to gain from such a study at a very early stage. Issues like engagement of users, ability for using technical probes, period for having and using the probe, are as important as the question to address.

This first CP-study left a lot of room for interpretation by the users. It is not actually bad, according to the material that we got from it. But it would be better to use a more restricted set of constraints in future experiments. Here we wanted to analyze the method itself, and therefore the users had to have a lot of freedom to try out things. The probes were designed and distributed with instructions like "use it as you want to", "return us a map describing you activities", "filter out activities yourself", "categorize the most relevant actions taken each day", etc. Instructions that, in a way, were very vague, letting the users room for experimentation.

For future CP design it will be interesting to use some method of synchronization that activates the activity in the users, so that the fact of doing the report will become like a game and not any longer an obligation. Actually, our second CP-study uses this method in a very successful way, as it will be explained later.

2.3 The K3 Nomads

This second CP-study was done ultimo November – primo December 2002. Because the probes were returned very recently this report only contains a very brief analysis of the process and the collected material.

2.3.1   Aim of probing

As mentioned in chapter 2.2 the HTH CP-study had some methodological problems. First a 'technological probe' requires a certain amount of time to get used to the technology that is contained in the probe. Second, the users' complained that many of our requirements were too time consuming. Finally, we would like to see if we could prompt users to make 'snapshots' at unexpected moments. In this way we can also get a more 'ethnographic' picture of the students' life, while it at the same time offers a more playful attitude to the participants. We believe that the playful attitude can create an engagement among the participants.

2.3.2   Recruiting and selection of participants

We wanted to have more probe users in this study. An announcement telling about the study was mailed to all students at K3. The only requirement for participating was to have a mobile phone. The first ten students replying to our announcement were chosen. Later it was reduced to nine because one never showed up. The students represented a variety of education programs, levels and both genders.

2.3.3   Probe design

At an early stage of this CP-study we adopted a metaphor for the students as nomads, roaming around the school, camping in the lounge suites, the workshops, and the computer labs.

The probe kit, placed in a customized bag, consisted of (see also figure 7 below):

* Ten different colored envelopes containing various assignments.
* A disposable camera
* Two maps of K3
* One map of Malmö City
* A pen
* A glue stick

Figure 7: The K3 Nomads probe kit

2.3.4   Probe process

SCENARIO

A typical day of the project is opened at 10:00 when the students receive a message telling them to open the green envelope. The instruction requests them to gather as many as possible of the participants in the project, as soon as possible to take a picture of the group.

The next message is sent out at 13:00, asking the students to photograph their current location.

The last message of the day, sent at 17:00 tells them to use the enclosed map of the city to show how they have moved in the city during the day.

SMS-PROBING

As the life of a student often tends to be quite hectic and demanding, we wanted the probe assignments to be welcome interruptions rather than additional burdens. Therefore we saw a need to emphasize the ludic aspects of our probe and decided to adopt the theories as described by Gaver (2001). Thus, the probe was given the characteristics of a game. A game based on elements of surprise, catching the participants' attention when they least expected it.

Nowadays just about everyone is equipped with a cellular phone. We considered the SMS service provided with the phones as a perfect base for communication with our test group. We decided to send out a couple of SMS's every day, each containing

different instructions. These messages would prompt the participants to perform certain tasks provided with the probe kit. We believe that the answers we get from the questions or assignments are very different from the ones we would have got by handing out a usual questionnaire. The context you're in when you get the question will influence what you answer or how you do your assignment.

The question or assignments contained in the envelopes were these:

1. How many hours do you plan to spend at K3 the following week? How many hours on lectures, on group work, on individual work (see also question 10).

2. What is your favourite respectively most disliked place at K3? Mark by the attached stickers (hearts and skulls). Motivate your choices.

3. Where have been today? Mark on the attached map of Malmö. Add details if you like.

4. How do the facilities at K3 support a) groupwork, b) individual work? Motivate.

5. What have you done today to earn your study grant (studie medel)?

6. Find the other members of the K3 Nomads study and take a group photo. Tell us how you proceeded with this task – when did you receive the assignment and when did you finish it? Which difficulties and positive surprises did you meet? Reflect on how such a task could be supported.

7. What have prevented you from being efficient today?

8. Take a picture of the locations at K3, which you like most for individual work, group work, relaxing. This can be done anytime during the probing period. Motivate your choice.

9. How would you like to furnish K3? Use the K3-map and 'cut-out' furniture. You should not feel limited about the provided furniture – you can add your own if you like. Motivate.

10. How long time did you spend at K3 during this probing period, and on which activities? Were there some tasks or assignments you didn't want to do or questions you didn't want to answer? Why?

2.3.5   Analysis of collected probe material

Since this material has been collected very recently is has only been possible to make a tentative analysis of the collected probe material.

INFORMING ABOUT K3-STUDENTS OR INSPIRING DESIGN?

Students are often a very studied and evaluated population, and usually they tend cooperate during such studies, but the university environment still has some situations that are difficult to study using ethnographic methods. It can be felt obtrusive if researchers are present during classes and in a student's home environment. By using cultural probes we can get an understanding of more intimate and private parts of the learning environments and activities.

In this application of cultural probes we have combined the informing and inspiring approaches. Information about students' learning activities and related situations have been collected through the students' own recording of views, activities, wishes, complaints, etc in a series of time-stamped 'snapshots'. Our developments of the original cultural probes concept towards a more provoking and playful probe kit served its purpose well. The students engaged trying to solve their assignments, and were generally very positive to our project afterwards. However, the probing process can still be improved. One of the assignments (9), where the students were supposed to furnish the school using a map, pictures of furniture and a glue stick, tended to demand too much time of them. Some of the students did not finish this

task; they felt they had to put to much time and effort into it. Possible explanations can either be that the students actually didn't have time to do it, but rather that we did not make the students enough committed to the probes study. It was not obvious from the presentation of the probes study, whether they in the end would be able to have influence on re-design of their own learning environment by participating in this study.

2.3.6   Discussion of CP-study and consequences for future CP-design

Also this application of the CP-method convinced us that the method has many advantages, but that we can still improve it, and that it in some respects needs to by supplied by other methods.

Specifically the way participants are committed to the engagement plays a major role in how successful the CP study is.

If we return to Bødker and Iversen's (2002) notions and recommendations they state that "The existence of such 'why' and 'where-to' artifacts is essential to the successfulness of design of interactive systems and constitute the very basis of a professional PD practice". The essence of this is that it should be clear not only to the designers, but also to the users why they are participating and where they are heading. Motivation for spending time on something is that you get something out of it in the end, e.g. the possibility of influencing your daily working environments.

In future full-scale use of cultural probes we should consider setting up an initial workshop with the participants before the probing period. This workshop should focus on the project's overall goals and methods, and letting the participants have an understanding of this as part of the process of engaging users. Otherwise we risk to end up in a situation where users just play the role as 'users' in a politically correct process of participatory design.

3   Tryckolera

The most interesting difference between the Micromobility and Learning Project's two sites, at K3 in Malmö and Tryckolera in Lund respectively, is as follows:

K3 deals with enabling concentration and in-depth meeting places for groups in an open and relatively noisy environment—in this case it is a matter of finding compensatory mechanisms relative to the disturbances.

Tryckolera deals with introducing variation and disturbances in order to make what is already a varied, learning-friendly and participation focused environment even more varied, learning-friendly, mobile (PDA) and participant controlled.

Certec has cooperated with Tryckolera for almost a decade and the technology we have introduced there in close collaboration with Tryckolera has resulted in a fundamental change of their learning environment. All of this is documented in English and Swedish (WEB-02). Descriptions of a picture-based communication tool as well as a user manual are available on the Certec web site as well (WEB-03).

