Supporting the Participatory Design Practice with Technology Probes

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ABSTRACT
Participatory Design (PD) is a popular set of methods in Human Computer Interaction (HCI) for designing interactive systems in collaboration with end users. By involving users alongside designers in the various stages of the design process, PD provide a strong empowerment of users over the design in which they are engaged and ensures better design accuracy and efficiency. PD practitioners commonly encounter challenges in gaining user engagement, empowering users and involving users in questions of technical relevance. In this paper, we propose a process centered on Technology Probes that helps PD practitioners overcome such issues. We illustrate this process through the collaborative study of a research observation tool – Zebra (Figure 1). We eventually provide a reflection on values of engagement and empowerment conveyed by technology probes.

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Technology Probes, Participatory Design, engagement, provocation, design process, field observation tool

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INTRODUCTION
In recent years, "probe-based" alternatives to existing research methods (such as field observations) have emerged. Well known examples include cultural probes aimed at inspiring design ideas [7, 8, 10] or gathering ethnographic data [5, 9] and technology probes, which provide a simple but stable functionality which can be deployed for a period of time in the field for the purpose of studying use through the logging of data gathered from user interactions [1, 12, 13].

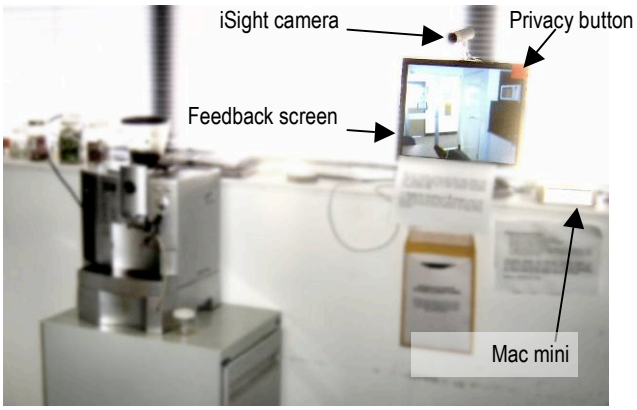

Figure 0. Technology Probe setup in the coffee room

Participatory Design (PD) is a set of methods that are aimed at co-designing technologies with users as active participants in the process [16]. Technology probes and low technology probes inspired by cultural probes have proven useful methods in PD processes [1, 17]. So far both have been integrated in design processes lasting for extended periods alongside other techniques such as prototyping, brainstorming and field observations. However, PD practitioners commonly encounter challenges in gaining user engagement, empowering users and involving users in technical discussions. By developing new methods for working with users, we are seeking ways to maximize the impact of the gathered insights while optimizing engagement with and empowerment of users.

In this paper, we suggest that technology probes can be a suitable alternative to existing techniques to support PD processes and offer an inclusive process for designing and deploying technology probes in a design process. By using a model which facilitates interaction through empowerment and engagement, we are able to suggest a new role for technology probes in design explorations. We then report

on a study using this process that explored the design of a research tool in collaboration with other HCI researchers.

RELATED WORK

Our work builds upon the technology probes and participatory design literatures. The following sections present relevant work in both areas.

Empowerment and Engagement in PD

Participatory Design has a long standing relationship both as a methodology for informing design in its own right and in the HCI domain [16]. The nature of participant engagement in the participatory design process can be demanding on all involved.

One such participant intensive technique is diary studies. As a method for exploring human experience, it is well documented, particularly in the workplace environment, our context of interest here. Brown et. al. used diary studies to inform user requirements in a range of mobile devices, from both an experiential and technological point of view [3]. Their study used photographs to capture information rather than requiring participants to undertake a written note taking exercise. This approach proved effective in engaging the participants through the low level of commitment and time investment required in photo taking.

Other PD practitioners often encounter challenges in engaging and empowering users in a design process. The focus of this work is to describe how technology probes can support PD practice through eased engagement and an empowering process.

Technology probes

A technology probe is a robust, simple to use device. It allows a rich and new interaction between an interactive system and its users while gathering data [12]. To date, technology probe deployments have raised users' interest and curiosity as well as stimulated their imagination and creativity [12]. They gathers users' interaction with the system for later analysis for unexpected behaviors and/or to confront predictions about how the device would be used. Technology probes capture real life and interaction context and provide a way to explore patterns of technology use. They allow researchers to set up, test and evaluate a technology in 'real life' settings. Through technology probes researchers are able to discover and reflect upon problems linked with the shift of technology from laboratory settings into everyday life, aiding the exploration of context, participants and technology.

