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Finding a New Hill to Climb in Transformative PSS Design

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Abstract

Product Service System (PSS) solutions have proven to be a valuable innovation approach for industry organizations to differentiate themselves in a competitive market. Modern interpretations of PSS design have urged a move towards developing transformative innovations which are more than the sum of their parts. Achieving this transition in PSS design requires new tools to support designers in broader exploration of the design space to find a potentially transformative solution concept. These solutions will involve looking three to four product generations in the future adding ambiguity to the inherent complexity of PSS solutions. To embody and gather insight on these complex concepts, this paper explores the impact of a tangible low fidelity scenario prototype activity in the early fuzzy front end of the PSS design process.
Keywords: PSS Design, Product-Service System, Lo-Fi Prototyping

1 Introduction

Product Service Systems (PSS) have been explored primarily as an innovative business model which illuminated the untapped value of bundling products with additional services into a solution package allowing manufacturers and service providers alike to distinguish themselves in the marketplace as a more sustainable alternative (reference here). Here the product is servitized, de-emphasized as the primary value driver while the interconnected services and system components enable the product's functions. While the primary existing methods and frameworks for PSS design focus on innovating individual components of the solution for optimization, recently Lugnet et al. [13]have highlighted a need to conduct "Holistic PSS design". Their rationale belies the sub-optimal implementation of PSS solutions as product enhancers. Typical product enhancement approaches ignore latent potential the PSS structure can offer to sustainability and customer needs satisfaction through more intertwined function or result oriented PSS solutions [22]. Lugnet et. al.[13] recommend a shift away from a preconceived inclination to keeping products, services, and the systems isolated in the design phase of PSS, instead of approaching the challenge of innovating across all three dimensions seamlessly.

This approach of "holistic" PSS design incurs added complexity at all phases of the process. However, this also allows designers to eschew current problems associated with carrying forward latent/existing solutions [25]. These problems, in a design context, are best embodied by the hill problem analogy carefully explained by Norman and Verganti [17]. In short, focusing on current solutions and needs causes localized optimization of existing solutions (incremental innovation) instead of exploring the broader body of solution variants

that could have higher potential value. For example a razor manufacturer taking time to explore other ways to remove hair or meeting the customer need of smooth skin instead of developing a sharper longer lasting razor.

For the purposes of this paper, we considered this "ground-up" approach to be a form of radical innovation. What makes an innovation radical? Radical innovations are marked by a transformative shift in technology or meaning [17]. Designing a radical PSS solution can then be about speculating a desirable future system within which we have a solution scenario consisting of products and services. This speculated solution concept will contain numerous assumptions about feasibility, desirability, viability, users, society, technology, etc. This level of speculation can create a cognition/belief communication threshold for co-designers or stakeholders to overcome before insights or feedback can be gathered to make design decisions. Here we are partially borrowing the threshold concept from pedagogy as it is defined as "being transformative in that once understood… can cause a significant shift in perception of a subject…" [16].

This threshold can be overcome in those attempting to provide input if they are able to suspend their disbelief in the assumptions upon which the future concept is based. Each co-designer or stakeholder has individual expertise or experience shaping their biases and preconceptions on what is possible. Most tend to lean towards "businesss-as-usual" and elaborate on familiar solutions[8]. However, if we are able to overcome those biases with a common tool and enable them to build empathy for the future stakeholders in the speculative scenario, there is a higher potential for open-ended design discussions leading to better exploration of the solution space. A common tool in design literature for facilitating this type of interaction is prototypes, based on its strength in helping teams make ideas tangible, iterate quickly at low cost and develop a shared language [1].