There are two key reports on the Issac Project available on the Certec web site, namely, [What Isaac taught us](#) (WEB-04) and [Art and science](#) (WEB-05).

3.1   Tryckolera – pedagogical directions, profile/history, facts

Tryckolera is a day activity center for adults with cognitive difficulties (WEB-09).

The program is situated on the bottom floor of an ordinary apartment building in a residential area in Lund. The first thing a visitor notices is the large picture rollers that cover two of the walls. On each of these there are hundreds of color photographs with bar codes. The rooms are open and light and there are no doors to the kitchen or the office. In order to increase contact between the rooms, they have made openings in the walls in several places as well. All the materials are stored in open cupboards or on tables to make it easier for the participants who find it difficult to imagine things that they cannot see.

In addition to the six people who have their daily activities at Tryckolera, there are two supervisors who are responsible for program content and administration.

Tryckolera started as an arts and crafts program with emphasis on pottery and screen printing. Since 1995, however, they have focused more on developing and using pictures as a source of knowledge, means of communication and artistic tool.

What characterizes the program is that whatever they do is always based on the participants' requests, dreams and needs. Since several of the participants cannot speak, pictures are necessary for revealing thoughts and opinions.

3.1.1   Activities

Socializing is central to Tryckolera and that is why they take every opportunity to come up with activities that result in the participants gathering together to do something that the entire group experiences as meaningful. They have, for example, chosen to grow vegetables in a garden plot near Landskrona. Each one decides what he or she will cultivate and is then responsible for purchasing the seeds, sowing them, weeding, harvesting and preserving the produce. They bake their own buns and cakes for coffee breaks and at least once a week they prepare lunch together.

Many steps in the food preparation process have proven to be very difficult. Thus, the supervisors have consistently and for a long time used other activities to train hands-on activities that can be used when preparing food as well. By rolling balls of clay, the participants practice what it is like to roll meatballs or dough. Using a screwdriver is motorically similar to turning a piece of meat over in a frying pan with a spatula.

It is also the participants' job to report if they are low on beverages, fruit, coffee and other groceries and in that way ensure that someone does the grocery shopping. No one at Tryckolera can manage the entire process on their own, but they have their areas of responsibility assisted by the supervisors, who help them to tie the steps together so that they can complete the whole chain of events.

The coffee breaks also require cooperation in fetching and putting the cups, spoons, milk, and coffee cake on the table and in cleaning up afterwards. One person is responsible for the café and collects payment for coffee, soda and coffee cake.

Another social activity the group enjoys doing together is watching TV/video. Many times they want to watch videos about themselves, but there can also be an interesting TV program that results in an exchange of thoughts. Even though they may have seen the video a hundred times, they continually discover new details that they ask questions about resulting in conversation.

In addition to the joint activities, each one has many opportunities to realize his or her potential by engaging in activities of special interest. One likes repairing bicycles and is given support in doing so. Another wants to find information on the Internet and spends a good amount of his day at the computer. A third likes to build complex constructions with Lego and a fourth wants to look at pictures in a catalogue in preparation for a shopping trip.

What all the activities have in common is that they are self-chosen. The supervisors' role is to provide support when the person so wishes but also to create the prerequisite conditions for different choices in order to give the participants opportunities to expand their repertoire in a narrow area of interest.

Because Tryckolera is a pioneer in using digital photographs, they have many groups of staff, relatives and people with cognitive limitations who come for study visits from all over Sweden. In order to carry out these visits, everyone is required to contribute with practical work but also - for those who are able to - tell about the organization and their own role.

3.1.2   Certec and Tryckolera

Pilot studies for this project can be said in a way to have been carried out over a 10-year period—which is how long the contacts and joint projects between Tryckolera and Certec have been going on. At the same time, something new is now being introduced. For a long time we have been looking for possibilities to further improve learning at Tryckolera, an organization that is already unique. With this in mind, we have initiated and interacted with Göran Plato, the initiator and pedagogical mentor, being able to see our suggestions carried out (though seldom as we originally had thought but according to Göran's artistic questioning and reformulation) and subsequently studying the effects of these efforts.

The Mobility and Learning Project urges us now by virtue of its mere existence and the interaction with K3 to initially, if anything, step aside and actively look for such phenomena that show that what is being carried out is not enough to meet the participants' needs.

As we now try to see the possibility for renewal through new eyeglasses, abduction requires (Alvesson, Sköldberg, 1994) that we not only should be able to describe what is new in what we see, but that we should also be able to discuss what is new about the "eyeglasses" through which we see it. A first attempt at this can already be found above: we are now *actively* looking for such phenomena that show that what has been done so far *is not enough.*

3.1.3   Special education considerations

Knowledge in the head and *two* interacting kinds of knowledge in the world are always present at Tryckolera. Digital pictures as a representation of the world have yielded *the* most important knowledge of the world for our users. That is, digital

representations have a much greater potential to awake and interfere with their already existing knowledge and patterns of thought than real objects have. Now we are interested in the possibility of strengthening the bonds between simultaneous digital representations and real objects and to observe and work with the interaction between these two and the knowledge in the person's head.

If you study the efforts of one of the participants to learn how to use a yard stick in *What Isaac taught us*, you find a clear example of how impossible it is for him to learn from an ongoing process and how easily he can learn by studying the still pictures afterwards. It is as if he needs to *see* himself in the situation but from the outside.

The same goes for collaborative learning. He cannot observe the learning process along with others while he is involved in it, but if we can find a way of creating a *digital representation* of him in a collaborative learning situation, it could change a lot. Thus, we want to invent a kind of mirror that makes collaborative learning more visible for the collaborative learners.

Even with the focus on *inspirational* learning, it could be that imitation and conditioning are the two atoms of learning. You not only imitate others but yourself as well. And you are conditioned not only by others but also by yourself. Can this insight be used for something meaningful in the project?

A teacher's most important role is to offer *structure* and broaden *horizons.* If the Mobility and Learning Project can make the environment more inspirational and learning, then the increase in possibilities for teachers to help structure knowledge and broaden horizons forms a part of the outcome and should be measured in one way or another.

3.2 Background to the *idea generator*

Tryckolera is a living environment, teeming with activity. At the same time, it is entirely dependent on Göran Plato for the generation of new ideas. The Mobility and Learning Project has inspired us to try to construct an *idea generator* at Tryckolera.

The function of the idea generator is to inspire the participants to break out of their routines. If it is possible to introduce a tool that can offer new ideas based on a guided yet random principle much broader and more often than what an individual supervisor or assistant can manage, learning would take a giant leap forward at Tryckolera; it would also provide insight into the participants' areas of interest.

The concept of an "idea generator" already existed during the early years of the Isaac Project in 1993-94. It was implemented then by putting the question, "What shall I do now?" as an icon on one of the six functional touch keys on the screen of the PDA. It is interesting to note now, eight years later, that this line of thought was never utilized to the fullest. There have been many reasons for this ranging from difficulties with the technology to difficulties moving from a prompt to *initiating a drive*.

The book *Den obändiga söklusten (The Unyielding Desire to Search),* (Jönsson, Rehman, 2000) presents a schematic drawing of a "knowledge reactor". On page 104 it says, "The knowledge reactor is always working. Some people have a strong aptitude to develop full and varied associations (associative creative people). It is as if they were self-pollinating: the knowledge reactor constantly offering suggestions— "could it be that. . . " —and being on the look out outwards, and on the ball inwards. Not so difficult if you are collecting input all the time.

