Interactive prototypes in the participatory development of product-service systems

INTERACTIVE PROTOTYPES IN THE PARTICIPATORY DEVELOPMENT OF PRODUCT-SERVICE SYSTEMS

MARTIJN TEN BHÖMER
EINDHOVEN UNIVERSITY OF TECHNOLOGY
M.T.BHOMER@TUE.NL

CATHERINE E. BROUWER
UNIVERSITY OF SOUTHERN DENMARK
RINEKE@SDU.DK

OSCAR TOMICO
EINDHOVEN UNIVERSITY OF TECHNOLOGY
O.TOMICO@TUE.NL

STEPHAN WENSVEEN
UNIVERSITY OF SOUTHERN DENMARK
S.A.G.WENSVEEN@MCI.SDU.DK

ABSTRACT

Stakeholders who are part of the development process of a new Product-Service System (PSS) could use interactive prototypes during meetings to exchange different point of views. Based on the findings of a conversation analyst and the reflections of a design researcher we compared three explication techniques of how a prototype was involved during such a meeting (for pointing and manipulating, for demonstrating its function and for imitating and/or demonstration through body movement and gesture) with the phases of a co-reflection session (exploration, ideation and confrontation). We found that the prototype was especially useful during the exploration and confrontation phases. Pointing and manipulating helped to make reflections concrete, made it easier to propose small design changes and helped the participants to reach common goals. Interactive prototypes do have their limits, during the ideation phase the prototype did not play an important role.

INTRODUCTION

Product Service System's (PSS) are combinations of tangible products and intangible services designed so that they jointly are capable of fulfilling specific customer needs (Tukker 2004). One of the challenges in the development of new PSS's is that companies need to extend their existing product and service chains into value networks built from multiple organizations (Pawar et al. 2009). This is why it is so important to transfer knowledge between the boundaries of different domains and organizations (Buur & Matthews 2008). This complex nature of the PSS is also a challenge for designers. Because a PSS allows for many different valid points of view, the grasp of the designer on the PSS is limited by his own point of view (Frens & Overbeeke 2009). This raises the following question: how can designers support the design of product-service systems, taking into account existing products and services of the stakeholders and at the same time fully acknowledge the diversity of the different viewpoints of stakeholders.

Within the fields of participatory design, human computer interaction, but also participatory innovation, artifacts play an important role in multi-stakeholder innovation processes. Boundary objects allow different parties within a community of practice to collaborate on a shared task. Such artifacts can also be considered as props that give input for performance and improvisation in sessions where multiple stakeholders are present, leading to reflection and new insights about their function (Foverskov & Yndigegn 2011). Provotypes are designed to let stakeholders experience a construction of a possible future and can help to bridge stages of analysis and design (Boer & Donovan 2012). Lim, Stolterman & Tenenberg's (2008) anatomy of prototypes includes a filtering dimension which the designer can use to focus the prototype on particular regions within an design space, and simultaneously eliminate unnecessary aspects of the design that a particular prototype does not need to explore. These filtering dimensions consist of appearance, data, functionality, interactivity and spatial structure. The interactivity dimension deals with behavior of the prototype, such as input behavior, output behavior, feedback behavior and information behavior.

We will investigate how a prototype that was designed to score high on interactivity (filter dimension), can play

a role during the development of a PSS. We focus on a meeting that is part of a longer development process in which stakeholders met on regular basis to share knowledge and discuss design decision. This article is part of a twin-paper written together with a conversation analyst (Brouwer & ten Bhömer this volume). We will first discuss relevant literature about the use of prototypes during the development of PSS's, and compare these to the interactive prototype we designed. Then, we will explain the different steps in the meeting in which this interactive prototype played an important role, and introduce the findings of the conversation analyst based on this meeting. We will compare these findings with the different steps of the meeting, and reflect on how these findings could be instrumental for the design of PSS's. We will conclude with a discussion on the use and limitations of such interactive prototypes in PSS design.

PROTOTYPING A PSS WITH MULTIPLE STAKEHOLDERS

Prototyping services is a topic gaining more and more interest in PSS research. Within this body of work prototyping is being explored as activity during the PSS design process itself, or, as a prototype of a service that can be used to evaluate and test a PSS experience. An example within the first approach is a recent study from Buur et al. (2013) which explores how the process of business model innovation can be opened up to a larger group of participants. By using tangible objects to redefine business elements or by letting people role-play a PSS scenario they explore activities to help organizations in creating, delivering and capturing value. As example of the second direction, Blomkvist & Holmlid (2012) pinpointed in their framework of perspectives for prototyping that the greatest challenges of prototyping a service are authenticity and validity. For these issues it is important to consider the larger context of implementation, use, location, as well as the use of real people; thus a holistic approach. Blomkvist et al. (2012) proposed the service walkthrough as one of the methods to address these issues, as it can show how different touchpoints of a service work together, how information travels through the service, and the general experience of the service while keeping in mind authenticity and validity (a holistic approach).