Historically, technology probes build upon the cultural probes methodology. Cultural probes consist of a pack of artifacts such as postcards, maps, diaries and disposable cameras that are given to participants to collect inspirational data, often in an environment that is difficult to study using other methods. Further techniques derived from cultural probes have been used in research to collect data in settings in which other investigation techniques (i.e. field observations, interviews) could be inappropriate if not harmful. These were used particularly in care [5, 9], domestic [2] and shopping [11] settings to inform the design of technology tailored to users. Technology probes are similarly intended to be deployed in settings difficult to investigate with other techniques. However, through systematic data collection and long term deployment, technology probes are able to collect insightful data that can be used to either inform or inspire designs.

Technology probes were originally designed to produce *"input to solve a particular design"* [12] in the design of intergenerational communication systems for remote families. Similarly, Langdale et al. [13] have used a "*light-weight technology probe*" to elicit users' responses to a domestic communication system called *Keep in Touch*. In doing so, they underlined some of the difficulties inherent in the technology probes methodology. Markopoulos et al. [15] have also used two technology probes to explore original ways of using mirrors and video in interactive systems.

Technology Probes are related to the concept of co-adaptation [14]. Mackay claims that both user and interactive systems have the potential to co-adapt (similar to biological co-adaptation). Users change their behavior to adapt to a new device while the device should possess enough flexibility to allow users to use it in different and unanticipated ways. Technology probes are a way to acknowledge and use the co-adaptation phenomena in the design process. They give participants an opportunity to interact with an open ended, provoking interactive system. Thus technology probes allow the capture of unexpected ways in which devices might be used to fulfill users' needs and desires.

In the interLiving project [12], technology probes were used to support the participatory design of an intergenerational communication device with families. However, the requirements and role of technology probes in this process are unclear. Furthermore, Langdale et al. [13] underline the difficulties of deploying technology probes in real contexts and extend their use in a participatory design workshop without longitudinal nor real setting deployment.

In [12] a description of the design and implementation of a set of technology probes provide a first step towards understanding the technique to reuse it. However, when faced with the prospect of reusing technology probes in a different context, more questions arise that hinder its reuse. So far, technology probes have been used to design communications [6, 12, 17] or to gather inspirational data about the use of video or mirrors [15]. To our knowledge, the technique has not been used outside this scope. We think that this is probably due to uncertainty about the overall role of technology probes in the design process. Much of our work is therefore motivated by the need to experiment with a methodology of technology probe design and deployment, in order to address this uncertainty.

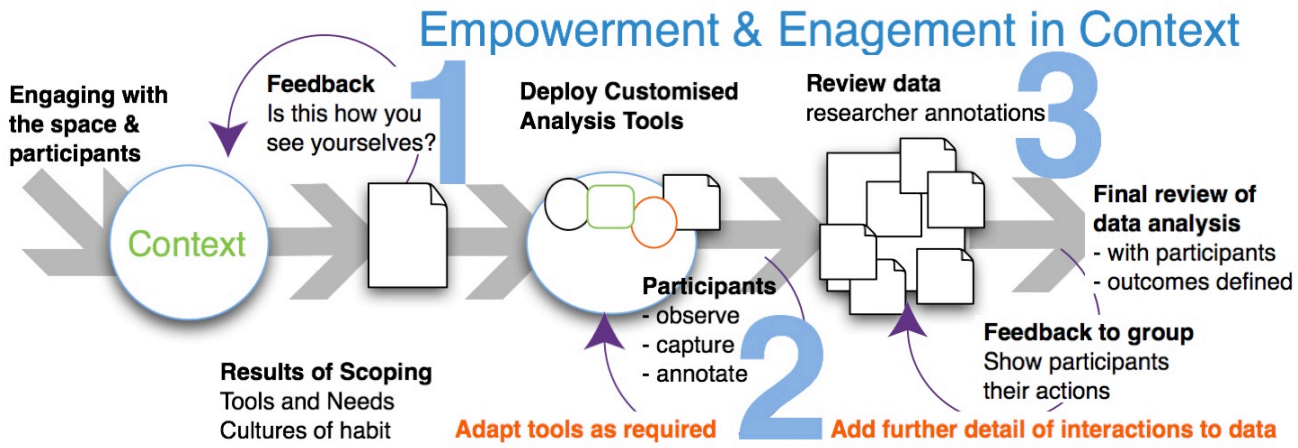

Figure 2. Empowerment and engagement model for design analysis

Our work extends the literature on Technology Probes by studying how the method can be used to support the PD practice through empowerment and engagement.

TECHNOLOGY PROBES FOR PD

Using technology probes, we propose a research approach aimed at maximizing users' engagement and empowerment.