Prototypes come in many different forms suited for a variety of purposes as shown by Houde & Hill [6], Shrage [20] and Mednold et al. [15]. Shrage [20] states that prototypes answer a question. This perspective is more applicable when designers are following an Ulrich and Eppinger [23] approach where the concept is an extrapolation of existing technology and time and capital investment to construct prototypes are considered high. In early transformative concept design phases, often characterized as the fuzzy front end by Carleton and Cockayne [1], we can say the goal is instead to further open up the design space (both problem and solution). Prototypes can also serve as a means to these ends. Paper mock-ups or other low-fidelity prototypes are effective means to rapidly elevate a theoretical concept into a communicable concept with low resource allocation. Particularly if they are designed to be instrumental discursive objects which emphasize the opening up of a conversation as opposed to terminal objects which elicit feedback aimed at closing loops (Johannessen 2017). It is in this research the concept of a sandbox prototype is introduced as means by which to develop and tell a more detailed story thread. This combination produces a strong narrative in which users or stakeholders can position themselves within the concepts and provide an empathetic vantage point from which to generate design questions or provide feedback from the future perspective. The aim of this prototype is to support consideration of the potential user or stakeholders' experience beyond the specific interaction with a product.

1.1 Aim

The aim of this paper was to explore the impact of lo-fi sandbox prototyping in the context of "Intentionally PSS Design".

1.2 Research Questions

- In what ways does the sandbox prototype enhance the narrative of the future scenario?

- How do co-designers (observers) interact with the sandbox prototype of the system?

2 Method

This work is part of a larger design research study conducted using Design Research Methodology, DRM [2], thus reflecting a Descriptive Study II towards the evaluation of a prescribed support tool. The support tool in focus for this paper has been generally accepted as successful in the larger field of design and this study evaluates the fit for a more specific area of design (i.e. early phase PSS prototyping). Collaborative workshops were used as the setting for capturing as they allow for contextual walkthroughs and task analysis to be conducted by the researcher in a controlled environment where the support tools being evaluated are the foremost variable [14][18]. The workshops were designed using the guidelines outlined in Thoring et al.'s [22] work emphasizing the connection between the desired goals, outcomes and data capturing methods. The qualitative data was gathered through direct observations and notes, periodic inquiry during the session, feedback and short interviews. The scope of this research is not to fully validate the activity under investigation, but to evaluate the various impacts of this nuanced approach on the early design phases of "Intentionally Designed" PSS type solutions.

The Sandbox prototyping activity under observation in this work was part of four different workshops and courses focused on designing transformational solution concepts. They included a 3 week workshop at Perth University, a 12 week course at University of St. Galen, a 16 week course at Blekinge Tekniska Högskola, and a 4 hour workshop at Blekinge Tekniska Högskola. All 85 participants were Masters level students from a variety of educational backgrounds with the majority being design students. The students in this research can be considered advanced beginners as Kleinsmann et al. [10] state, who understand how to conduct design and take into account situational factors. This sample of participants is a diverse and representative sample of novice designers.

3 Results

3.1 Prototyping For Sensemaking:

Transitioning from paper based ideation and benchmarking or market research in general to building a tangible model of the system, concept and scenario like seen in fig.1 brings to light many unspoken misunderstandings. Teams tended to feel they had a collective shared understanding of their area, concept and vision going into the prototyping sessions. However, in most teams the discrepancies became clear when discussions turned towards deciding what was most important to build or represent. Teams would be split on many different dimensions: What to include in the system, where the boundaries should be, what level of the system are we aiming to explore, what planet this will occur on, just to name a few. This design friction caused teams to rapidly (matter of minutes or hours depending on the session observed) coalesce their diverse views into a clearly bounded system and scenario as an initial starting point.

Figure 1 First Iteration Sandbox Prototype

The low fidelity materials initially pose a challenge to the teams as they are attempting to reconcile their complex future scenarios with simple bottles, fruits and cardboard. As the team conversations continue the participants were able to let go of their preconceived notions towards prototypes as finished products. Once overcoming this hurdle they recognized the power of utilizing these simple tools as a way to tell their story of the future scenario. The simplicity of tools in-fact unlocked their ability to combine their collective mental model into a tangible object through which a story can be told.

Some teams used the cardboard to build visually representative models of city structures or similar elements creating nearly stand-alone prototypes (see example in fig 2). Others went more abstract using simple items like fruits or markers to represent entire institutions (see example fig 3). The more abstract materials a team used, the more small and rapid redesign moments occurred early, where the banana could represent the government institution one second and the next it was the medical facility where treatments were manufactured. They could quickly explore and define the boundaries of their system scenarios generally leading to better clarity in the overall concept context.