We follow the line of the second direction: we are less interested in how making prototypes as shared activity can help in the development of a new PSS, but how the design of prototypes and usage of them in the process can support a holistic approach. By designing prototypes the viewpoints and expertise of stakeholders, including the designers are already included: the process to design the prototypes is the same process to develop the PSS. This is the case because: (a) the people that are involved in developing and evaluating the prototypes are the same people that will be necessary to later implement the PSS, and (b) the context where the prototypes are evaluated is already the same as where the PSS will later need to work as well. Because of these reasons the prototype can function as a boundary object to trigger reflection and new design possibilities by stakeholders.

In the Smart Textile Services project of the Dutch Creative Industry Scientific Program (CRISP) we are investigating how to design and develop services that include smart textiles (textiles with integrated technology such as sensors and actuators). This is an collaborative process with small and medium enterprises from Dutch textile and technology industries, service partners, creative hubs and universities (CRISP 2013). Based on earlier experiences we found that it is important to involve stakeholders in a value network, realize a team mental model and maintain shared ownership during the process (ten Bhömer et al. 2012). During this process we often relied on artifacts, such as prototypes, to form bridges between different stakeholders. We noticed that especially the dynamic character of the PSS is difficult to deal with in this process. For example, it is easy to discuss the material properties based on a piece of fabric. However, it is more difficult to discuss how the smart textiles connect to existing services of the stakeholders, because of the time dimension and the interaction between the textiles and the users. To explore this dynamic behavior of the smart textiles, we designed an interactive prototype, and analyzed it with a group of stakeholders.

VIGOUR: AN HIGHLY INTERACTIVE PROTOTYPES

Vigour is a garment that could be used during physical rehabilitation exercises of elderly. During a longer process an interactive prototype of Vigour was developed by a group of stakeholders, who are also responsible for implementing the PSS further (a photo of a prototype of the garment is showed in Figure 1). Therapists and a knitting expert configured the shirt with sensor areas on specific parts of the body that can be used to measure movement of the arms and lower back. Caretakers were interested in lowering their workload by monitoring physical activity of their clients and tracking the progress of their clients. Therapists wanted to improve the rehabilitation services by keeping the exercises challenging for every different client. The design researcher designed sound feedback coming from an external computer. The further a particular sensor was stretched, the higher the pitch of the piano. The sensitivity of the sensors and the activation of each sensor surface could be wirelessly controlled using an interface displayed on a laptop (shown in Figure 2).

ANALYSING A PSS CO-REFLECTION SESSION

A meeting was organized with the design researcher, two therapists and a care manager specialized in dementia care to discuss the prototype of Vigour. On one hand this meeting aimed to reflect on the current state of the PSS, to envision new possibilities and

decide on next steps. On the other hand; analyzing meetings like these, that happen in a real project, with real stakeholders, can help us to find out more about the development process of PSS's, and in particular the role of prototypes.

Figure 1: The shirt with sensors (the gray areas) that was part of the Vigour PSS prototype.

The group of people that took part in the meeting has met regularly during the course of the project to take important design decisions together. The two therapists have used the prototype during one day in their daily practice before the meeting to get familiar with the prototype itself. For the third person, the care manager, it is the first time to see the prototype working. The meeting consisted of four steps (the different steps of the meeting are illustrated in Figure 3). In each step the participants filled in their findings on different forms and discussed their findings together. During the meeting the design researcher played a moderating role, by asking questions and steering the discussion. We will first describe the set-up of the meeting, then the insights that the design researcher got from this meeting and finally the observations by the conversation analyst who analyzed the interactions between the participants and with the interactive prototype.

SET-UP OF THE CO-REFLECTION SESSION

The set-up of this meeting is based on a co-reflection structure, which consists of an exploration, an ideation, and a confrontation phase (Tomico et al. 2009; 2011). The goal of these phases is that through reflecting on different ideas, people will be confronted with different viewpoints, which can change the frame of reference of both the design researcher and stakeholders. Similar to the exploration phase of co-reflection, the goal of the first two steps of the meeting was to let the participants reflect and explore the current prototype. This was done in the first step by asking the participants to reflect on their individual contributions and filling in their finding on individual forms. During the second step of the workshop the participants where asked to indicate positive and negative aspects of the current prototype on individual forms, this exercise was based on bi-polar laddering (Pifarré & Tomico 2007).