"In other knowledge reactors, the ability to create cross connections on one's own is very weak. People with these kinds of knowledge reactors easily develop monotonous inner thoughts, which in turn easily result in external rituals."

It is this recycling of thought that we want to compensate for by developing tools that constantly are prepared to come up with new ideas.

This short excerpt is meant to briefly provide the theoretical background to "The Idea Generator".

3.3 Tryckolera—bringing to light obstacles and needs

3.3.1   Aim of cultural probes

The relationships between the users at Tryckolera and the researchers at Certec are that long-standing that there was a need for a renewal of the cooperation. A conscious use of cultural probes is such a renewal – more or less just because it is conscious and more diverse. In one way, the cooperation has always been based on cultural probes. The digital pictures and the mail communication have had a probe character – the results have often been an unexpected response. For the designers, information about the competences, needs, wishes and dreams of the users is most often also an inspiration. For the users, inspiration is the most important aspect.

Besides prompting, inspirational learning is *the* form of learning that dominates the learning processes among differently abled persons.

3.3.2   Probe Design

In general, the people at Tryckolera who are going to interact with our probes need a long time to learn new skills. In order to save time and the users' trouble, we have chosen to focus on media that the participants had been in contact with in different ways previously. The probes consisted of

- picture mail,
- computer games
- home videos

In the first phase, the design was meant to provide a clear picture of the participants' areas of interest and needs so that during the rest of the project we will be able to present probes that are more appropriate.

3.3.3   Probe Process

Before we introduced our probes, we had carried out several extended visits at Tryckolera in order to get an idea of who might be interested in participating in the project and if they were suitable candidates. Simultaneously, we learned more about the daily routines and in that way came up with ideas as to how one could introduce different kinds of probes without making too many changes in these routines. We also video filmed the participants and the activities they were involved in during our visits. They received a copy of the video in the mail a few days later. From the start, these films were meant only to be used as documentation, but due to the interest that the participants displayed, we choose to continue using them as cultural probes as well. In order to make it easier for the participants to choose which video they wanted to see, we labeled each cassette with pictures describing what they contained. A system for borrowing the videos will make it possible for us to find out which videos are viewed by which participants and how often. The picture mail is something that many at Tryckolera are used to communicating with and it felt natural to also use them as probes. We currently view easy computer games as probes primarily as a source of inspiration.

After about ten visits as a pre-project in this research to observe again (but in a different way) the environment, the people, the activities and the interaction and with the aid of digital pictures, mail, telephone conversations and videos (used in part as cultural probes) try to bring to light obstacles in order to come further based on the participants' most important needs and wishes, we decided on two sub-areas for which we would like to develop micro-mobile opportunities:

- To pass information on
- To introduce an idea generator at Tryckolera

Here are two examples of how videos have been used as cultural probes:

A surprising effect of a video of everyday activities.

"During a study visit at Tryckolera we used the video camera to document what happened. A few days later we showed the video to some of the participants at Tryckolera who had been present during the visit. Towards the end of the video, another participant comes in to watch. He sits about 4 meters from the TV, sometimes looking at the screen and some times at us. After a few minutes there is a scene in which he is standing in the kitchen washing dishes. It is then that we notice how his total attention is focused on the TV. After a few seconds he starts to point at himself with his hand very energetically at the same time as he says "mi, mi, mi, mi." He starts laughing and his body language shows how involved he is in what is being shown on the screen. After a few more minutes, the video zooms in on some colored pictures of the participants' personal possessions. Again, he reacts very strongly at the exact moment his own keys and wallet are shown on the TV screen."

We have had regular contact with this man for several years, but it wasn't until that moment when we saw how he reacted to the video that we understood that he was able to recognize himself in a picture as well as his beloved possessions. The difference between sitting with him and looking at his photo album and watching the video is that the personal photos are so familiar to him that when he points at them in reference to himself, you can never be sure if he means that they represent him or that they belong to him. He had never seen the video film before and because of that, due to the immediate and obvious correspondence between his reactions and what was shown on the screen, revealed that it was definitely a matter of recognition.

For the continuation of this project it is, of course, important to know who can be reached though pictures.

Video for observation of one's self and for observation of friends

One of the participants at Tryckolera celebrated his birthday with friends and acquaintances. Many came with presents and then they all sat down in the café to have cake and coffee. Different stages of the birthday celebration were documented on video and a few days later it was sent by mail to Tryckolera. The content of the tape was evident from the picture on the cover.

Only two of the participants watched the first showing and they commented on the high-pitched voice of another participant who was not present and thought that it spoiled the party. Such comments did not occur during the actual birthday celebration, so it wasn't until they examined the events at their leisure that they discovered this.

A few days later they wanted to look at the video again and this time the "loud" person was also watching. After a few minutes he noticed his high-pitched voice and immediately left the room with a worried look on his face.

Our interpretation is that when these three people were caught up in the actual celebration, so much of their energy went to processing all the visual and sound input that they did not detect that one of them was so dominating. Afterwards, when they could study what happened in detail, it became suddenly apparent for all of them who did what, and in that way set the stage for them being able to discus the feelings they had about it.

3.4 Idea generator

Right now at Tryckolera they are beta testing a new Isaac software application, the final version of which will be released in January. It can store digital photos with corresponding sound and text (it is important that even those who cannot read can be conveyors of printed information—provided that they deliver it themselves). The picture packages are stored under tabs in albums, and what we plan to do is to simply download onto a PDA the entire contents under a given tab with *many* pictures of, for example, possible activities. The user can carry the PDA around and run through the pictures as an inspirational slide show (randomly arranged). We hope to be able to ascertain how much this is used in and outside of Tryckolera and what the users like and use the most

In the course of the project, this could be developed into a thought stimulating, random generator that continuously can be evaluated and updated. It would be both a solution and a cultural probe: "What is it that I really want to do *now* when I can actually do this or that?" What is it that soon turns into nagging, what is it that has an almost unlimited power of attraction so that it is chosen, day after day, month after month?

3.4.1   Dealing with every day information

The supervisors at Tryckolera (particularly Göran Plato) play a key roll when it comes to interpreting and conveying everyday information *to* the people at Tryckolera and *between* the day activity center and the person's residence. During our visits we have over and over again experienced how the participants become frustrated when we do not understand what they are trying to express or, even worse, when we misunderstand their message.

We interpret this frustration as one of many signs of the need for a tool that works as a sort of lubricant in daily communication. Such an aid cannot replace the supervisors' instinctive feelings and intuitions in delicate situations, of course, but could be a tool that one uses in relatively structured, daily routines and situations.

Three examples that demonstrate the outcome of planned and unplanned initial cultural probe studies are presented below. In order to give the reader some insight into what they are about, a list of the subjects of conversation that one of the participants *on his own initiative* repeatedly tried to talk about is presented first.

- How did I get to Tryckolera?
- How will I get from home from here?
- Shall I/we have some coffee?
- Shall I/we eat something?
- Do I have any children?
- He or she is sick!
- Newspaper on Friday?
- Is Bodil coming for a visit?
- What has NN said or done?
- Can I have what you're holding in your hand?
- Can I have some paper from your bag?
- What time will ......?
- Look at that!
- Who is going to drive the bus home in the afternoon?
- Can't you sit down on the couch with me?
- Thing about the contact person at home in the residence.

To convey information that is understood by those who can read and for whom the message is intended, and by those who cannot read, who are doing the communicating

On one occasion, one of the supervisors had to drive a participant home since the man had fallen ill. While the supervisor was gone, we were communicating with a man who has no verbal language. By using pictures, he could show us what his new apartment looked like and we could give feedback through pictures and spoken language. There were occasional misunderstandings and then the man used objects nearby to refer to the absent supervisor and the man who was sick. During our half-hour long conversation, he left the couch on at least five occasions to go the ten meters or so out to the kitchen where he asked the other supervisor for help in explaining something that he had not succeeded in conveying to us. On a few occasions, he felt he needed to bring her over to the couch so that she could address us directly.

