

# Wearable probes for service design

*Aaron Mullane, Jarmo Laaksohalmi, Dag Svanæs*

*amullane@gmail.com*

*IT-University of Copenhagen, Denmark*

## Abstract

Probes are used as a design method in user-centred design to allow end-users to inform design by collecting data from their lives. Probes are potentially useful in service innovation, but current probing methods require users to interrupt their activity and are consequently not ideal for use by service employees in reflecting on the delivery of a service. In this paper, we present the ‘wearable probe’, a probe concept that captures sensor data without distracting service employees. Data captured by the probe can be used by the service employees to reflect and co-reflect on the service journey, helping to identify opportunities for service evolution and innovation.

**KEYWORDS:** Service innovation, design probes, reflection, participatory design, personal informatics

## Introduction

Service designers rely on a broad range of methods to elicit insights and contributions from stakeholders at different stages of the design process. Examples include role play (Svanaes & Seland, 2004); co-design (Sanders & Stappers, 2008); ethnography (Blomberg et. al, 1993); design games (Brandt & Messeter, 2004); make-tools (Sanders, 2000); situated and participative enactment of scenarios (Iacucci, Kuutti & Ranta, 2000); and design probes (Mattelmäki, 2006; Gaver, Dunne & Pacenti, 1999).

The above methods have to a large extent been used to learn about end customers, but currently service designers are increasingly involving service employees rather than end customers in their service innovation projects (Blomkvist & Holmlid, 2011) for reasons of efficiency, time, and availability. Various methods have been developed that focus on capturing insights into the service moments from a service employee perspective, including service mapping, sequential incident technique, and customer-sensitive walkthroughs (Rasila, 2012). However, little has been done on capturing the in-situ, moment-by-moment aspects

of the service delivery that provides a more detailed understanding of the service as it is performed (Holmlid, 2009).

In user-centred design, probes allow end-users to inform design by collecting in-situ data from their lives. This paper proposes a probing approach that enables service designers to continuously gather insights, elicit reflections, and establish a dialogue amongst the service employees. This can be used both for innovating new services and for improving existing services.

## Probes in design

Probes have traditionally been used in user-centred design to provide user participation through self-documentation. Users are given specific assignments that match the information needs of the designer. The assignments are generally in a form that enables the user to capture the tasks and describe them through reflections; most commonly using diaries and cameras (Graham & Rouncefield, 2008). The results of a probe enable a designer to take a look into the personal context of a participant, uncovering elements such as cultural environment, feelings, values, needs, and attitudes. Probes must have open and exploratory qualities. These qualities enable the participant to record and reflect, in addition to exploring new opportunities for design. Since the early 90's, Gaver et al. (1999) and colleagues' *cultural probes* have manifested into various forms: Informational probes (Crabtree et al., 2003); Technology probes (Hutchinson et al., 2003); Domestic probes (Vetere et al., 2003); Mobile probes (Hulkko et al., 2004); Empathy probes (Mattelmäki & Battarbee, 2002); and Urban probes (Paulos & Jenkins, 2005).

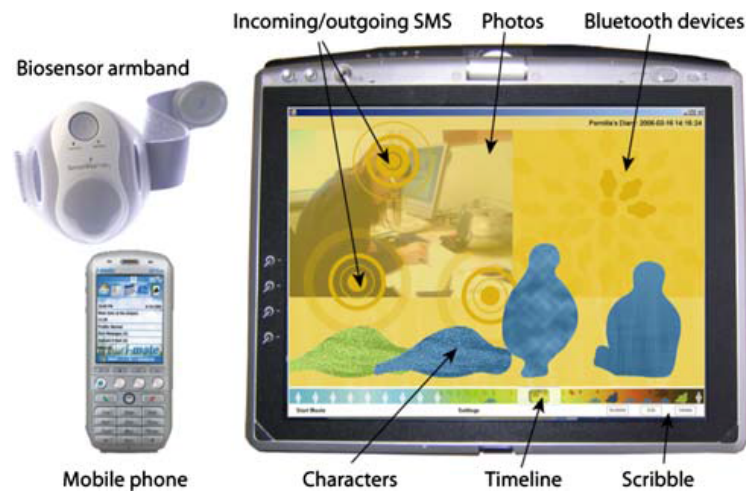
*Mobile probes* (Hulkko et al., 2004) allow for in-situ capturing of data, and can provoke dialogue between the participant and the designer during and after their use. One drawback with the existing mobile probes is that they are disruptive by asking the users to stop and reflect on their actions. Taking inspiration from the emerging field of personal informatics and self-monitoring, we believe that a probe can be built that reduces these in-action disruptions on service delivery moments, while at the same time promoting individual and collective reflection.