Figure 2 Low Fidelity Sandbox Prototype

Figure 3 Abstract Fidelity Sandbox Prototype

During the building of the sandbox prototypes the last elements included were the customers. This deliberate instruction allows the designers to put themselves into their future scenarios and gain empathy for the assumed future users. By creating the environment first the designers are able to better extrapolate who the users might be and what sort of experiences they may be having. With this in mind they are able to capture a detailed picture of their future needs, problems and normalized behaviors.

3.2 Sharing the Prototypes

This section discusses the experiences and learnings from participants pitching their concept via their sandbox prototypes. The courses had more time to separate out presenting their "eco-system" prototypes and the solution prototypes. The workshops, due to time restrictions, focused on presenting both simultaneously. Each team was exploring unique concepts and system boundaries, so no concept was the same as any other. The only primary connecting thread is that each concept is a transformative innovation which is not possible today or in the very near future.

During presentations of the systems if the presenter(s) became lost they were able to recenter the pitch using some physical elements of their prototype to remind themselves of all the inherently important aspects. This type of interaction was more present in the conversational portions of the presentation after the pitch. If observers (other workshop participants or course members) were unclear from the verbal story they could play out the interaction through the tangible prototype components. One interviewee summed up the sentiment of the participants' experiences saying, *"the complexity of our concept was verbally confusing to the customer, but those physical interactions solidified their understanding of what we were trying to do."* The interaction brought the observers up to speed quickly in terms of comprehension. It was at this point where much of the co-design commentary and insightful feedback could take place.

This comprehension allowed observers to place themselves in the scenario and ask questions from the point of view of various different actors present. These interactions lead to teams identifying additional previously unincluded customers or stakeholders. Through this lens observers helped raise questions within the design teams of where, when and how will these new actors impact the current vision of the support systems for the concept to thrive. The seemingly most shocking revelation of the students hinged on understanding if their concept users are 20-30 year olds and the scenario is on a 20 year horizon then they are currently babies or unborn. This raised the question of how they could affect/condition these future users over the course of their lifetime to be comfortable with their future concept. For

example looking at how the current generation of children are conditioned to scroll on their phones or interact with the world via the computer.

The input from the observers can be divided into two primary categories, open design suggestions and direct concept feedback. The open design questions provided previously unconsidered solution opportunities or directions to expand the design space. The direct feedback style of questions help flesh out the existing concept and identify unforeseen user concerns and needs.

A team working on uploading consciousness into a virtual world provides a clear example of both types of deep feedback. They received direct design questions like "*what if my body gets hungry?*", "*What if I get lost?*", "*What about my digital brain data, how will that be secure?*" Questions of this type provide the designers with a deeper insight creating a desirable user experience and identify ancillary needs that will require services or other infrastructure to be added to the primary solution concept. While the open ended questions were "*What else can we use this for?*", "*Could it help my grandparents do traveling they were never able to?*", "*Can we go back and relive pivotal historic moments?*", "*Could we preserve our consciousness past death?*". These questions each provided the team with a new arena of opportunity to explore including all the relevant boundaries stakeholders.

4 Discussion

4.1 PSS Narrative Building Through Sandbox Prototypes

Many state-of-the-art PSS Prototyping methodologies have been proposed [25] including some which prescribbe prototyping like Exner et al., [5] and Ilg et al.[7]. However only one (SHP4PSS) includes elements of tangible 3D prototyping. All other prototyping is conducted as a 2D approach including storyboards, system maps, offering diagrams, Product-Service blueprint, etc. Ilg et al., [7] overlayed these approaches on a timeline of PSS phases. The fuzzy front end here is defined as the Idea Generation and Potential Analysis phases. Reviewing the suggested approaches, there is a need to map out the system, define the scenario, identify the customer journey, map out the actor/interaction network and develop an offering concept. The results from observing the teams in the workshops demonstrated the ability for accomplishing all of the above goals through the development of their sandbox prototype. This does not suggest eliminating any or all of the above approaches, but instead insists that through this tangible building phase of the prototype teams were able to develop and populate a narrative for each of these approaches more transparently. Not all humans are natural storytellers, instead the tangible elements of this approach allow them to initiate the development of a concept/scenario narrative through simple shapeable materials.