Method

As Figure 2 reveals, our overarching approach to empowerment and engagement are as follows:

1. Participants are engaged in context, feedback of initial scoping is provided,
2. Capture mechanism and collated data is available for participants to review, interact with, and comment on, Participants are actively engaged in critiquing the technology probe during the deployment process.
3. Feedback of participants is re-presented to them after analysis, revealing participant actions/interactions.

We believe that Technology Probes can be used in the design process to engage and empower participants while limiting the intensive input they demand on them. As Technology Probes (TP) encompass an initial design concept, they allow discussions around concrete ideas, creating opportunities for more constructive feedback. Through TPs' open endness and ambiguity, participants are provided the opportunity to suggest changes and through this empowerment are more likely to feel confident enough to do so. Through the probes longitudinal deployment, participants are engaged over time, not in a one-off manner, enabling a sense of familiarity with the probes to occur. Over this time, they provide users the opportunity to experiment with design concepts without being obstructive on other activities. A process which taking advantage of technology probes to support engagement and empowerment in the design process is outlined in Figure 2.

The following guidelines outline the process of designing and deploying a Technology Probe with the aim to maximize engagement while limiting participants load.

1. Find core idea around which design discussion is to occur, based on initial contextual scoping studies, studies in the appropriate domains of the context,
2. Design a Technology Probe that balances: 1.) an embodiment of the idea (to allow concrete discussions around the idea), 2.) a degree of open ended-ness and ambiguity (to leave space for critiques and suggestions and provoke participants' reactions).
3. Develop the tech probe for deployment in the chosen context,
4. Inform participants of Technology Probe deployment to raise potential issues and gain informed consent,
5. Organize an initial Workshop to introduce the probe. Explain the probe's role, what is expected from participants, what data will be recorded, how and why. Explain how the data will be reviewed, captured and utilized. Explain how participants are given the opportunity to engage and influence that nature of captured data. Gather initial ideas and scenarios for the design concept.
6. Leave the probe to run for period (one or two weeks depending on circumstance) while looking for major usability issues that may need to be addressed. Wander around and engage in informal chats about the probe with people to uncover potential issues or interesting insights. In the meantime, analyze incoming data to ensure the probe gathers what is expected
7. Revise the probe to address major issues revealed over first period. Inform participants of revisions.
8. Run an intermediate workshop to review initial data with users, and provide a demonstration for analysis. Discuss further ideas for the design concept based on experiences,
9. Let the Probe run for another period (several weeks)

10. Engage users in interviews to gather impressions on the exposed concepts which have arisen from the initial ideas, gather alternatives and expose relevant data for discussion,
11. Run a final workshop to raise discussions around alternatives gathered in interviews and reveal data and outcomes to participants.

STUDY OF THE DESIGN OF A RESEARCH TOOL: ZEBRA

Using the proposed process, we conducted a two month study to design a research tool in collaboration with HCI researchers from various disciplines.

The aim of this tool is to capture video data in a particular setting and provide users with the opportunity to review and comment on the captured videos in a lightweight manner. The tool provides a systematic, long term, automated video data collection. To empower users in the observation process, participants are given the opportunity to refine observations and disambiguate pieces of video by the feedback mechanism. This mechanism is also expected to collect stories as told by participants themselves, engaging them actively in the data analysis stage. Eventually, this feedback helps researchers make sense of the video data prior to further analysis. From a researcher's perspective, the tool collects body of data that can be quantitatively analyzed and but also collect participants' subjective view of the data the researcher has collected.

While we could have decided to design the tool relying solely on our own knowledge and experience, we wanted to broaden the scope of the tool to encompass different aspects of HCI: sociology, psychology, engineering and design. The study allowed us to easily involve fellow HCI researchers in the design of the observation tool and gather different disciplines' perspectives on such a tool as a technology probe. To realize that, a technology probe encompassing the tool's basic concepts was developed and deployed for 2 months in the coffee room of our lab. Over the course of the deployment, fellow researchers (referred later as participants) were prompted through workshops and interviews for views and analysis of the tool concept as experienced through their interaction with the technology probe.

Study Methods

The study included of three main techniques:

Technology probe are used to expose participants to concepts we want to them to engage with.

Workshops are organized at different points of the study to review and exchange impressions with participants, address potential issues, collect group feedback and organize discussions.

Semi Structured interviews are conducted towards the end of the study to collect in-depth feedback from participants. Building upon their experience with the probe, they are asked to review and critique the existing implementation, describe their own use and expectations and suggest improvements or alternatives. Eventually participants are asked to imagine how they could transfer the proposed concept into their own research context.