## Sensing and reflecting

The role and purpose of reflection and reflective practice in supporting technology for learning and play has been of interest to the Interaction Design and HCI community for some time (Fleck & Fitzgerald, 2010). Schön (1987:102) defines the concept of reflective practice as "*the capacity to reflect on action so as to engage in a process of continuous learning*". It can be seen as a three stage process: (1) going back to the experience that has happened in the past; (2) re-evaluating and understanding the experience in the light of current knowledge or experiences; (3) and deriving insights for future behaviour (Prilla et. al, 2013).

Reflecting on action through interaction with technology has extended through approaches in slow design, reflective design, critical design, inquisitive design, and technology as experience (Dalsgaard, 2008; Hällnas & Redström, 2001; Sas & Dix, 2009).

More recently *personal informatics* tools have reignited this interest in the community with research moving towards defining the many purposes of reflection (Fleck & Fitzgerald, 2010), and in particular making use of these new sensor-based technologies for reflecting on felt-life everyday experiences (Sas & Dix, 2009). Personal informatics tools and services facilitate the process of collecting, analysing, and presenting personal data on various aspects of an individual's life for reflection. A large percentage of the services focus on monitoring and understanding patterns in relation to wellbeing and health (Swan, 2009).



**Figure 1: Affective Diary (Lindström, 2006, page)**

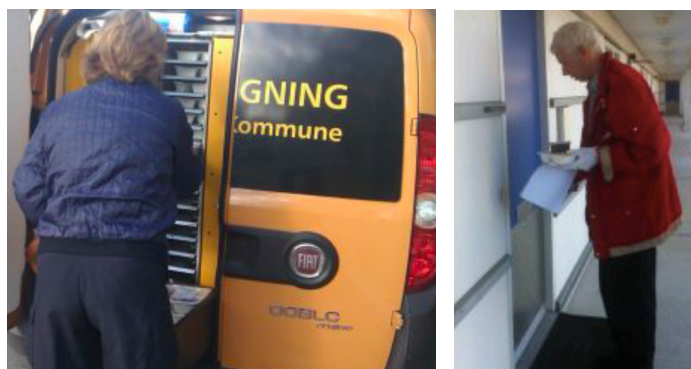
Figure 1 shows the Affective Diary system (Lindström 2006), a personal informatics tool for stress management. It allows the user to automatically record stress levels during the day through a skin conductance biosensor that continuously sends data to the user's smartphone. The recorded stress levels are uploaded to the user's PC in the evening, allowing for reflection and annotation on a timeline. The resulting stress diary can be shared with others, e.g. a therapist, to allow for co-reflection.

In the context of work, it has been advocated the importance of the social dimension in reflection (Boud et al., 2006; Hoyrup, 2004) and the ability of collaborative reflection to craft new knowledge from shared experiences that can inform work redesign (Wood 1997; Hoyrup, 2004). As discussed by Prilla et al. (2013), little has been done in tapping into and designing tools to inform this type of collaborative reflection on work practice, or as in this case, service delivery. Müller et al. (2013) recently studied the use of proximity sensors to record daily interactions and duration of the service provided by home carers and dementia patient. The visualisation of data enabled carers to reflect on their work, identifying behaviour patterns, and was used as a starting point to discuss carer practices.