During our conversation, we mentioned that it would be exciting to visit his new apartment and that we would bring a coffeecake if he provided the coffee. In spite of several visits to the kitchen, this proved to be such a complicated message that even the supervisor could not understand. Then we wrote down what we had said on a slip of paper and he took it out to the kitchen so that the supervisor could read it aloud. When he had received confirmation that what we said was what actually was written on the note, he showed it to the first supervisor who had just returned and the participant's joy was complete when even he read the same text aloud.

The conversation concluded with the man taking out a picture and pointing at a woman who we assumed was the assistant in his new apartment. We asked if he would like to show her the note as well and by nodding his head, he showed us that we had interpreted him correctly and with that he was satisfied.

This example of an everyday conversation is only one of many that we encountered during our visits to Tryckolera. Written language fulfills all the criteria needed with the exception of the most important one: that it can also be "read" by the person who cannot read himself. His problem is not that he does not understand the content of the message—he knows exactly what it says. But he could not manage on his own to go from one supervisor to the other and convey the message that affected only him.

2. The small talk problem

As an occasional visitor to Tryckolera, one encounters difficulties time and again when it comes to interpreting some of the participants' very down-to-earth questions and statements.

How did you get here? When are you going home? Are you going to stay and have coffee?

When does my van leave for home? Who is driving today? I've been sick. NN is in the hospital because he has a stomachache. Did my cat get any food? When is NN coming next time?

Even a slight misunderstanding results in a long chain of clarifications and contacts with the supervisors who are expected to know more about what is going on. In general, every message has to, at some point, take a detour past the supervisors before it can be considered to be properly dealt with. If the supervisor is busy with something else or has left the premises, it can be very difficult for us as visitors to carry on communication.

But it is not only the occasional visitor who finds it hard to communicate; depending on their memory difficulties, the participants may need to be given the same information from their supervisors many time during the day. Today they try to solve memory problems by means of digital photographs that illustrate certain regularly recurring activities or phenomena, but sometimes important puzzle pieces are missing or the pictures are not at hand when you need them the most.

All the parties involved would feel better if it was possible to invent tools that facilitate everyday conversations and routine questions and that do not require the supervisors' assistance to the same extent as today.

3. Information's micromobility *between fixed point*

Even if the communication at Tryckolera limps along at times, it is still often possible to agree on the message's content because there is so much to refer to in the environment (the entire area is an interesting example of distributed cognition (Hutchins, 1996)). If the supervisor is out, one can point at his indoor shoes or a picture to show whom you mean and if a friend is sick you can go to his desk and put your hand on it as an indication.

Conversations dealing with phenomena in the home are considerably harder to talk about since there is nothing tangible to refer to.

All the participants at Tryckolera have relationships in their home environments that are enormously important for their well being and security. If a contact person is sick or on vacation, there is a need to discuss it at the day activity center too. *How long will she be away? What will happen while he is gone? Who can help me now? Will she really come back?* This places great demands on the supervisors to continuously keep up to date on everything that happens at their participants' residencies in order to make sure that the information they give the participants is correct.

Likewise, it is just as important at home to be able to tell about what has happened at Tryckolera during the day. It can be about anything including today's lunch or that someone fell and hurt himself. This communication takes place at present with digital pictures that the person himself thinks are representative for the things and events they wish to relate. One problem can be that what is experienced as unambiguous at Tryckolera can result in problems at home because it is out of context. Another recurrent problem is that participants find it difficult to report on the feedback they have received on their picture to the Tryckolera staff because there are no digital cameras at home

It might seem unreasonable that these communication difficulties have not yet been solved in spite of all the years of collaboration involving IT. But the difficulties are genuine and are the result of the reduced motor abilities of the participants and the culture in group-homes versus the one at Tryckolera. Having an *open link* between the participants' apartments and Tryckolera based on relevant software could be a solution. The ongoing development of an Isaac picture mail (including sound) from a stationary computer has provided us with some insight into how it would work. For the individual's mobile use, we would replace the Isaac picture mail with a PDA, making it possible for a person to have the information with him and share it or not.

3.4.2   Analysis of collected probe material

We have decided here to analyze one of the results from using picture mail as a probe in order to illustrate how full of nuances the outcome can be:

One of the designers sent a picture mail containing several pictures of himself with different facial expression to one of the users. The designer's intention was to get a conversation going about the feelings the pictures illustrated. The recipient of the pictures understood them, however, not as informative material but instead as inspirational material for imitating facial expressions and body language. His supervisor, cleverly enough, photographed the recipient as he imitated and these pictures were then placed next to the originals to see how close he had come. We as designers learned that we can never be certain that our intentions are perceived as we had imagined. We were also surprised and impressed by the precision in the recipient's imitations of the facial expressions and that, in turn, inspires us now to try and find other picture sequences with which the person can interact. The

recipient studies these pictures every day and often receives positive comments from those in his surroundings, which hopefully, strengthens his sense of being able to accomplish something.

We have benefited greatly from the constellation of concepts "user, designer, information, inspiration, concrete, abstract" to analyze the numerous aspects of this example:

The designer sends the picture mail to the user intended to fulfill *user*, *information*, *concrete.*

The user interprets it as *user, inspiration, concrete.*

The designers are informed about the alternative interpretations and about a much greater ability than we had imagined (for example, being able to distinguish left from right)— *designer, information, concrete*

The designers are inspired to look for more opportunities to bring other phenomena to light— *designer, inspiration, concrete.*

Something has also been conveyed on the abstract level. The feelings that have been set free have made us realize that the user has been able to think abstractly, "I surprised them! I did it!" and the designers to realize that "they think this is fun," and "it will work in other situations".

3.5 Technological infrastructure and facilities

At the beginning of next year (2003), three of the participants at Tryckolera will be the first to use their own PDAs. The users will interact with the PDA by means of a touch screen, something we have already tested to be sure that they have mastered the necessary skills. They will receive feedback in the form of pictures and sound, which the supervisor has assembled on the main computer and then downloaded to the PDA. The users will be able to see and hear the picture and sound stories, listen to music or watch video sequences.

The PDA will have some accessories that we plan to test during the project:

- With the *barcode reading module*, the user will be able to interact with objects in his immediate surroundings. The PDA can in picture and sound provide the user with more information about the object by reading the barcode attached to it.
- With the *digital camera module*, the user will be able to take pictures of an object or event that interests her. With the built-in microphone she can also speak, sing, and add sound messages to the digital pictures.
- *The GPS module* with specially designed touch-see-and-hear interface to orientate one's self in the neighborhood.

At Tryckolera, the users will be able to communicate cordlessly with one or more of the following systems:

- BlueTooth which is already built into the PDAs
- Radio-LAN for greater distances indoors
- GSM module for global communication

This means that one will have opportunities to:

- Send pictures/sound to friends
- Print photographs from PDAs directly from the printer
- Activate different devices, turn on and off the lights, etc.
- Communicate with supervisors and friends even when they cannot see one another
- Play picture and role-playing games with one another

4   Technology for mobility in collaboration and learning

Most digital technology for supporting remote collaboration and learning is not truly mobile. Rather almost all tools for remote collaboration, such as desktop conferencing, groupware, and e-learning platforms are fixed to desktop-solutions and located on inflexible workstations (Luff and Heath, 1998).