Participants

In the course of this study, around 25 persons were engaged in the interaction with the probe. However, only 14 people participated in later workshops and interviews. Participants were recruited in our lab through email and informal chats. Participants were aged between 23 and 45, with expertise in HCI ranging from postgraduate student to senior researcher. To maximize the diversity of views we could capture in the study, we sampled our participants to include experienced practitioners in the different disciplines of HCI. Participants included interaction designers, engineering, Computer Supported Collaborative Work (CSCW), human factors and participatory design researchers, an anthropologist and various research students.

The Zebra probe

The starting point for the design of the probe was the following basic concept: An automated video recording device and a feedback mechanism which would allow participants to comment and annotate the captured video clips. In order to reinforce privacy and increase participants' acceptance of the probe, no sound was recorded by the device. The participants' inputs were

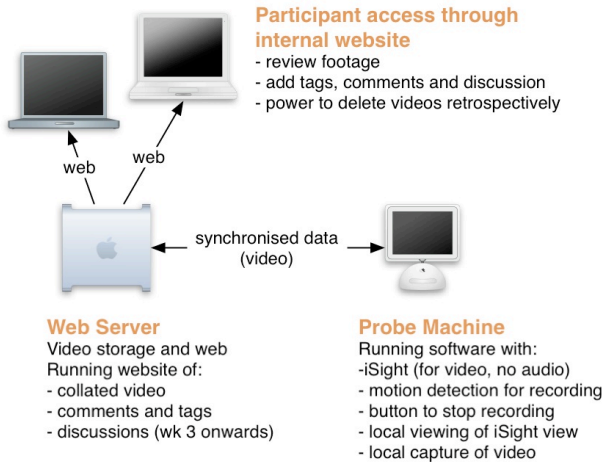

Figure 3. Overview of the zebra configuration and points of user interaction

expected to enhance and refine video data and provide a means by which they could take part in the analysis of collected data. Zebra was to provide useful objective, subjective and inspirational data for designers and/or researchers while supporting end participants' empowerment and engagement within the design context (see Figure 3).

The configuration of Zebra is shown in Figure 3. The probe is composed of two modules: a video recording device fitted with a motion detector to create separate video clips for different interaction sequences and ignore periods of inactivity, and a web server presenting the captured data and providing basic input features to participants.

The capture device itself was deployed on a Mac mini running an iSight with a localized display of the video being captured. Next to the screen a red button was placed with appropriate signage (See Figure 1) to allow participants to stop the current video recording for a predetermined amount of time (typically 5 minutes) if the participants were uncomfortable with their interactions being captured. On-screen feedback informed participants when the system was recording or the remaining pause time before reactivation.

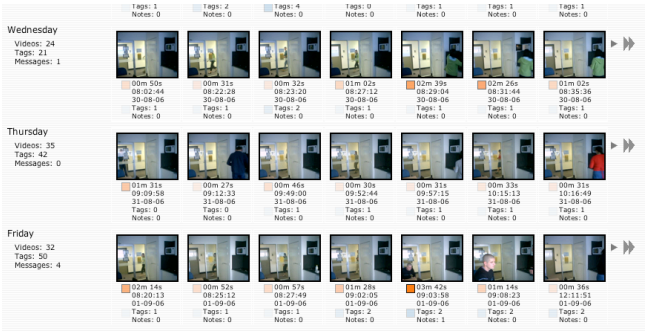

Figure 4. Week View – Overview of all videos captured

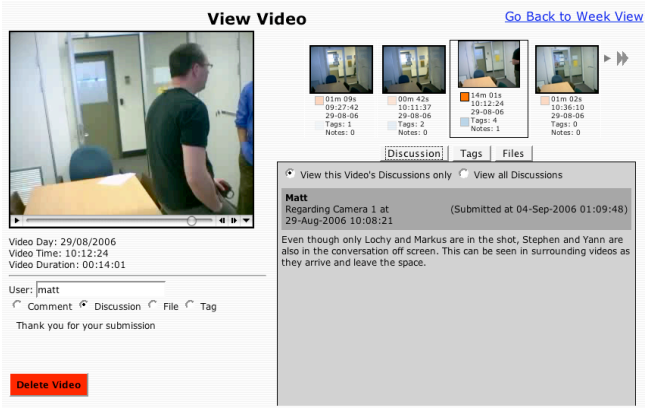

Figure 5. Individual Video View

An separate machine ran the web server which hosted the restricted access website displaying of the captured data, synchronized from the capture device. This enabled participants to access the data without it being available to the world at large.