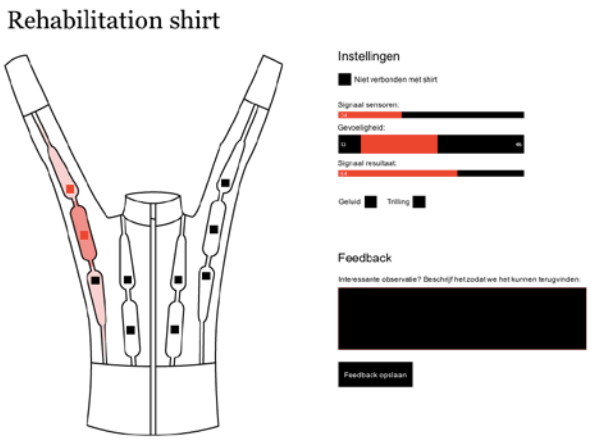

Figure 2: The image that the therapist saw on the computer, the red parts on the shirt indicate which sensors are currently being stretched. With the bars on the right side the therapists could change the sensitivity of the sensors.

Based on the ideation phase of co-reflection, in the third step of the meeting the participants where asked to individually use these positive and negative aspects to generate an ideal future service and each sketch it out on separated papers. Based on the confrontation phase of co-reflection, in the final step of the meeting it was the goal to collaboratively decide on concrete activities for the stakeholders to continue working on.

DESIGN INSIGHTS FROM THE CO-REFLECTION SESSION

To give an idea about what kind of insights the interactive prototype elicited during the meeting we will first discuss some of the topics that were discussed. Having a prototype that could be touched, worn and interacted with helped to make the requirements of the stakeholders very clear. The shirt needed to be fashionable, have a good fit and the sensors needed to be located on the right positions to provide accurate sensor data. Discussing the prototype also helped to open the discussion about what are the next things to consider when the PSS needs to be implemented. The stakeholders came up with a multitude of different scenarios in which the shirt could be applied. For example: for individual use, for group use, with family of the client or without, to measure daily activities, to be used in rehabilitation exercises. Finally, the meeting helped the design researcher and the stakeholders to together create a list of prioritized next steps that should be taken for the shirt to have value in the larger PSS. These were very concrete aspects such as: making the sensors more sensitive, choosing the target group for first tests, deciding on how many people to test the shirt with.

OBSERVATIONS BY A CONVERSATION ANALYST

The conversation analyst looked at the meeting from a different point of view than the designer, as further

explained in Brouwer & ten Bhömer (2013). The analysis focused on the type involvement of the participants had with the prototype and how they explicated the points they made in the discussion with or without making use of the prototype. This analysis was substantiated with excerpts from the meeting video recording. A description by the conversation analyst of each excerpt in relation to the prototype is showed in Figure 3. The first finding is that the prototype might be referred to both as and idea and as an artifact. This is the case because the prototype in the meeting is known to the participants from earlier experience, and therefore the object does not necessarily figure as a visible and tangible resource in explicating design features. This finding is shown by excerpt 1, 2 and 3. As a second finding three techniques for explicating design issues that exploit the prototype were identified: (a) gazing simultaneously with pointing, touching and/or manipulating (moving, stretching, turning), these are showed by excerpts 4 and 5, (b) demonstrating by taking the prototype into use the way it is supposed to be used, showed in excerpt 6 and 7, and (c) demonstrating by imitating the manipulation or use of the prototype through gesture - an 'imagined' dealing with the prototype, which is illustrated with excerpt 8.

RELATING THE EXPLICATION TECHNIQUES WITH THE CO-REFLECTION PHASES

To find out more about the implications of using an interactive prototype in a co-reflection session, we are especially interested in the explication techniques that exploited the prototype during the meeting. To find out how these techniques were embedded in the meeting, we relate the explication techniques that the conversation analyst described in her analysis to the phases of the co-reflection set-up in which the explication was found. We will reflect on the role of the prototype in the particular combination of explication and co-reflection phase, and discuss how this relation could be instrumental during the development of a PSS.