Different modalities of mobility are suggested by Kristoffersen and Ljungberg (1999). They distinguish between three different activity modalities like wandering, traveling and visiting, and between three different technological configurations: mobile, portable and desktop (table 2).

Technology

	Mobile	Portable	Desktop
Wandering	✔		
Travelling	✔	✔	
Visiting	✔	✔	✔

(Modality — row labels; Technology — column headers)

Table 2: Activity modalities and technological configurations

True mobile technology is the kind of mobile devices that allows for use while wandering (or at least traveling). While traveling often implies having a table, wandering typically requires that the device can be used by one hand because the other hand is used to hold the device.

Another important issue when designing mobile learning environments is the question of whether the technological solutions are oriented towards individual use or towards collaborative use. An example of how PDA's can be used as invitations for collaborative work is the Proxy Lady (Dahlberg et al. 2002). Such applications for PDA's are still quite rare.

A third design consideration, which is important when designing mobile environments for collaboration is the so-called 'form factor'. For most applications the mobile phone display or the PDA-display is insufficient just with little complexity for individual use, and hardly impossible to use when it comes to collaborative use.

A fourth issue, which we shall not go into in this state of the project, is the question of privacy versus collaborative use. Making resources available in a collaborative setting also implies difficult questions about how to handle privacy – not only when it comes to sensitive information, but also because you would like to keep design sketches, notes etc for your self until they are ready for others to put a critical view on.

In the following we will present the work we have done so far in order to qualify our discussion of and suggestions for possible communication platforms and for an adequate ubiquitous computing environment for mobile, collaborative learning.

4.1 Our approach to ubiquitous computing

Ubiquitous computing has many approaches, in what concerns to the technical infrastructure supporting it. The attempt of making computers, and the ways of

interacting with them, transparent to the users implies an extra effort from the system-designer's perspective.

So far, the task to be developed by the user influences system's infrastructure in a big extent. E.g. the experiments run in Taiwanese schools (Chan & Sheu, 2002) using ad-hoc mobile lecture rooms, present a completely different network's backbone than the ones done for the indoor experiments both in Taiwan and the US (Liu, Wang, Chan, & Yang, 2002, and Farooq, Schafer, Rosson & Carroll, 2002). The Learning Task Force at the IEEE is trying to make some effort in standardizing a common infrastructure that can support mobile learning scenarios (Milrad, Hoppe & Perez, 2002), but the experience shows that the different experiments done within this field created ad-hoc infrastructures for running their experiments.

Even if we like to position ourselves out of the discussion around the right infrastructure to use, focusing more in the ways in which users can interact with the system, there is a need to choose one technical solution for the realization of experiments.

4.2 Distributed infrastructure
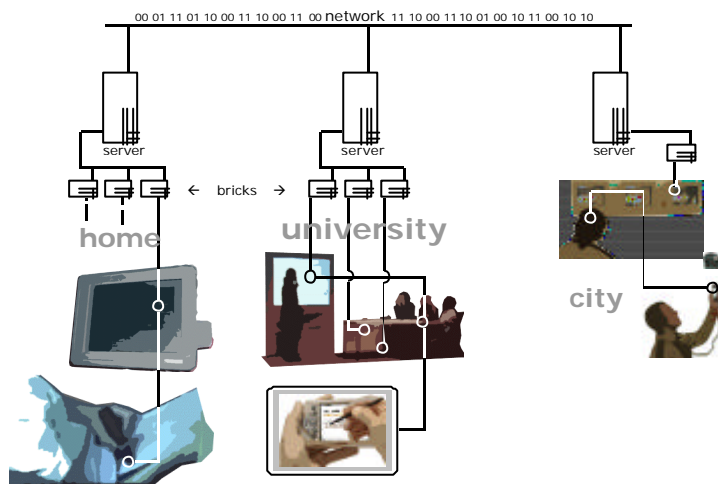
Figure 8: Structure for ubiquitous computing in-out-doors

Figure 8 shows how we envision a possible infrastructure that will support our augmented learning environments. After a research process approached from many different perspectives, we now have much more precise and detailed picture of the kind of communication methods that fit the best for different purposes. The explanation about priorities is presented later in the chapter titled "Accessing the network". Here we define the different strategies for getting access to the services, augmented spaces, etc.

In the particular case we are working with, one of the most important characteristics is that students need to access their information sources, project folders, in-progress documents, as far as several physical work tools like displays, printers, interaction devices, etc. Thus the main issue in our network concept is related to communication.

Figure 9: Star-like network structure

Nowadays, the existing learning systems are working under a star-like structure, where a central server delivers information, centralizes services like e-mail, news, chat-boards, etc. When in a traditional learning environment such system presents lots of advantages, many times the server becomes a communication's bottleneck. The quality of access to the services decreases with the amount of users connected to them.

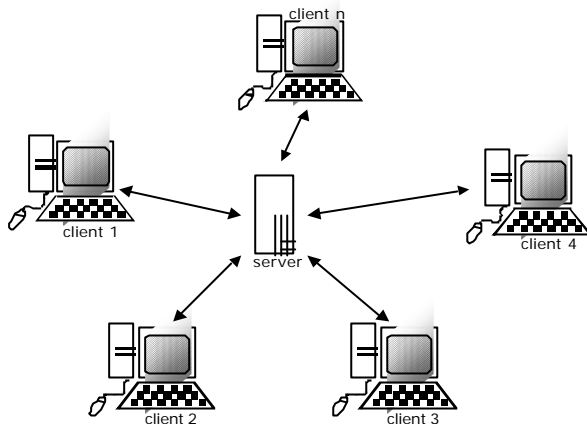If we are thinking about supporting a ubiquitous computing system where the operations are handled by the infrastructure and not by the devices carried by the users, a star-like structure presents lots of disadvantages. Just think about the reasons why the mainframe-model was discarded in the past, towards a system where the machines in the network were capable of executing programs themselves.

Instead of using the star-like (or mainframe) model, we defend a partly distributed system, where users' equipment will act not only as receiver of information, but as server of it. In this way, the distribution of information would be speeded up by the amount of users asking for it. It is like the reproduction cycle of an amoeba: it follows an exponential distribution … the more amoebas we have, the more we will get in the next reproduction cycle. Thus the more computers serving one file, the more users we can reach with that "piece" of information. This presents obvious analogies to peer-to-peer based networks.

4.3 The new form of the computer

A structure like this has a need of new tools for maintaining, e.g. a file system. If the members of a group are working on a document, there will exist many different versions of that piece of information. Therefore, the users should be concerned about it, and get access to the one that better suits them. This implies that we need to define software tools like "distributed version controllers" and "version navigators".

Going back to the discussion about the form of the computer, and taking in consideration issues like transparency to the users, we reach a new concept for the computer. Instead of consisting in a screen attached to a box with some intelligence and a set of peripherals, we conceive it as an architectonical brick, a part of the normal construction of a building that offers a set of interfaces to it. Those –the interfaces- could be again other bricks (like fixed touchable displays) or more loose access systems.

4.4 Accessing the network

Nowadays it is difficult to conceive many of our everyday operations without using different data networks. Furthermore, if we want to design a system that could reach almost any country in the world, and if such needs any communication facilities, the easiest way of doing it, is thinking about using the Internet as a transmission media. Furthermore, we just need a phone line that could give us access to gateways to the network, without caring about our location, nor the gateways' one. Extending this idea, we will realizes that the discussion about how our students will access the information will be through the Internet, because we can find everything there, in terms of information. Course material, exercises, inspirational traces, solutions to projects developed in the past, and many other things can be found in different servers.