Figure 4 and Figure 5 show the interface of the website which forms the participant interaction portion of Zebra. The first screen (Figure 4) provides a weekly overview of the videos captured on each day with the tags and discussions visible. The video view (Figure 5) provides an embedded view of the selected video segment, the surrounding video thumbnails in the timeline, tags for that segment and discussion with a form to submit additional instances of these items. Finally, the website incorporates a privacy enforcing feature that gives participants the opportunity to withdraw a particular video from the study after it had been stored.

Systematic Data collection

Zebra logged video (but not audio) data depending on various attributes of the images to filter the amount of data collected. A motion detection algorithm was used to detect activity and to start recording as required. After 20 seconds without motion, the video recording was interrupted. If a recorded interaction was shorter than 5 seconds, the video was archived but ignored for the rest of the study. The aim of this was to filter the number of video clips made

Figure 6. Tag Cloud from all video data. Users can click on tag to see which videos the tag relates to

available. The web server logged every contribution made through the website. We also used the web server log to explore when participants were visiting the website and to determine navigation patterns from this. We also recorded any relevant events we initiated such as emails and workshops to explore their impact on the probe's feedback functionality usage.

Deployment

Zebra was deployed in the coffee room of our lab, where people engage in coffee chats, lunch get togethers and, on occasion, meetings (for example, between PhD students and their advisors). The deployment lasted two months, during which minor changes were made to the probe mostly focused around camera position and changes to enhance usability of the feedback website.

The deployment of Zebra was preceded by a test phase in a limited use research lab, enabling some participants to preview the probe. An announcement of the deployment was made through email 3 weeks prior to its occurrence in order to prepare participants and address any potential initial concerns. This was followed up with an email to

announce the deployment start and provide details of the study being undertaken.

After two weeks of deployment an exploratory workshop was organized to engage participants in consultation over the project direction and gain initial feedback and participants' perception of Zebra. This enabled us to reiterate the aims of the study and to discuss any concerns and questions the participants may have had about the study (on both a deployment and an interaction level). The workshop allowed for the introduction of the next stage—the inclusion of discussion and revision of probe interaction based upon the workshop.

Stage two added the ability for participants to have open discussions about particular video clips through a web-based forum. New features were implemented, including a tag cloud and the ability search view videos based on tags to enable faster tagging and discussion (Figure 6).

The final workshop held at the end of the study provided participants with some of its outcomes and discuss the methodology.

Participation to workshops and interviews was strongly influenced by participants' availability. Typically, between 8 and 12 participants collaborated during workshop sessions and 8 key participants were interviewed towards the end of the study. Interviews lasted between 30 and 90 minutes.

Results

"I have been on [the website]. […] Usually to read the comments that other people make. They're quite funny sometimes." (One of the participant in the zebra study)

Using the interviews and the workshops, the study permitted the researcher participants to discuss different approaches to the observation tool, building upon their experience of Zebra, tailored for different research and design audiences. While we engaged the room of occupants (researchers of the research group) as the study participants, there were occasions we made a distinction between their perception and impression about their exposure to Zebra and their critique and review of the concepts the probe incorporates. We highlighted these points of distinction between roles played by participants during workshops and interview sessions by focusing questions on either aspect subsequently.

In interviews and workshops, participating researchers provided insightful comments on how the data would be used, other deployment contexts and aims for potential extension of the tools capabilities.

Participatory Design Approach

One participant interviewed is an experienced researcher in the field of participatory design. During the interview, we suggested he provide a different iteration for the tool based on his research experiences and his experience with Zebra. Two alternatives were provided, both focused on enhancing the engagement of participants through maximizing exposure, provocation and motivation.

The first suggestion was to create an observation tool to engage people with it and confront them with the previously recorded videos. Instead of providing systematic recording and feedback, the device would randomly switch between two modes when motion is detected: playback of previously recorded video, on which people in the room are then given the opportunity to comment; and recording (as described previously). This system would not provide the systematic recording ability of the probe, but it would significantly increase the provocation of participants and their access to the recorded data. This technique addresses the issue of exposure effectively (how do you get exposed to the collected material so that you can comment on it).

The second suggestion was to design a tool to maximize exposure of people to the collected material and lower the threshold necessary to take part in the data analysis. In this alternative, the feedback screen would be removed and replaced by printouts from the videos that have been tagged by researchers and organized, then pinned on the wall of the coffee room. Participants would be free to write additional tags and comments on the screen grabs and review particular videos by scanning the grab on a RFID tag reader. The video corresponding to the grab is then played on the screen. Eventually, people are asked to re arrange the videos any way they feel appropriate. The resulting organization is recorded every evening for record keeping and other videos are arranged on the wall.