Similarly, in this research, we see the potential of using probes as part of a longitudinal method of evolving the service. This could be achieved by probing, non-intrusively, elements of the service employees' service moments, then facilitating both individual and collaborative reflection at a later stage on what was collected regarding this moments over time. We believe that this method can act as kind of feedback mechanism that will help both designers and service employees in a dialogue that will inform the continuous evolution and improvement of the service in question.

## Service Case: Food Delivery for Elderly Citizens

As part of a research project on technology support for service innovation, we were presented with the challenge of designing technology to capture the experience of service employees distributing pre-prepared meals to elderly citizens in a large Northern European city (Figure 2). They were employees of a large logistics organisation that had not provided services of this kind in the past. The organisation's goal in the research project was to enhance the dialogue between the service employees and management, in an attempt to tune into insights that could improve the existing service or help identify new service opportunities for innovation.



**Figure 2: Food delivery service (preparation and delivery).**

To learn more about the service context we did a small fieldwork involving shadowing three service employees, observing and interviewing, during the completion of a typical daily route of delivering meals. We found that even though every move is monitored, controlled and planned down to seconds, the service employees still find room to do things their own way. In fact their ability to 're-design' or fine-tune the procedures seems a necessary part of what makes the logistic of this service work in practice. From this, it was clear that these service employees have the potential to identify and re-imagine new service opportunities.

The following insights from the fieldwork identified specific characteristics of this type of service:

- » *Flow and mobility*: Quick delivery interactions are required to fulfil their service obligations.
- » *Tacit Knowledge*: They take on the task of looking out for the elderly citizens they deliver to: calling for assistance; dealing with incidences; understanding that Mrs. X takes longer to answer the door; and sometimes becoming a 'handy-man' (e.g.. change batteries in a wall clock).
- » *Community-driven*: They share experiences and stories from their job with each other during breaks, they discuss the planning of the routes together, and they occasionally help each other out when they are out on their delivery routes.

## Requirements for the probe

From the service insights a list of requirements were identified that were specific to this type of service and therefore considered important for the use of existing, or the development of new, design methods for gathering insights from service employees:

- A. *“In the service moment”*: The method should allow for capturing data about the service and the service context *in-situ*;
- B. *Non-disruptive*: Due to the nature of the service employee’s work, there should be minimal disruption from an external task, or method;
- C. *Mobile (on the user)*: The varying contexts and movements caused by the high degree of mobility and non-disruptive nature of the service prove the need for an “on the user” method of capturing their service moments;
- D. *Capturing the temporal aspects of service moments*: The method must employ an approach that takes into consideration the entire service journey;
- E. *Senses the environment*: The method should have the ability to sense the external factors that surround the employees environment;
- F. *Supports collaborative reflection*: It must have the facility to support collaborative reflection;
- G. *Scalable*: It can be used by all service employees;
- H. *Longitudinal usage*: It can be used over a short or even continuous period in identifying the changing nature of events and various contexts.

## Analysis of existing service design research methods

To help us understand how existing research methods in service design fit the service context outlined in this paper, we mapped the methods against the requirements A-H identified above. The results are shown in Table 1.

	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
<b>Interviews</b>	-	+	-	-	-	-	+/-	-
<b>Observation</b>	+	+	-	+	+	-	-	+/-
<b>Cultural Probes</b>	+	-	+	-	+	+	+	+
<b>Technology Probes</b>	+	-	-	+/-	-	+	+	+
<b>Mobile Probes</b>	+	-	+	-	+	+	+	+