POINTING AND MANIPULATING FOR THE EXPLORATION PHASE

Pointing and manipulation was an explication technique that was picked-up twice during the exploration phase by the conversation analyst. In excerpt 4 one of the therapists discussed the sensitivity of a particular sensor. To establish a locus of joint attention in relation to what she was talking about she held the two sensors in her hands and stretched them. In excerpt 5, the other therapist discovered that one of the sensors in the garment slowly twisted when wearing it on the body. She pointed her finger towards the particular sensor to raise the issue to the other participants. For the design researcher these pointing and manipulation interactions with the prototype helped to make the issues the participants were describing more concrete. These two excerpts have in common that they support the exploration phase because the participants expressed and substantiated their individual viewpoints. The discussion about the sensitivity of the stretch sensors was an issue that was already discovered before the actual meeting, but the discussion about the twisting sensor was an issue that was discovered during the meeting itself. What this means for PSS development is that having a prototype that can be pointed at and manipulated enables participants to express their viewpoints. A problem like the sensitivity of the sensors, or the rotation of the fabric, would make it impossible for the PSS to function. By making these problems transparent and concrete, everybody has to agree that a solution needs to be found.

DEMONSTRATING THE PROTOTYPE'S FUNCTION FOR THE EXPLORATION AND CONFRONTATION PHASES

During the meeting the prototype was demonstrated multiple times (because one of the therapists was wearing the garment). In excerpt 6, in the exploration phase, the therapist gave a demonstration of the shirt and emphasized that the sensors were not sensitive enough, by showing the relation between the movements and the visual and auditory feedback on the computer. In excerpt 7, part of the confrontation phase of the meeting, the therapists discussed how the lower back sensor should be positioned for better functioning. Because the demonstration of the positioning took place on the back of the therapist, it was impossible for the two other participants to have a good view on the situation. For the design researcher these demonstrations were very valuable because they showed to a certain extend how the interactive prototype would be used in the real setting. For example, the therapist showed how she used the interface to change the sensor sensitivity. The design researcher noticed that this process would be very difficult with a real client, but the therapist did not further discuss this issue. During the exploration phase the therapist is using the demonstration to further substantiate the point that she made in a previous excerpt (that the sensors were not sensitive enough), the demonstration provided evidence to the other participants. In the confrontation part the participants were looking collaboratively for a better location for the sensor on the back, they used demonstrations of the prototype to try several alternatives and demonstrated how they would like the ideal situation to be. For the development of PSS we can learn that demonstrations can serve multiple purposes. Firstly, it can help to convince stakeholders of a problem that an individual notices. Secondly, it can help to collaboratively find and try new solutions for issues that were detected earlier in the meeting.

IMITATING MANIPULATION AND/OR DEMONSTRATION OF THE PROTOTYPE THROUGH BODY MOVEMENT AND GESTURES FOR THE CONFRONTATION PHASE

In excerpt 8, one of the participants explained how the sensor should be placed and stretched when a particular movement is made. Because she was not wearing the