This technique is strongly related to the video card game [4], a technique for analyzing video in collaboration with participants in a study which uses raw clips of video from the design setting to identify interaction themes.

Human studies approaches: Augmented diaries

Building upon work in qualitative methods, several of the participants suggested the use of the tool to support a diary study. Instead of commonly used pen and paper diaries, video would be automatically recorded by the device and serve as a prompt for the researchers to inquire about the details of a particular interaction. It could also be a powerful media to help users recall a specific instant. However, diaries involve the user making the entries and choosing what to report instead of relying on systematic data collection, making them susceptible to omissions and other mis-reporting of events. During our interviews, an alternative was suggested in the form of a bookmark button, which would allow users to create diary entries in the recording. These entries would take the form of a marker to particular moments of the video. They would then be reviewed by either the researcher or the participant (or both) for further discussions. Researchers would still have access to the full body of collected data, but could prompt users based on their own markers as well.

Suggested benefits also included the ability to run the study, review data and prompt users remotely in an automated way. Entries as markers would also be easier for the participants to make and the context of the marker is recorded as a video, therefore rich in details to support remembering. This technique aids the level of empowerment. More, users would be given the right to highlight certain moments within their day that they consider important in the study at hand. Similarly to Cultural Probes, users are active collators of data for the design.

Reviewing and analyzing the data

At the end of our interviews and during our final workshops, we discussed how participants would like to manipulate the data to analyze it. The current implementation of the system using the website constituted a promising approach. The tagging capability was suggested as a way to sort the videos into categories and support qualitative analysis.

In an intermediate workshop, participants suggested that they would like to be able to easily retrieve every video in which they appear to make commenting of actions easier. To help facilitate this feature, researchers started to review data from the server regularly during the day in order to tag them with the name of the people appearing on them. At the same time, the tag cloud feature (Figure 6) was implemented. Viewing the tag cloud allowed us to observe which users were using the coffee room the more often as by doing so their name would be tagged more often and therefore appear bigger in the cloud.

While reviewing video, we observed that most participants tended to glance at the video instead of going through it entirely. They would hold the video marker and slide it to view an accelerated version of the video, efficient to recall memories and most interaction taking place in low details. This fast-browsing of videos was later suggested in the form of selected key frames allowing participants and researchers to highlight important moments in a video for later discussion, but also as a summary of the video.

For further data analysis, it was suggested that we could implement a way to compare different days in terms of what interaction occurs. Using tags as filters, we could compare lunch times, types of informal interactions, etc. to observe and analyze temporal patterns. It was also suggested the key moments of an interaction sequence could be displayed as stills to provide a contextual overview for those not wishing to review all the video footage.

Learning about the informal interaction and social networks

An initial qualitative analysis of videos showed many aspects of the space that could trigger ideas for designs. It provided both inspiration and information on how to use the space to enhance remote collaboration. For example, people waiting for the coffee to brew often look for something to occupy themselves. They sometimes read the scattered newspaper form last week, but sometime would go into quite an effort to do a funny video for the people watching it. Using this aspect of the room could be interesting to create non work related links between collaborators.

On preliminary analysis of the data, patterns of social networks began to be revealed. The use of tags as markers of participant involvement in video files enabled an overview, which not only aided the participants in annotating their own experiences, but also revealed a rich relationship of groupings of people to activities in context. This activity while revealing people's cultures of habit in the space on a daily basis also provided the participants with an insight into each other's activities interactions and engagements. This situated social network was raised in the workshops as an insight into colleagues' activities and aided in people adapting their activities in response to their colleagues' routines. Through revealing this hidden data, participants were provided with new insights and opportunities to interact with colleagues.

Reactions to Zebra's introduction

Participants in this study were not only required ot react as researchers from the Zebra's perspective, but were also observed by it. They therefore provided interesting insights on reactions of participants to the introduction of a video recording device in a space. In an interview, a designer suggested that we should remove the screen with the always on feedback as it was thought to be too intrusive, or "in your face". Talking with participants, we realized that a group decided not to use the coffee room anymore in order to avoid being recorded. Further investigation led to the understanding that the recording was not the main cause, but the fact that they were always aware of being recorded made them too self conscious about what they were doing. The review of the videos allowed observing the gradual desertion of the coffee room by this group. However, after the second workshop where we addressed some of their questions on the finality of the study, this group returned to the room, though never as extensively as before. This suggests that removing the always on screen feedback would probably lower the impact of the tool on the environment and proves to be less intrusive as a result.