To portray this point one team working on a biotech gene editing concept had developed a customer persona during the early portions before the sandbox prototype. The team was unable to make clear assumptions about the details of this potential customer's needs, lifestyle, environment leading to uncertainty about why, where or when anyone would use their solution. The Sandbox prototyping session initiated deep debates about the details of the scenario, the boundaries/elements of the system and the stakeholders/elements of their solution. Once the prototype was constructed the potential users became more obvious to the team who went back to the persona sheet and created visceral narratives for two new users. This exemplified the potential for interplay between tangible prototyping of complex environments feeding the necessary details to drive the creative design process in the early stages.

4.2 Transcending Conceptual Thresholds

Narratives, scenarios, and personas have been championed since the early 1990s as valued design tools in coalescing meaning and understanding amongst design teams and to stakeholders [3]. Spaulding & Faste [21] conducted a study in the area of Human-Computer Interaction using narrative in prototyping to uncover deeper and more meaningful responses from users by engaging them in the co-creation around the design. Exner et al. [4] conducted a detailed validation of their PSS prototyping method (SHP4PSS) to foster co-creation where they eschewed the need for low-fidelity prototyping in favor of virtual methods for flexibility and only incorporating physical mockups as pre-production testing. While Spaulding's & Faste's [21] work centered around digital media and words to tell the story and Exner et al.'s [4] work ignored low fidelity physical prototyping, this research explored the capability of low-fidelity physical prototypes to drive narrative, scenarios and comprehension for to foster co-creation in early phase transformational PSS design.

Future scenarios are ambiguous due to the speculative nature of their details. Thus, concepts that are three or four product cycles into the future are difficult to get meaningful insight or feedback as the observers tend to not have any heuristical comparisons in their minds. The course participants shared frequently how difficult it was to convince users of their concept's feasibility or desirability during purely solution prototype needfinding sessions. In contrast, the workshop/course sessions utilizing the sandbox prototypes, teams were eager to share how interested the observers were in sharing design feedback and insights. The phenomenon observed here is best summed up by a quote during a feedback session from an observer, "*I feel like I can just place myself in there from any perspective*". This quote emphasizes the power of the sandbox prototypes' ability to accomplish both overcoming the comprehension threshold and generating broad stakeholder empathy through the narrative-prototype combination visible in fig.4.

Figure 4 Participants Fielding Feedback on Space Mining Concept

Other quotes reinforcing this connection come from the participants, "*the story alone was not sufficient to convince them, but the prototype and the story convinced them it was at least not too crazy*", "*we had many [observers] share their ah-ha moments when they finally understood why anyone would want this*". This low fidelity prototype was a different approach than most participants' previous prototyping experience, but was reported as *"easy to grasp after a little practice"* and *"very fun to do something different than powerpoint"*. Activities that can produce a depth of clarity and insight on complex concepts, at a low investment, early in the design phase are powerful tools for both novice and experienced designers.

4.3 Abstract Fidelity and Looks-Like Fidelity

New tools for designing physical/technical products have been deployed over time, but these tools have lacked the larger goal of creating transformative innovations through a PSS becoming more than a sum of its components (Wall et al. 2020)(Lugnet 2020). Carleton and Cockayne's (2009) work investigated the use of tangible prototypes in practice to envision complex systems and help reveal the path of progression from today's solutions to tomorrow's opportunities. The desired goal of this work through the lens of the hill problem is how do we identify new hills with higher potential for value? New hills can be interpreted in the context of PSS design as the implementation of a transformative new technology or meaning and designing the rest of the system to support the required paradigm shift. Identification of new hills requires a vast exploration of the design space due to the infinite variability of PSS solutions. If tangible prototypes are to support this effort they must support this goal.