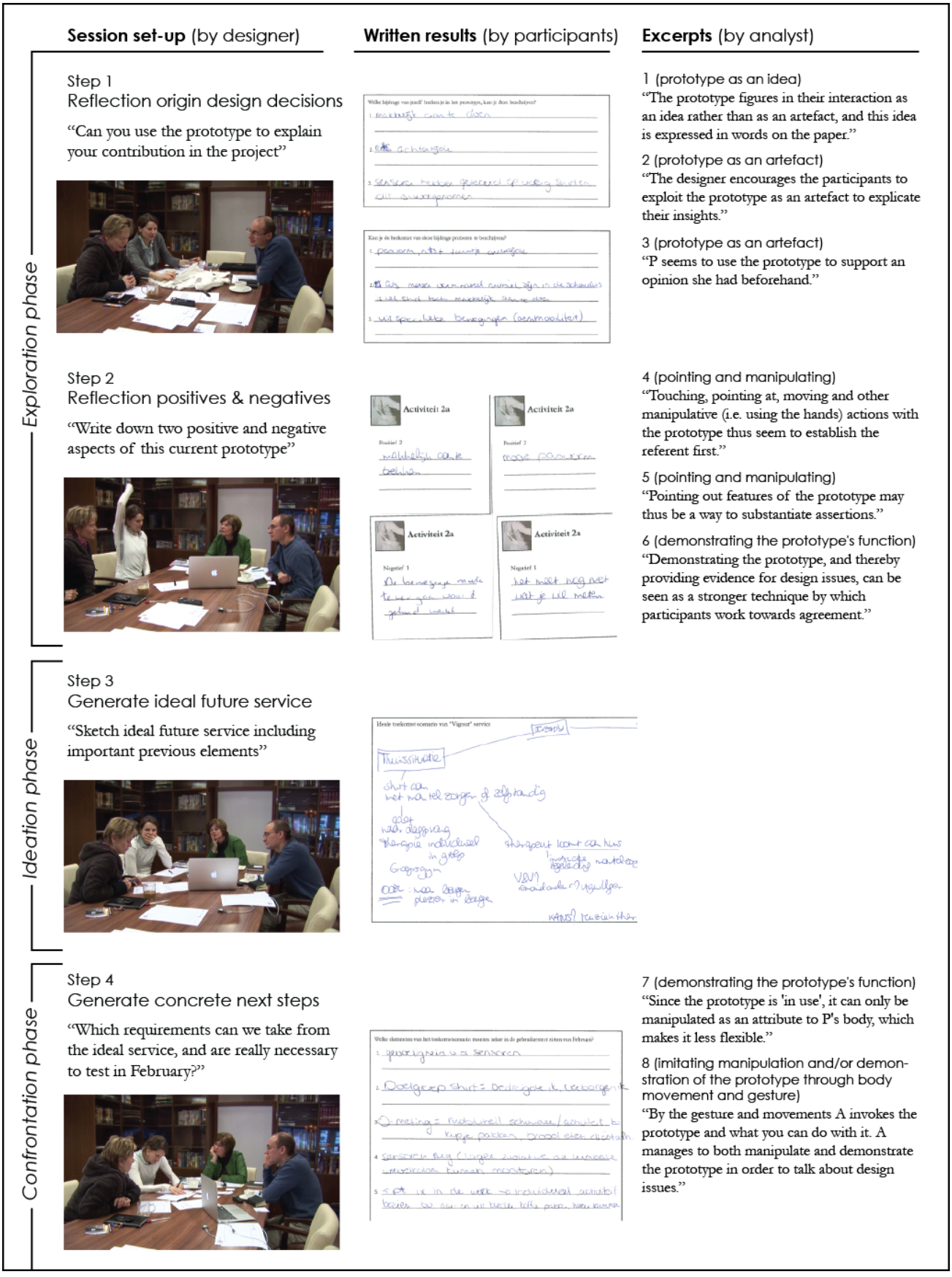

Figure 3: 1st column: visualization of the different phases of the meeting, 2nd column: the forms that were filled in, 3rd column: the excerpts that were selected by the conversation analyst.

prototype it became impossible for her to demonstrate this idea. By using gestures with her hand to explain the behavior of the prototype, and at the same time moving with her body to show the specific movement she solved this issue. For the design researcher this made it clear what the therapist meant when she was talking about measuring a specific movement, at the same time it showed how a new sensor would need to be placed on the garment to be able to measure this movement. The confrontation phase is about creating common ground, and combining each other's individual viewpoints. Because there is only one prototype, the balance between the participants became distorted, the other participants not wearing the prototype couldn't directly demonstrate the ideas they had to the other people. This excerpt showed that using gestures to imitate the prototype, based on prior experience with the prototype, was a way in which participants solved this issue. During the development of PSS some aspects might not be developed or prototyped yet. By imitating manipulation it might be possible for participants to envision and communicate these aspects. We saw in this example that these imitations are most powerful when they can be related to an existing prototype, which serves as common ground to all the participants.

DISCUSSION

We started with the question: how can designers support the design of product-service systems, taking into account existing products and services of the stakeholders and at the same time fully acknowledge the diversity of the different viewpoints of stakeholders? As a proposed solution for this issue we analyzed how stakeholders who are part of the development process of a new PSS use interactive prototypes to explicate their reflections, envision new possibilities and decide on concrete next steps. We compared three explication techniques that the conversation analyst found with the phases of a co-reflection session, and use these to come to some conclusion for the design of PSS.

Interactive prototypes are especially useful for the exploration and confrontation phases. Pointing and manipulating with the prototype helped to make reflections concrete, made it easier to propose small design changes and thereby helped the participants to reach common goals. In the development of a PSS this is especially valuable because it can make certain problems transparent and concrete, everybody has to agree that a solution needs to be found. The demonstrations with the prototype provided evidence for certain design issues (for example the demonstration of the sensitivity of the sensors). It helped to make the insight recognizable through experiences that other participants not necessarily had beforehand. During PSS development the demonstrations can help to convince stakeholders of a problem that an individual notices and can help to collaboratively find and try new solutions.