DISCUSSION

Measure of success of the methodology

In this study, our intentions were to confront the tool concept to the real life deployment and participants. We also wanted to refine the concept and elicit researchers' responses to it in order to better understand its different aspects and how it could be reused. Through the design and deployment of the technology probe, we were able to gather invaluable insights on real conditions of deployment, including camera perspective, possible breakdown, and participants' required involvement. Building upon the collected tags, discussions and captured video data, we

were able to discuss with participants about issues and attitudes towards the tool and its feedback interface. We then further discuss its potential for research in participants' context and research expertise.

By acknowledging the co-adaptation process, we observed and measured participants' interaction with the technology probe and drew upon these findings for the creation of further observation tools. We encouraged participants to build upon their experience with the probe to suggest improvements, alternatives and contexts of use.

The study was successful in that it engaged participants as both observed participants and researchers. Three-quarters of the participants were active collators of contextual data that helped the data analysis in varying degrees, ranging from adding single comments and tags on video to leading discussions around themes arising from the context.

These are clear measures of participant engagement and connection in the project, and reveal an insight into researchers proposed adaptations of the system. Researchers drew upon personal experiences with the study (as participants) and explored their familiarity, from a research perspective, with the above aspects, to inform the design critique.

Engagement in the three workshops enabled a continuous flow of data to be collated on both the material captured in the study of informal interaction and the discussion of the study and technology probe deployment. This was made possible without extra burden on participants through timed workshops, and subtle encouragement to interaction with the system (as well as personal motivation and investment).

The results of the study are presented as "alternative approaches", grounded in both the interview with the participants and their recorded experience as raw video and as tags and discussion through the web interface. These alternatives provide a clear and useful summary of the probe's results that can be easily reapplied. Captured or annotated data can easily be matched with the different alternatives for illustration.

The success of the methodology cannot be measured without reflection from a design perspective.

Design reflection

Whilst we have so far presented results of deploying Zebra in the form of a user study, our engagement with the probe has also been as designers. As such, we also feel it is important for us to reflect on the design of this probe, and what we have learned about the role that technology probes can play in design. Further, we want to reflect on the impact our approach to engage and empower our participants had on the design process for the probe.

Role in design

Zebra was introduced to the participants with only a workshop and a set of emails prior to the deployment. The objectives of the study had not been set in collaboration with participants through previous activities such as cultural probes and workshops, used in the interLiving project. The nature of the participatory design process around the study deployment enabled participants to engage in a manner which was less intrusive to daily activities and workflows. The background deployment of Zebra in a commonly used public environment allowed for participants to become familiar with the presence of the device, the interface and main system features. The extended period of the study deployment enabled participants to engage in their own time, choosing when and how they wished to be involved in the collating and analyzing of data. The gradual deployment of the features of Zebra over several weeks assisted in renewing interest in the tool, while gradually building participants' knowledge of the interactions possible and increasing the level of control they had over reflection of the captured moments of their lives. The formal sessions of researcher – participant engagement and feedback were short considering the two-month deployment of Zebra. The three hours cumulated reflection on the device (during interviews or workshops), its usage and use outside of the deployed context, required a minimal investment from participants while efficiently maximizing the feedback and dialogue to ensure participants felt both informed and empowered by the process. By using this process, most of the shared understanding about the occurring design was built over time through participants' exposure to the probe and opportunistic discussions as well as intermediate workshops.

In this design process, technology probes represent a central artifact around which discussions and reflection evolve. More than a step in the design process, it is a stepping stone into a design discussion and interaction with participants.

Provocation for engagement

We identified provocation as a strong reinforcement of engagement from users. Through challenging or entertaining aspects of the technology probe, we were able to elicit participants' reaction to the introduction of Zebra. These reactions served to fine tune the available interaction with the device and raise issues of navigation in the web interface provided. Other ways of provoking users are suggested in the literature. Gaver's initial cultural probes [8] were designed for provocation, challenging participants to look at the world from a different perspective and to collect data creatively. Provocation is a strong factor for engagement, which is particularly suitable when investigating the interaction of a participant with a technology probe. However, if the technology probe investigates a particular task, using provocation could divert the user from his/her primary task and gather little useful data on how the task is supported. For example, when deploying the MessageProbe [12], the interLiving researchers could have encouraged participants to use the probe by explaining to them that they could draw pictures and keep them for later, very much like kids bringing

drawings back. This could have influenced participants' view of the probe and encouraged the drawing task at the detriment of a more communication oriented task (we however acknowledge the potential role of these drawings for communication and awareness). Conversely when the focus of the probe is narrow, the researcher would benefit from ensuring that what the probe gathers data useful to him/her, as suggest earlier. Clearly, a compromise needs to be found between the "inspirational" and the "informal" aspect of the probe prior to its deployment.