The low fidelity prototypes implemented are capable of being produced and modified rapidly. Further analysis of the results pointed to a differentiation in how teams interpreted the term low fidelity. Lim et al. [12], Liker & Pereira [11], Real et al. [19] and others have all contributed to the understanding and characterization of Fidelity levels and the variability in different prototyping methods. Some teams in this research picked an abstract starting point for their fidelity level of bananas, coins, olives, sugar packets, etc. These teams tended to explore more rapidly various combinations of solution, system and scenario elements than teams which started directly with cardboard, paper, pipe cleaner based "looks-like" prototypes. Exploration came easier as the more abstract materials allowed for rapid meaning change of the elements perhaps also engaging the imagination more. This was beneficial for exploration internally, but when presenting these abstract sandbox prototypes they relied more heavily on the story and took longer on average to convey the message. Alternatively, teams who went towards "looks-like" prototypes benefited from the tangible objects being more easily understood and even initiating conversations with external observers. The abstract prototyping teams did eventually move towards higher fidelity materials and tended to benefit from the broader early exploration of the design space fueling more discussions evident in the more cohesive narrative threads.

5 Conclusions

The aim of this paper was to explore the impact of lo-fi sandbox prototyping/prototypes in the context of "Intentional PSS Design". The diversity of the workshops, courses and participants provides enough variation to uphold the findings within the defined aim. All of the workshops and courses, although not identical, did produce similar triangulated results as far as impact of the prototyping activity in question.

This provides the basis from which we will answer the stated research questions:

In what ways does the sandbox prototype enhance the narrative of the future scenario? The primary identified impacts on the narrative capability were evident during the construction of the sandbox prototype. Teams were able to share their internal comprehension of the concept via the tangible materials and work out the discrepancies thoroughly. Starting in 3D allowed the participants to construct a detailed scenario through which they could extract necessary design details for framing stakeholder and potential user perspectives.

How do co-designers (observers) interact with the sandbox prototype of the system? The observers were able to achieve two difficult requirements for providing meaningful insight on unfamiliar speculative futures scenarios. First, comprehension of the scenario and the assumptions its based upon allowed the observers to overcome a threshold of disbelief.

Second, once over that threshold of understanding they could put themselves into the stakeholder/user points of view with enough empathy to produce open and detailed design discussions.

6 Future Work

In order to further verify these findings, more continuity of the preceding activities must exist across all the case studies. The initial reactions of most participants was positive, however some were lost or incapable of overcoming the unfamiliarity of the approach. As much as this research provides insight it opens up many more questions. How do we determine when to increase fidelity levels? What should the prototyping materials consist of? Can this be adapted for practice? How does it connect to a larger design framework to produce the desired result? These are just some of the open questions we encourage the field to explore.

Acknowledgement

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References

[1]Carleton, Tamara, and William Cockayne. "The power of prototypes in foresight engineering." DS 58-6: Proceedings of ICED 09, the 17th International Conference on Engineering Design, Vol. 6, Design Methods and Tools (pt. 2), Palo Alto, CA, USA, 24.-27.08. 2009.

[2] Blessing, LT, & Chakrabarti, A. (2009). DRM: A design research methodology (pp. 13-42). Springer London.

[3]Cooper, A. About Face III: The Essentials of Interaction Design, Wiley, 2007.

[4]Exner, Konrad, et al. "Validation of product-service systems–a prototyping approach." Procedia CIRP 16 (2014): 68-73.

[5]Exner, Konrad, Thomas Damerau, and Rainer Stark. "Innovation in product-service system engineering based on early customer integration and prototyping." Procedia Cirp 47 (2016): 30-35.

[6]Houde S. and Hill C. What do prototypes prototype? Handbook of Human-Computer Interaction (2nd Ed.); Helander M., Landauer T., and P. Prabhu (eds.); 1997 (Elsevier Science B.V.: Amsterdam).

[7]Ilg, Julian, Claas Christian Wuttke, and Andre Siefert. "Systematic prototyping of product-service systems." Procedia CIRP 73 (2018): 50-55.

[8]Johannessen, Leon Karlsen. "The Young Designer's Guide to Speculative and Critical Design." Norwegian University of Science and Technology (2017).