**Table 1: Matrix representing method capability against service requirement**

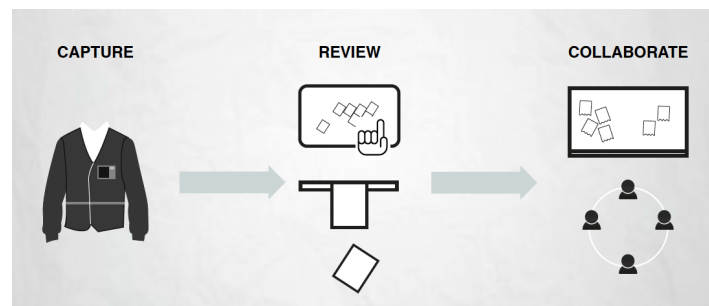
The list of methods is based on Segelström’s (2013) review of current research methods in service design. Comparing eight commonly used textbooks in the field, including (Stickdorn & Schneider, 2010), he found that the three most popular methods were *interviews*, *observation* and *probes/diaries*. We have divided the probes category into *cultural probes*, *technology probes* and *mobile probes*.

A plus indicates that the requirement is supported by the method, a minus indicate that it is not supported, while a “+/-” means that it is supported to some degree. Observation and interviewing are less disruptive in the reflective process during service moments. However, in these methods do not support collaborative reflection. Methods like traditional culture probes and mobile probes can be kept on the user (mobile) and they are good at capturing the environment (e.g. photos) and support reflection. However, their disruptive nature

proves to be cumbersome for this service context. We see from Table 1 that no single method satisfies all requirements, and there is consequently clearly a need for new design methods for this kind of service design projects.

## The Wearable Probe Concept

The requirements inspired the *Wearable Probe* - an exploratory probing concept that helps elicit forms of reflection after a daily route of a service employee for developing dialogue toward service improvement. The probing device (leftmost in Figure 3) disguised as an app. running on a mobile phone, placed in the service employees uniform, captures changes in the environmental elements of service moments throughout the entire service journey. The captured sensor data are later represented using an ambiguous representation (middle of Figure 3). This interface is intended to be used upon completion of a route to prompt individual reflection on past service moments (reflection-on-action) during the route. The reflections of one service employee can later be shared with other service employees through a collaborative reflection space (rightmost in Figure 3).



**Figure 3: Three steps for reflecting using the Wearable Probe**

## Capturing service moments

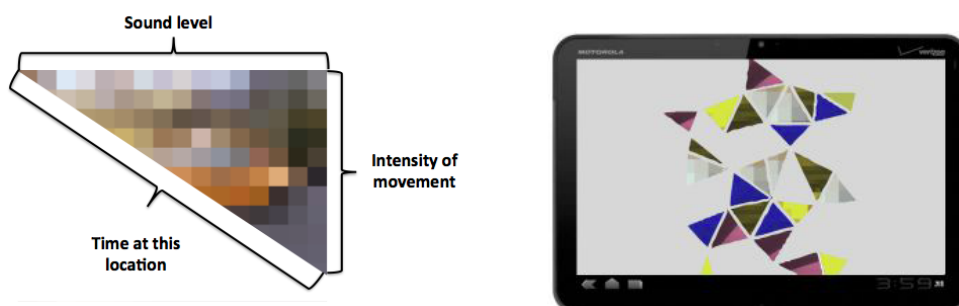
Today the service employee uses various cues to help them reflect on the service route. At this stage, the following more concrete and visual elements of prompting reflection were considered as cues: physical location; people they interact with; activities; time of day; duration; landmarks; temperature; and sounds.

We decided to use a standard Android smartphone as a prototyping platform and built an app running in the background capturing the following data elements solely from sensors on the smartphone.

- » *Smartphone camera: Blurred/pixelated photo of the surroundings.* Using the power of visual imagery for meaning making; we focused on using light intensity and colours as a source for ambiguity;
- » *Smartphone microphone: Sound levels.* Sudden changes in sound levels were recorder;
- » *Smartphone accelerometer: Movement.* The accelerometer captured elements of physical movement over a period of time (i.e. running up stairs), and incidents leading to quick actions (i.e. helping citizen falling out of bed);
- » *Smartphone GPS: Location.* The GPS gave data that about time used at various locations, and the speed between locations.