Interactive prototypes do have their limits, as we noticed during the analysis of this meeting. During the ideation phase the interactive prototype did not play a large role. The reason for this might be that for ideation the prototype is already too specific. This is especially a problem for the design of new elements in a PSS because these are more difficult to base on existing prototype. We saw in the meeting that by imitating manipulation it might be possible for participants to envision and communicate these aspects, but his only happened in the case of incremental design changes. It could be interesting in the development of PSS to include parts where techniques such as bodystorming (Oulasvirta et al. 2003) are used to trigger participants to project the PSS in the future.

Developing the prototype is part of the development of the PSS: knowledge from different stakeholders comes together in the physical prototype. In this case the stake of the therapists and care manager in the project is to give good care to the end-users and run a profitable business with this service. For future work it would be interesting to find out how other stakeholders deal with the interactive prototypes in co-reflection sessions, for example, production partners or technology partners.

ACKNOWLEDGEMENTS

This work is being carried out as part of the project "Smart Textile Services" sponsored by the Dutch Ministry of Economic Affairs under the CRISP program. We like to thank the STS CRISP partners from De Wever for participating in the meeting, and allowing us to analyze and publish the video data.

REFERENCES

Blomkvist, J., Åberg, J. & Holmlid, S., 2012. Service walkthroughs to support service development. In Proceedings of Service Design and Innovation Conference (ServDes '12). Helsinki, Finland.

Boer, L. & Donovan, J., 2012. Provotypes for participatory innovation. In Proceedings of the Designing Interactive Systems Conference (DIS '12). Newcastle, UK.

Brouwer, C.E. & ten Bhömer, M., 2013. Imagining the prototype. In Proceedings of the 3rd Participatory Innovation Conference (PIN-C 2013). Lahti, Finland.

Buur, J. & Matthews, B., 2008. Participatory innovation: a research agenda. In Proceedings of the 10th Anniversary Conference on Participatory Design 2008 (PDC '08). Bloomington, Indiana, USA.

Buur, J., Ankenbrand, B. & Mitchell, R., 2013. Participatory business modelling. *CoDesign: International Journal of CoCreation in Design and the Arts*, 9(1), pp.55–71.

CRISP, 2013. Creative Industry Scientific Programme. *crispplatform.nl*. Available at: http://www.crispplatform.nl/ [Accessed May 5, 2013].

Foverskov, M. & Yndigegn, S.L., 2011. Props to evoke

"the new" by staging the everyday into future scenarios. In Proceedings of the 1st Participatory Innovation Conference (PINC 2011). Sønderborg, Denmark.

Frens, J.W. & Overbeeke, C.J., 2009. Setting the stage for the design of highly interactive systems. In International Association of Societies of Design Research (IASDR '09). Seoul, South Korea.

Lim, Y.K., Stolterman, E. & Tenenberg, J., 2008. The anatomy of prototypes: Prototypes as filters, prototypes as manifestations of design ideas. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 15(2), pp.7:1–7:27.

Oulasvirta, A., Kurvinen, E. & Kankainen, T., 2003. Understanding contexts by being there: case studies in bodystorming. *Personal and Ubiquitous Computing*, 7(2), pp.125–134.

Pawar, K.S., Beltagui, A. & Riedel, J.C.K.H., 2009. The PSO triangle: designing product, service and organisation to create value. *International Journal of Operations & Production Management*, 29(5), pp.468–493.

Pifarré, M. & Tomico, O., 2007. Bipolar Laddering (BLA): a Participatory Subjective Exploration Method on User Experience. In Proceedings of the 2007 conference on Designing for User eXperiences (DUX '07). Chicago, IL, USA.

ten Bhömer, M; Tomico, O; Kleinsmann, M; Kuusk, K; Wensveen, S. 2012. Designing Smart Textile Services through value networks, team mental models and shared ownership. In Proceedings of Service Design and Innovation Conference (ServDes '12). Espoo, Finland.

Tomico, O. et al., 2011. Designers Initiating Open Innovation with Multi-Stakeholder Through co-Reflection Sessions. In Proceedings of IADSR2011, the 4th World Conference on Design Research. Delft, The Netherlands.

Tomico, O., Frens, J.W. & Overbeeke, C.J., 2009. Co-reflection: user involvement for highly dynamic design processes. In CHI "09 Extended Abstracts on Human Factors in Computing Systems (CHI EA "09). Boston, MA, USA.

Tukker, A., 2004. Eight types of product–service system: eight ways to sustainability? Experiences from SusProNet. *Business Strategy and the Environment*, 4(13), pp.246–260.