[9]Kaner, S.; Lind, L.; Toldi, C.; Fisk, S.; Berger, D. Facilitator's Guide to Participatory Decision-Making; Jossey-Bass: San Francisco, CA, USA, 2007.

[10]Kleinsmann, M., Deken, F., Dong, A., Lauche, K., (2012), "Development of design collaboration skills", Journal of Engineering Design, 23(7), 485-506.https://doi.org/10.1080/09544828.2011.619499

[11]Liker J.K. and Pereira R.M., "Virtual and Physical Prototyping Practices: Finding the Right Fidelity Starts With Understanding the Product," in IEEE Engineering Management Review, vol. 46, no. 4, pp. 71-85, Fourthquarter,Dec. 2018, doi: 10.1109/EMR.2018.2873792.

[12]Lim YK, Stoltermann E, Tenenberg J. The Anatomy of Prototypes as Filters – Prototypes as Manifestations of Design Ideas. In: Adenauer J, Petruschat J (ed.). Prototype!. Physical, virtual, hybrid, smart – tackling new challenges in design & engineering. Berlin: Spreedruck Berlin; 2012.
[13]Lugnet, J.; Ericson, Å.; Larsson, T. Design of Product–Service Systems: Toward An Updated Discourse. Systems 2020, 8, 45. https://doi.org/10.3390/systems8040045
[14]Magnusson, C., Larsson, A., Warell, A. and Eftring, H., 2011. Key scenarios, contextual walkthrough and context trails–Tools for better and more accessible mobile designs. In Workshop on Mobile Accessibility.
[15] Menold, J., Simpson, T. W., & Jablokow, K. (2019). The prototype for X framework: exploring the effects of a structured prototyping framework on functional prototypes. Research in Engineering Design, 30(2), 187-201.
[16]Meyer, Jan, and Ray Land. "Threshold Concepts and Troublesome Knowledge: Linkages to Ways of Thinking and." (2003).
[17]Norman, Donald A., and Roberto Verganti. “Incremental and Radical Innovation: Design Research vs. Technology and Meaning Change.” Design Issues, vol. 30, no. 1, The MIT Press, 2014, pp. 78–96, http://www.jstor.org/stable/24267027.
[18]Ørngreen, R. and Levinsen, K., 2017. Workshops as a Research Methodology. Electronic Journal of E-learning, 15(1), pp.70-81.
[19]Real, Ricardo, et al. “DIMENSIONS OF KNOWLEDGE IN PROTOTYPING: A REVIEW AND CHARACTERISATION OF PROTOTYPING METHODS AND THEIR CONTRIBUTIONS TO DESIGN KNOWLEDGE.” Proceedings of the Design Society, vol. 1, 2021, pp. 1303–1312., doi:10.1017/pds.2021.130.
[20]Schrage M. Serious Play: How the World’s Best Companies Simulate to Innovate, 1999 (Harvard Business School Press, Boston, Mass.).
[21]Spaulding, Eric, and Haakon Faste. "Design-driven narrative: using stories to prototype and build immersive design worlds." Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. 2013.
[22]Thoring, K., Mueller, R., & Badke-Schaub, P. (2020). Workshops as a research method: Guidelines for designing and evaluating artifacts through workshops.
[23]Tukker, Arnold. "Eight types of product–service system: eight ways to sustainability? Experiences from SusProNet." Business strategy and the environment 13.4 (2004): 246-260.
[24] Ulrich, K. T. and Eppinger, D. S. (2000), Product design and development. McGraw-Hill.
[25]Vasantha, Gokula Vijaykumar Annamalai, et al. "A review of product–service systems design methodologies." Journal of Engineering Design 23.9 (2012): 635-659.
[26]Verganti, Roberto "User-Centered Innovation Is Not Sustainable," Harvard Business Review Blogs, 2014 http:// blogs.hbr.org/cs/2010/03/user-centered_ innovation_is_no.html
[27]Wall, J.; Bertoni, M.; Larsson, A. The Model-Driven Decision Arena: Augmented Decision-Making for Product-Service Systems Design. Systems 2020, 8, 22.