## Visualisation and reflection-on-action

In the first version of the probe, we have used ambiguity as an approach. Ambiguity empowers people to form their own understandings from what is perceived during the reflective practice (Gaver & Beaver, 2003). Thieme et al. (2011, p. 284), state “*design of more open-ended artefacts that leave space for multiple and idiosyncratic interpretations have the potential to challenge individuals to resolve their inherent ambiguity through sense-making processes*”. Furthermore, too narrowly constructed artefacts are less likely to make us reflect, or even wonder (Paulos & Beckmann, 2006).



**Figure 4: (left) Data from service moments as prisms and (right) prisms mosaic.**

The service moment prism is the starting point for visualising a service moment. A prism represents a snapshot of a period of time based on the surrounding elements captured by the smartphone. The triangle shows a pixelated snapshot from the smartphone camera, while the lengths of the three sides of the prism represent sound level, intensity of movement, and duration. The temporal aspects of data from the service moments captured were represented spatially as a mosaic; in towards out indicated the time it was captured during the route (Figure 4).

## Collaborative reflection

The service moment prisms can be printed and viewed in a shared physical or virtual space by service employees. The reflections that have taken place, notes and discussion held amongst peers, can then be discussed, as *collaborative reflection*, in meetings held amongst the supervisor and colleagues. The ability by the service employees to print any of the prisms enables further pondering, annotation, and usage in collaboration with each other and management. The physicality of such interactions creates richer dialogues that express insights into possible new ideas for services or improvement of existing services.

## Prototype and initial trial

A working prototype of the *Wearable Probe* was developed on an Android-based smartphone, and as an initial proof-of-concept test we captured data elements during a route with three service employees carrying the phone in the pocket of their uniform. This initial test was purely a feasibility and technical test aimed to give us a first impression of what kind of data will be captured by the probes. The probes recorded a snapshot every 10th second, each consisting of: a pixelated image from the camera, the sound level from the microphone, the activity level from the accelerometer, and the position from the GPS. Each route lasted

about two hours, leading to a total of approx. 250.000 snapshots from the three routes. The prototype was found to work, and to provide data that could be used for visualisations.

Further evaluations of the concept in dialogue with the users are required. These evaluations will focus on experimenting with the representations and range of experience elements captured by the probe. The concept as it stands focuses heavily on extreme changes which would result in more the unfamiliar (i.e. loud sounds, long durations, etc.), however representing data elements of common experiences, once exposed, may result in questioning the familiar which makes way for alternative ways of reflecting on moments between events of delivering the service.

## Discussion

We are interested in further exploring collaborative reflection. The concept has similarities personal informatics systems such as the Affective Dairy (Lindström, 2006) that focuses on capturing data for individual use, however we are also interested in the process required to share reflections and work on them collaboratively. We believe it is possible to create methods and tools, such as the *Wearable Probe*, that extend individual reflection into a collaborative dialogue.

An obstacle of the probe is related to issues with privacy and security of the data captured. Employees could become hostile in their use of the probe if management does not enforce policies regarding access to raw data. They would be worried that their daily routes are being monitored and the raw data would be used to gauge their efficiency. There is also an issue in the motivation to use such a probe. Here, further studies are required to help understand the incentive-driven and motivational qualities of use and to what degree the ambiguous elements of data, and their representations, decrease/increase motivation for use. It has been advocated that employees that have shared elements likened to a community of practice benefit from the social dimension of *collaborative reflection*, and that it generally leads to positive outcomes (Prilla et. al., 2013). However, there are also the mechanisms required to prompt employees to reflect on their data and best practices that should be employed require further investigation.