The question is then, under a learning situation where mobility is an issue, which is the best way of accessing the network? Before we discussed about the idea that "wireless is not necessarily mobile", even thought we want to focus here in the different wireless technologies that could be used in our model, without further considerations.

There are two main groups of technologies, in terms of who is controlling the transmission-spectrum. We distinguish between "user controlled" and "corporation controlled" gateways. The first ones are based in technologies that operate in parts of the spectrum that are opened to everyone, while the second ones use parts of the spectrum that are controlled by the governments, which assure the coverage in large areas of the different countries, by "renting" the spectrum to corporations. In the first group we place WLAN (in its very extended form 802.11b) and Bluetooth, while in the second we group all the rest: GSM, GPRS, UMTS.

From a technical perspective it is very easy to distinguish which one is more suitable for each kind of situation, since the ones in the first group do not have a very long coverage (the designs with omni-directional antennas for laptops reach less than 80 meters in both cases), for being truly mobile, we will need to think about the second group, where the coverage is granted by the government itself (mobile telephony reaches 70% of the population in the countries within the EU).

Technology	Coverage	Bandwidth	Observations
GSM	95% of the territory of many European countries	9600 bps	Voice cell-telephony and short messaging
GPRS	Main cities and transit areas in Europe	25-38 Kbps	Mobile internet
UMTS	Main cities and transit areas in the whole world	350 Kbps up to 2 Mbps	Under development
Bluetooth	Up to 10 metres with standard antennas	100 Kbps	Allows coexistence of an endless amount of devices in the same space
802.11b (WLAN)	Up to 100 metres with standard antennas, but the distribution of those creates huge coverage areas in cities all across the world	Up to 11 Mbps (Ethernet protocol)	Alternative to UMTS, cheaper, quick expansion among users

Table 3: Comparison of bandwidth in the different systems.

Talking further about the second group of technologies, the differences between them are easy to understand. GSM is a network that was designed for voice transfers, where the operators charge for every call the users make. GPRS is a data network, where the business model is based in charging per transferred megabyte.

Finally, UMTS is an evolution of GPRS with a wider bandwidth. In terms of coverage, we can see that GSM is covering until 95% of many European countries, while GPRS can be found in some cities, and over important transit areas (motorways). The plans for UMTS are to get it installed in important commercial centres, as a first step, but it is not ready for the market, yet. This leads us to conclude saying that, if we want to use any of these, it should be GPRS, if we don't go away from cities, when we would need to use GSM.

Somehow, the bandwidth provided by any of the technologies discussed before is not enough for the kind of applications we are envisioning, Just imagine to download a text document with some images, having a weight of e.g. 150KB with a GSM modem, that works at 9600bps. If the user would need to do this process once a day, it wouldn't be very problematic, but that is not usually the case. On the other hand, 150KB is a very small size for the kind of documents/files we usually work with. For inspiration and brainstorming processes, we use images, sounds, and video, where such a bandwidth is not enough.

In this comparison of technologies, we found ourselves in the centre of the discussion about the use of Bluetooth and WLAN. In the beginning we decided to use Bluetooth as a common technology for networking and device communication. The system seemed to be very promising, and the companies developing it announced major improvements for the second revision of the standard (like the inclusion of a channel of high bandwidth per access-point, or a more flexible distribution of the bandwidth if there weren't that many devices connected at a time). Bluetooth came to the market with a huge selection of profiles that were designed to allow communication towards video, audio, and data devices. The only problem seemed to be the fact that it wasn't very extended.

After the launch of WLAN in the market, there was a debate in the engineering arena about which one of the two systems would become the standard for home communication. Many indicators pointed to Bluetooth as the future standard wireless communication method for home electronics. While Bluetooth showed clear advantages when confronted to WLAN in terms of the amount of devices that could co-exist in the same physical environment, maintaining a certain quality in the bandwidth, the not closed standard for Bluetooth 1.1 and the launch in the market of many hardware solutions running on 802.11b, defined the second one as the most used wireless communication protocol. There is a believe that 802.11b will become the standard for wireless networking in the cities, where many users will give out the "rests" of their broadband connections for free to those who need it. There are many examples of such around the world, like Central Park in New York (US), Madrid (E), London (UK), Copenhagen (DK), Berlin (G), etc. This is one of the reasons that brings us to decide for 802.11b as the standard for communication between user devices towards the infrastructure, while we will use Bluetooth for the communication between the device and several of the sensors attached to it (in fact, Bluetooth was called "cable replacement", for reducing the amount of cables connected to the different machines).

4.5 Application of Free Software Models into education and documentation

The free software community has developed new ways for collaborative software documentation that can become a model for the publication of any kind of educational material used for PBL educational models. PBL, as we apply it in K3 Malmö, is based in solving problems in a collaborative way, where the educator becomes a moderator of the learning process. Educators are dedicated to filter information and bring references into the process, while students learn in the interplay between discussions, personal information searches, and praxis.

Going back to the free software model, the whole development and documentation process is based in the use of a special way of licensing the materials produced.

This type of license is called GPL (General Public License,as explained in (WEB-06)), and it allows the receiver of the information to reuse the whole contents for his own purposes. It is possible to change the texts, the code, to sell it, etc. The only condition is to respect the GPL license in the products coming out of the original object.

One of the requirements of our project is to explore the possibilities for providing students with access to educational material for free, or at a reasonable price. In many cases, when accessing e.g. a book, we are interested only in a very small part of it, but we still need to buy the whole of it. It is for this reason that we approached the major Swedish distributor of university texts: Studentlitteratur. As part of the discussion, we introduced the free software model for documentation, where we tried to envision a way that would still be profitable for companies dedicated to the production of written material, and at the same time, allow the information be free of charge at a certain extent.

Our vision includes a method for development literature following the free software model, converting the publishers into moderators of the discussion among different e.g. teachers in a certain topic. In the beginning, they could distribute responsibilities, like each one writing one chapter, or proposing exercises at different levels. After that, they would revise the different part independently and adapt it to their own courses. The role of the publishing company would be to support a data structure capable of handling different versions of the documents, exercises, experiments, etc. and publish revised compilations of such. The whole raw material should be there in GPL basis, and the publishers would make money selling the compilations. The advantages for the users are easy to see: documents created and revised by many experts instead of by just one. For the companies, the benefit is that the production cost is reduced, while the quality of the product increases. Furthermore, under this method the "book" never dies, because the production thread for such goes on with new revisions, and new exercises coming from the users themselves –in the free software model, users and developers merge into one unique entity.

4.6 The services and the augmented spaces

Nowadays, attached to the model of any infrastructure, designers must envision possibilities for offering services over that. The content is brought to users by the so-called "content providers". When it comes to the education arena, service and content merge into one, especially considering the new way of developing software and documentation brought to life by the different free software and open source movements. In such model, where many users and developers share information, the service of providing access to the network merges with the content itself, and with its production. This requires the creation of new business models that can support such a flexible way of production of contents. Nowadays, the most extended model is the "pay-per-view" when it comes to visual media, and the "pay-per-container" for audio-based media. Digital text presents many different forms of distribution, but the most promising for us, is the one followed by many digital newspapers, where users pay for a subscription that gives access to the paper, and to the archive. It would not make sense to have different ways of distribution, thus different business models for such, within the content providing for learning situations, and we defend the time-based license model, even if our vision is that information should be free and accessible to everyone in some way (like the role of the libraries, where everyone can go and get access to any of the books for free).

Service and content become one in many cases, and need to be accessed from the space. We believe in the possibility of augmenting spaces by the use of what we define as "architectonical bricks", which we believe will become standard construction parts taken in consideration by architects when it comes to design those spaces. Augmentation can be defined as the process of bi-directional

interaction between users and the environment. So far, this information-flow is supported by devices that try to make the communication as transparent as possible.