Empowerment

By providing a transparent collection of data, we were able to provide a transparent analysis of the data. Technology probes can encompass similar empowering aspects by including participants in the design loop in further stages. Analysis is a crucial stage in making sense of collected data. Removed from its context, data is complex to understand and easy to misunderstand or ignore. While certain unfamiliarity is essential for a critical exploration of data, some misconceptions can be misleading. By implementing a transparent analytic phase, users are able to review abstractions and findings extracted from data and refine and critique them. This stage provides valuable details and validates collected data.

In our study, findings were systematically provided to concerned participants for them to review and critique our analysis. Therefore the close relationship involved by PD was maintained and reinforced all throughout the study.

Making sense of data

Data was collected by automated means (video, web server logs), from participants (discussions, comments) and by researchers (interviews, workshops). Analysis took place in different stages through the course of the study.

It appears difficult to systematically draw a separation between qualitative and inspirational data emerging from Zebra. We were often confronted by unexpected qualitative data that served as a trigger for new design ideas and choices. The lack of interaction with the given interface accounts for the poverty of quantitative data.

The qualitative data was found to be more effective gaining participant's insight, from the workshop sessions and the interviews. These direct interactions provided clear insight into participant views on design requirements and inspirations. The focused task of workshop and interview interaction allowed for direct engagement of participants, with prompting and provocation of uncover detailed feedback. This level of exploration in person was beyond the scope of what participants were prepared in commit to through zebra discussion interface.

Tags allow participants to give details on a video but also to join them using key attributes drawn from the footage. For further analysis, the grouping of sets of tags was suggested, in order for researchers to organize videos and associated discussions at a secondary level for later analysis.

Distinctions to prototypes

At many levels, technology probes are similar to working prototypes. However, the probe has deliberate ambiguity such as the lack of filtering for the videos. Moreover, the probe logs data through its use, for the purpose of analyzing when, how and by whom it is used. The purpose of a prototype is to provide a step towards a final design. Technology probes are designed to explore a design concept or space, but not a particular solution for a given problem. Technology probes will be deliberately open ended and look at particular aspects of the design space to elicit responses from users, but also capture their reactions and interactions. Eventually, the technology probes are designed and developed for a long term deployment allowing participants to build an intimate understanding of the design concept at hand. This process potentially allows participants to build self confidence towards the technology and raising discussions and self observations. Meanwhile, the technology probes capture the how the participants adapt, and adapt to, the given technology.

Difference to Cultural Probes

Technology probes are often misleadingly assumed to be a type of cultural probes. However, some important distinctions exist between both methods. First, while cultural probes are designed to capture inspiration or information, they do not incorporate a clear design intent. They are not intended to elicit participants' design input on a particular technology or design concept. Technology probes embed a design concept and therefore can serve as a base for discussion for possible solutions or input in the design space.

Secondly, cultural probes provide a means for participants to collect data for designers or researchers (often referred to as returns). The data is collected for the sole purpose of giving it to the investigator. On the other hand, the logging capability of technology probes allows the collation of data as users interact with the device for their own purpose, without biasing the data to fit what users think the investigator wants to gather. Finally, cultural probes are largely cheaper than technology probes to design, develop and deploy. They require fewer resources and therefore can play a more open ended and exploratory role in the design process. In comparison, we suggest that technology probes require a strong definition of the measure of success prior to its development and deployment. This definition is to ensure the capture of useful data complemented by exploratory findings that are the very nature of "probes methodologies".

CONCLUSION

In this paper, we have proposed that technology probes can be used not only as a technique in a participatory design process alongside other techniques, but as a core element to

raise discussions and generate ideas. Because the technology probe was not deployed in a single one off design workshop, but longitudinally, it provided users with a personal experience with the design concept without requiring an extensive amount of time. However, this design process still enables users with a level of engagement and empowerment not available in traditional contextual analysis methods. To this respect, technology probes can be used as the starting point in the design process.

In our study, we have used a technology probe and a limited number of workshops and interviews to gain rich, valuable feedback on the design of a research tool in collaboration with researchers. Through their intimate experience with the tool, participant researchers were in a position to understand and elaborate suggestions and alternatives of the proposed concept.

Building upon this study, we are exploring how we can modify and incorporate participants' feedback in a working implementation of the research tool. The tool is to be designed in different versions to deploy into different contexts, including collaborative design involving physical artifacts, and physician surgeries. We are continuing to study analysis techniques that can be suggested and facilitated by the tool. These include pattern recognition, comparisons, coding and categorization, log review and statistical analysis.

Eventually, we are planning to redeploy technology probes for design processes in different contexts, including design of communication with seniors.

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