## Conclusion

Through a proof-of-concept prototype we have shown that design tools inspired by personal informatics, such as the *Wearable Probe*, can be used to capture sensor-data from the service context for eliciting reflection from service employees. The insights from the captured data can be used as a form of memory-aid on past experiences, for identifying patterns, or for exploring discrepancies. We believe that the *Wearable Probe* used as a tool for reflection and co-reflection has the potential to uncover insights that can lead to improvements of existing service and innovation of new services through a dialogue with management and designers

Future work will focus on: types of sensor data being captured; algorithms that can analyse multiple sources of data; visual representations for meaning-making and thus reflection; and mechanism to prompt reflection on data and forming dialogue amongst peers.



## Acknowledgments

Thanks to our colleagues in the Community-Based Innovation (CBI) project for useful feedback on idea, and to the workers who had patience with us during fieldwork, discussions, interviews and trials.

## References

- Blomberg, J., Giacomi, J., Mosher, A., & Swenton-Wall, P. (1993). Ethnographic field methods and their relation to design. In D. Schuler, & A. Namioka (Eds.), *Participatory Design: Perspectives on Systems Design* (pp. 123-154). Hillsdale, New Jersey: Lawrence Erlbaum Associates.
- Blomkvist, J., & Holmlid, S. (2011). Service designers on including stakeholders in service prototyping. In *Proceedings of Include 2011*, London, UK: Royal College of Art.
- Boud, D., Cressey, P. & P. Docherty (2006). *Productive reflection at work: Learning for changing organizations*. London, UK: Routledge.
- Brandt, E., & Messeter, J. (2004, July). Facilitating collaboration through design games. In *Proceedings of the 8th conference on Participatory design*, Vol. 1 (pp. 121-131), New York, USA: ACM Press.
- Crabtree, A., Hemmings, T., Rodden, T., Cheverst, K., Clarke, K., Dewsbury, G., Hughes, J., & Rouncefield, M. (2003, November). Designing with Care: Adapting cultural probes to inform design in sensitive settings. In *Proceedings of the 2004 Australasian Conference on Computer-Human Interaction (OZCHI2004)* (pp. 4-13), Brisbane, Australia: ACM Press.
- Dalsgaard, P. (2008, February). Designing for inquisitive use. *Proceedings of the 7th ACM conference on Designing interactive systems - DIS '08* (pp. 21-30), New York, USA: ACM Press.
- Fleck, R., & Fitzpatrick, G. (2010, November). Reflecting on Reflection: Framing a Design Landscape. In *Proceedings of the 2010 Australasian Conference on Computer-Human Interaction (OZCHI2010)* (pp. 216-223), Brisbane, Australia: ACM Press.
- Gaver, B., Dunne, T., & Pacenti, E. (1999). Cultural Probes. *Interactions*, (February), 21–29.
- Graham, C., & Rouncefield, M. (2008, October). Probes and participation. In *Proceedings of the Tenth Anniversary Conference on Participatory Design 2008* (pp. 194-197). Bloomington, IN, USA: Indiana University Conferences.
- Gaver, W., & Beaver, J. (2003, April). Ambiguity as a resource for design. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 233-240). New York, USA: ACM Press.
- Hällnas, J., & Redström, J. (2001). Slow technology—designing for reflection. *Personal and ubiquitous computing*, 5(3), 201-212.
- Holmlid, S. (2009, November). Participative, co-operative, emancipatory: From participatory design to service design. In *Proceedings of 1st Nordic Conference on Service Design and Service Innovation*, Oslo, Norway.
- Hoyrup, S. (2004). Reflection as a core process in organisational learning. *Journal of Workplace Learning*, 16(8), 442–454.
- Hulkko, S., Mattelmäki, T., Virtanen, K., & Keinonen, T. (2004, October). Mobile probes. In *Proceedings of the third Nordic conference on Human-computer interaction* (pp. 43-51). ACM.
- Hutchinson, H., Mackay, W., Westerlund, B., Bederson, B. B., Druin, A., Plaisant, C., ... & Eiderbäck, B. (2003, April). Technology probes: inspiring design for and with families. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 17-24). New York, USA: ACM Press.
- Iacucci, G, Kuutti, K, & Ranta, M (2000). On the move with a magical thing. In *Proceedings of Designing Interactive Systems 2000* (pp. 193- 202), New York, USA: ACM Press.