4.6.1   Devices

Since the infrastructure is not handled directly by the user (according to our model), if we can reach a design that is sustainable enough, it will be less susceptible to arbitrary change.

On the other hand, devices, understood as the evolution of tools into technologically augmented gadgets, have a much sorter lifetime, since they have both a product face, and a functional one. Devices, as tools, have a function that is basically the treatment of information. Information -digital data- is quite a young way of representation, what makes it to be in a constant change. As products, devices are under a constant process of "fashionalisation", they are nothing but consumables for a mass market. This makes them into something more, designed for looking good, taking less care about the life of the different components that integrate them.

For those reasons, together with the constant evolution of technology and materials, the final device hasn't been defined, yet. If we analyze the history of interfaces, we will discover that, since the invention of the mouse, it hasn't happened a major development of anything that can easily reach anyone. So far, users have to learn how to use interfaces to the computer. It seems to be quite easy to see how the computer can "send" information to the user via visual, sound-based, or force-feedback-related stimuli. What seems to be a different issue is how to send information to the computer. Almost each device presents different ways of doing it. Desktop computers offer mouse and keyboard as standard interaction devices. Laptops usually have a mouse-pad or even a small joystick together with a keyboard. PDAs use the stylus and a touch-sensitive screen. Finally, the Anoto Pen and Paper technology implies a new interaction method based on handwriting, which to most people is a very intuitive way of working. Based on former studies done at K3 for technically skilled users (with understanding of email, cellular telephony, and computer graphics) our experience is that the adoption time of this device is almost zero.

Several studies show that the existing displays in small personal devices –PDA like ones- are not sufficient for everyday tasks like reading or writing (Waycott, 2002). On the other hand, while experimenting in K-12 schools, the researchers from the Center for Highly Interactive Computing in Education, at the University of Michigan (Curtis, Luchini, Bobrowsky, Quintana & Soloway, 2002) showed that PDAs are not useful for mind-mapping processes, because it is not possible to get a whole picture at a reasonable zoom, where it is possible to understand all the contents. The question to address here is if the new devices coming to the market will give a better view of information.

Anyway, the use of the devices is still under exploration, and especially their influence on learning processes.

4.6.2   Architectonical bricks

We define the "architectonical bricks" as pieces of digital technology that, integrated in the constructed space, can be used in the interaction processes between users, and in those when users access/treat/handle information. As we explained before, we dismount the traditional image of the computer into two pieces. First are those that can be integrated in the infrastructure, reducing the amount of machinery to be carried by users. Secondly we find the direct interface that is represented by the device. The ones in the first group are the bricks, which we can use and reuse in many different spaces.

As examples of bricks, we envision collaborative displays, were users can work together with representations of information with no priority in the use. This means, that many devices can get access to the displays simultaneously. There have been experiments in such already, like the development of the Jazz API for Java (WEB-07) that allows the use of 4 mice on the same computer screen.

Other parts include positioning systems that will establish the relationships between the users and the space. This can help for attaching virtual behaviors to certain places, enabling the augmentation of those.

The access to different networks, like WLAN for high-bandwidth data transfers to devices, or among bricks; Bluetooth for smart devices; Gateway to the internet, all of them could be integrated into a server-brick that would take care of the communication processes in the house and towards the outside world.

About the communication between bricks we can just say that there exist many methods for doing such. There are many efforts for standardizing how different elements in a network communicate to each other. The bricks are nothing but entities that can be represented from a UML perspective, that "talk" to each other following a Markup Language (XML). There are different strategies for doing such like the ones proposed by the University of Oulu, Finland within the Atelier project (WEB-08), or the ones proposed by Mario Milrad and others in C-Notes (Milrad, Hoppe & Perez, 2002).

4.7 Future design issues

So far we have explored technologies for establishing a full-scale study and mobile learning environment at K3, Malmö, and we have identified several bricks that need to be integrated. Our next step in this field will be to design the bricks that we want to integrate in the experiments that will take place during the next academic year, and to develop the software tools that will be needed for following/documenting the processes that we consider relevant in our experiments.

As a first step, we will need to concentrate in the development of a collaborative display, what will give us an overview of the design both technical issues regarding communication between bricks, integration/gateway towards different technologies, as far as other questions related to aesthetics, or interaction design. As part of this development, we have started a very positive contact to Anoto, in a try of integrating their technology in the development of a new application.

5   Discussion and planning of future work

During this first part of the Mobility and Learning Environments project we have primarily focused on methodological issues. Specifically the application of cultural probes as a possible and interesting way of engaging users at two radically different sites: K3 and Tryckolera.

We have outlined a framework for understanding the different ways of using cultural probes based on three dimensions. 1) users / designers, 2) inspiring / informing, and 3) abstract / concrete.

Regarding the dimension users / designers we found that cultural probes can be used by users themselves without any intrusion or support by designers, i.e. letting the probes 'live their own life' with the users during the period of probing, like in the High Tech Hunters case and the K3 Nomads case. In other contexts the cultural probe can be used by the designers to create friction or provoking among user in order to stimulate new ways of viewing well-known situations, like the video probe at the Tryckolera site.

When it comes to the dimension of inspiring / informing, we found that the cultural probes method can support both. Here it is important to stress that the belief that we can study the world without affecting it will never be true. Even if the probe is designed to primarily inform the designers about the participants' working and living environments the presence of the probe itself and the attention it creates will influence their acting, and hopefully also create attention on perspectives on and details in their environment and ways of working, which they were not aware of earlier. This have been used consciously in all three CP studies to create inspirational material and perspectives on ideas for future designs.

The third dimension of abstract versus concrete made it obvious to us that cultural probes first and foremost helps to gain very concrete knowledge both on the current situation and technological possibilities, but also on visions for future design. In an early state of a design process we believe that this concrete knowledge is of major importance and furthermore in accordance with our general methodological approach, which we earlier described as abduction (see chapter 1).

The application of cultural probes at Tryckolera challenged our ability as designers to balance the degree of friction (or provocation) and informative aspects of the probe in order to fit into a work place for people with different cognitive abilities. At Tryckolera, pictures work as probes. This does not mean that they are monotonous—the content of picture communication is just as differentiated as the objects on the K3 list. After Christmas, when the new Isaac software is released, we can *easily* make use of a large quantity of pictures with associated sound, and in appropriate cases text, as cultural probes. The attempt to achieve inspiration as well as information for both the users and designers, both concrete and abstract, will continue. An important perspective is that in the Tryckolera study, the cultural probes are used in the *system* of the end users and their supervisors. This does not detract from using the probes—on the contrary, it can also clarify the interaction between the user and the supervisor. Another good example of this can be found in the interaction between Ingegärd and her husband Bengt in the master's thesis *Ingegärd and the Green Mailbox* (WEB-01).

In future full-scale use of cultural probes we should consider setting up an initial workshop with the participants before the probing period. This workshop should focus on the project's overall goals and methods, and letting the participants have an understanding of this as part of the process of engaging users. Otherwise we risk to end up in a situation where users just play the role as 'users' in a politically correct process of participatory design.

When it comes to conclusions and future work in the area of technology for mobility in collaboration and learning there is still considerable work to be done. As a first step, we will need to concentrate in the development of a collaborative display, what will give us an overview of the design both technical issues regarding communication between bricks, integration/gateway towards different technologies, as far as other questions related to aesthetics and to interaction design.