- Lindström, M., Ståhl, A., Höök, K., Sundström, P., Laaksothi, J., Combetto, M., ... & Bresin, R. (2006, April). Affective diary: designing for bodily expressiveness and self-reflection. In *CHI'06 extended abstracts on Human factors in computing systems* (pp. 1037-1042). ACM.
- Mattelmäki, T., Battarbee, K. (2002, June). Empathy Probes. In *Proceedings of the Participatory Design Conference*, Malmö, Sweden.
- Mattelmäki, T. (2006). *Design probes*. PhD thesis. Helsinki, Finland; University of Art and Design Helsinki.
- Müller, L., Sonnentag, M., & Heuer, S. (2013, May). Supporting reflection on dementia care using proximity sensors. In *Pervasive Computing Technologies for Healthcare (PervasiveHealth), 2013* (pp. 89-92). IEEE.
- Paulos, E., & Jenkins, T. (2005, April). Urban probes: encountering our emerging urban atmospheres. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 341-350). ACM.
- Paulos, E., & Beckmann, C. (2006, April). Sashay: designing for wonderment. In *Proceedings of the SIGCHI conference on Human Factors in computing systems* (pp. 881-884). ACM.
- Prilla, M., Pammer, V., & Krogstie, B. (2013, January). Fostering Collaborative Redesign of Work Practice: Challenges for Tools Supporting Reflection at Work. In *ECSCW 2013: Proceedings of the 13th European Conference on Computer Supported Cooperative Work* (pp. 249-268). London, UK: Springer.
- Rasila, H. (2012). Using employee insights in fine-tuning the customer experience. In *Proceedings of 3rd Nordic Conference on Service Design and Service Innovation* (pp. 218-228), Linköping, Sweden; Linköping University Electronic Press
- Sanders, E. B.-N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. *CoDesign*, 4(1), 5–18.
- Sanders, E. B. N. (2000). Generative tools for CoDesigning. In Scrivner, S. Ball, L. and Woodcock, A. (Eds). *Collaborative Design* (pp. 3-12). London: Springer-Verlag.
- Sas, C., & Dix, A. (2009, April). Designing for reflection on experience. In *CHI'09 Extended Abstracts on Human Factors in Computing Systems* (pp. 4741-4744). ACM.
- Schön, D. (1987). *Educating the reflective practitioner*. San Francisco: Jossey-Bass.
- Segelström, F. (2013). *Stakeholder Engagement for Service Design. How service designers identify and communicate insights*. PhD thesis, Linköping, Sweden: Linköping University.
- Stickdorn, M., & Schneider, J. (Eds.) (2010). *This is Service Design Thinking: Basics - Tools - Cases*. Amsterdam, The Netherlands: BIS Publishers.
- Svanaes, D., & Seland, G. (2004, April). Putting the users center stage: role playing and low-fi prototyping enable end users to design mobile systems. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 479-486). ACM.
- Swan, M. (2009). Emerging patient-driven health care models: an examination of health social networks, consumer personalized medicine and quantified self-tracking. *International journal of environmental research and public health*, 6(2), 492-525.
- Thieme, A., Wallace, J., Thomas, J. & Le Chen, K. (2011). Lovers' box: Designing for reflection within romantic relationships. *International Journal of Human Computer Studies*, 69(5), 283-297.
- Vetere, F., Gibbs, M. R., Kjeldskov, J., Howard, S., Mueller, F. F., Pedell, S., ... & Bunyan, M. (2005, April). Mediating intimacy: designing technologies to support strong-tie relationships. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 471-480). ACM.
- Wood Daudelin, M. (1997). Learning from experience through reflection. *Organizational dynamics*, 24(3), 36-48.