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(WEB-02) *About the Isaac Project:* http://www.english.certec.lth.se/isaac/

(WEB-03) http://www.isaac.certec.lth.se/

(WEB-04) *What Isaac taught us.* Jönsson, B.; Philipson, L.; Svensk, A. Certec, 1998. http://www.certec.lth.se/doc/whatisaac/index.html

(WEB-05) *Art and Science-A Different Convergence.* Plato,G.; Jönsson, B. Report, Certec,1:2001. http://www.certec.lth.se/doc/artandscience/

(WEB-06) http://www.gnu.org

(WEB-07) Jazz API for Java, University of Maryland, US: http://www.cs.umd.edu/hci/jazz/

(WEB-08) Presentation of the Atelier Project at the Disappearing Computer Group Web Site: http://www.disappearing-computer.net/projects/ATELIER.html

(WEB-09) *Tryckolera's web site:* http://www.tryckolera.certec.lth.se/

Appendix 1: Project plan

Until now we have fulfilled all planned activities and even extended some. The original project plan has only been revised in minor details.

Overall activities:

2002: Pilot-study at K3-site and satellite-site in order to apply at get experience with methods for engaging users, get experiences with current technology, and set up possible study design.

2003: Design and undertake full-scale study (25 users) at K3. Analyze results.

2004: Design of more general applicable tools, methods and environments for micro-mobile and flexible learning.
Report on proposed concepts, designs and technical platform for mobile environment

2005: Write applications for continuation of project, as a minimum for finishing the PhD projects.

Theme 1:

2002: Creating use scenarios for small groups of students as part of existing courses at K3Creating a spatial layout prototype for learning based on architectural, technological, cognitive and pedagogical considerations.

2003: Design of learning environments for and with students at K3 by augmenting physical environments by digital technology.

2004: Formulating conceptual and technical framework for micro-mobile environment for learning and work processes in general
Report on augmented mobile environments for learning.

2005: Write applications for continuation of project, as a minimum for finishing the PhD projects.

Theme 2:

2002: Introductory work for permeating the project as a whole with existing insights at Tryckolera of environmental influences on learning. Elaborating guidelines for the satellite context and role, utilizing the common technology as the core link for the different experiences in the different environments.
Pilot-study (3 users) of the current relevant technology and its influences on the existing special communication at Tryckolera, mainly based on digital pictures. Analysis of the interdependence between peer-to-peer-communication and regular contacts within some Certec courses.

2003: Design of learning environments for and with the participants at Tryckolera by augmenting physical environments by digital technology. Challenging, inspiring, questioning the main project and at the same time modifying its solutions for special needs.

2004: Contributing through making familiar aspects of learning strange and strange aspects of learning familiar through the interplay between the experiences in Theme 1 and 2. Formulating conceptual and technical framework for micro-mobile environment for learning and work processes, in special and in general. Report on design concepts and solutions.

2005: Write applications for continuation of project, as a minimum for finishing the PhD projects.

Theme 3:

2002: Designing a small-scale wireless platform with PDA's, Anoto-pens, displays. Exploring technical possibilities and problems in micro-mobile learning environments. Exploring protocols for distributed data-structures ('gnutella')

2003:   Designing solutions for positioning, tracking and tagging in micro mobile environments. Implement distributed data-structures.

2004:   Designing a portfolio of possible configurations of micro mobile spaces for learning. Describe distributed data-structure solutions.
Report on technical platform.
Continued work on maturing of technological concepts and solutions together with companies (CE-PhD work). Take out patent for positioning solution.

2005: Write applications for continuation of project, as a minimum for finishing the PhD projects.

Appendix 2: Budget and accounts 2002 (in Swedish)

Mobility & Learning	Budget SEK	
	2002	
	2002-08-01	2002-12-31
	Budget	**Utfall**
245004		
Personal	434.375	393.520
Förbrukningsinventarier		34.314
Förbrukningsmaterial	10.000	0
Reparation och underhåll		0
Diverse främmande tjänster	45.000	0
Telefon, post		314
Fakter, transporter, resor	46.000	6.961
Representation		665
Information		0
Diverse kostnader	15.000	0
Förvaltningsavgifter	172.613	130.732
Avskrivningar enl plan	70.000	
TOTALT	792.988	566.506
Personal:		
CE Ph.D student David Cuartielles 80%		
CE Senior researcher (Lone Malmborg) 25%		
CE Senior technician (Pierre Schlaucher) 10%		
Certec - senior researcher (Bodil Jönsson) 20%		
Certec- PhD student (Arne Svensk) 50%		
Utbetalningar:		
(första) 2002-09-15 300 000 SEK		

Comments:
- Parts of the hardware investments have been postponed since we still need to test different hardware types before we decide which type to use.
- Some costs have not been entered yet, because a delay in the university accounting system.
- It is not possible to make a precise account to 2002-12-15 until around February 2003

Appendix 3: Project related publications and activities 2002

Publications

Almér, R., L. Bolin, P. Ellgård, S. Westberg (2002). Game, Set, Probe! Cultural probes in a university setting. Shortpaper submitted for Computer Supported Cooperative Learning Conference, Bergen, June 2003 (supervised by L. Malmborg).

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Darmark, J., Karlsson, T., Nilsson, L., & Skön, M. (2002). Thoughts On Documenting And Supporting A Work Process. Shortpaper submitted for Computer Supported Cooperative Learning Conference, Bergen, June 2003 (supervised by D. Cuartielles and L. Malmborg).

Eden, H., Hornecker, E., Malmborg, L. (2002). Designing Tangible User Interfaces to Support Participation - report of a PDC 2002 workshop, *artec-Paper Nr. 97*, Oktober 2002, Universität Bremen Forschungszentrum Arbeit und Technik.

Fibiger, B., L. Gjedde, S. Heilesen, K. Hornbæk, L. Malmborg (2002). Human-Computer Interaction and E-learning. Bertelsen, O.B., Bødker, S., and Kuuti, K. (eds.) In *Workshops at NordiCHI 2002*, Aarhus, Denmark, October 19-23, 2002.

Jönsson, B. (2002). Enabling Communication. Invited keynote at *NordiCHI 2002*, Aarhus, Denmark, October 19-23, 2002.
http://www.certec.lth.se/doc/enablingcommunication/

Activities

Participation in and presentation (Lone Malmborg, David Cuartielles) at Wireless and Mobile Technologies in Education conference 2002, Växjö, August 2002.

Project presentation and workshop (Lone Malmborg, David Cuartielles) at E-learning Øresund Hotshop 7: Det kreativa och digitala lärandemiljö, Creative Environments, K3, Malmö University, 7 October 2002 (with participation from industrial project partner Anoto).

Workshop organizer (Lone Malmborg) at NordiCHI 2002, Aarhus, Denmark, October 19-23, 2002.

Invited keynote speaker (Bodil Jönsson) at NordiCHI 2002, Aarhus, Denmark, October 19-23, 2002.

Participation in course (David Cuartielles, Mandus Schön (exam student related to the project)) on technical development of applications for digital pens, November 2002.

Student course at K3 on research methodologies supervised by Lone Malmborg. 8 interaction technology students (in two groups) did research assignments related to the Mobility and Learning Environments project

(http://webzone.k3.mah.se/projects/GFit00/) Two academic shortpapers are submitted to CSCL2003 (see publications above).

Participation in (Lone Malmborg) EU conference IST, Copenhagen November 2002.

Demonstration and presentation (Arne Svensk, Bodil Jönsson) of Tryckolera Mobility and Learning concept at Hjälpmedelsinstitutets ID-dagar (Information and Demonstration-days) 8-10 October 2002, Factory, Nacka Strand, Stockholm.