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ROADMAP AND TOOLBOX FOR THE IDEATION STAGE OF THE DEVELOPMENT PROCESS OF PRODUCT SERVICE SYSTEMS

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ABSTRACT
Product service systems (PSS) provide an opportunity to create innovative interactions between consumers, the products and services they use and the providers offering these products. In contrast to traditional services related to products, the service component of a PSS significantly adds value to the experience of the consumer. Within the context of this paper, we add 'smart' to the PSS, because advances in information and communication technology have made it possible to combine products and services in innovative ways. Although PSS introduces new elements to a design process that require a thorough rethinking of how designers should relate to this specific kind of products, the main challenge is to manage the variety of underlying design processes. Especially in relation to the front end of innovation, there is a need for new and adapted tools in order to explore emerging PSS opportunities. In this paper, we report on a ten weeklong project. This project was targeted at first master students in product development, as a case to explore how existing service design tools - modified with a specific PSS focus - can be introduced in the early stages of PSS concept creation and definition. We use the creativity support index (CSI) as a metric to evaluate the tools used. The paper brings forward several lessons learned related to the implementation of the adjusted tools for a PSS design project.

Keywords: Integrated product development, connected products, product service systems, ideation

1 INTRODUCTION

'Smart' product service systems (PSS) [9], based on electronics, advanced information and communication technology are introducing several elements to a design process that require a thorough rethinking of how designers should relate to this specific kind of product category. The main challenge is to manage the variety of underlying design processes at play during the design of connected 'smart' PSS: electronics design, software design, service design and product design. By merging these disciplines, the design opportunity is that the user experience and interaction can be placed as a central element instead of placing technological possibilities as a central element. Often an 'intangible' service component is included as part of an ecosystem or product service system (PSS), and therefore requires a different design approach that copes with an increased complexity. Especially in relation to the front end of innovation, there is a need for a set of new and better-adapted tools, based on service design, usability and user experience design in order to explore the opportunities provided by emerging PSS concepts.

2 METHODOLOGICAL APPROACH

2.1 The PSS project in design educational setting

Within the 'integrated product design' (IPD) project, an interdisciplinary approach was used as a case to explore how existing tools can be introduced during the conceptualization of PSS. It represents a workload of 14 ECTS (European credits) and is compulsory for first year master students. The project focuses on the development of competences in product service system design. The focus is both on concept generation, definition and integration. During this ten-week project, fifty-two design students participated. They were evenly divided in seventeen groups of three students each. Each group was challenged to define innovative concepts to enrich the interaction during the important moments of

life, such as childbirth, first job, retirement, buying a house, etc. These were defined based on the concept of a 'lifeline', which is a technique used in psychological analysis [7]. The exploration of these (predefined) 'nodes of life' started from defining the context, the interaction, the experience and the functional and emotional aspects related to actors and activities present within each 'node'. Based on this exploration, new opportunities for PSS were to be defined. During this design assignment, an interdisciplinary team of five people guided the students. The team consisted of two assistant teachers in product development that provided educational guidance and design input. Two doctoral researchers introduced and weekly supported in the design of PSS, one with a focus on interaction design and prototyping of complex systems [2], the other on the design of PSS with a focus on the user experience [4]. In addition, one professional member from a service design agency was included to introduce and monitor service design principles and tools during the process. The follow up of the teams was based on a weekly presentation using the templates provided by the PSS toolbox, thus showing a standardized visualization of the projects and allowing a comparison between the different projects and their progress.

2.2 Product-service design, a nexus between academics and industry

In order to start from a given set of tools, collaboration was set up with a design agency which is specialized in user centred and service design. Together with Design Flanders, the service design agency updated their existing *service design toolkit* in the context of the 'spider project' [10], which supports public service innovation using design in European regions. The toolkit [3] contains a set of ten service design tools and related templates, which - together with the design agency - were modified with a specific PSS focus. The goal of this toolbox was to support the exploratory research and interdisciplinary analysis, resulting in user insights, design requirements and innovative PSS concepts. A toolbox of student activities was set up and every week a set of design tools was introduced, each tool having a specific goal.

2.3 The PSS toolbox overview

The toolbox followed the distinctive path of the front-end of innovation, its characteristics and principles according to current research on PSS [4,5]. The tools in the toolbox were provided as printed templates and canvasses, which aimed to provide students with a structure during the early phases of their design process to explore, ideate, define and finally design innovative PSS concepts (Figure 1).

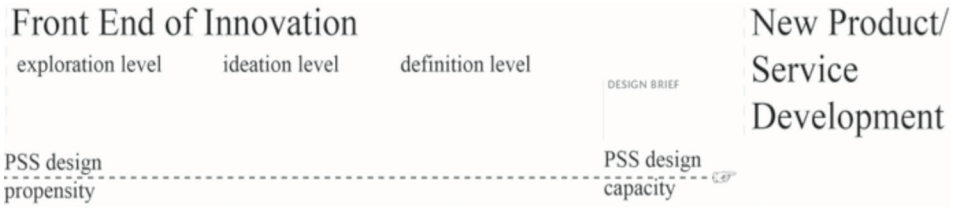


Figure 1. FEI - process

Chronologically, the introduced tools were:

i. Stakeholders experience journey

This first tool supports the analysis of the experience of the user with respect to the specific 'node of life' and enables to choose a user/provider combination of the product-service. It aims to identify key stakeholders; experiencing the node, relatives and people involved in e.g. care or support. The tool allows a mapping of key moments for each stakeholder. These key moments provide insight into what the stakeholder is doing whether s/he feels positive or negative about that activity.

ii. Context and objectives mapping

It is important to come to a better understanding of the user / provider interaction(s). The context and objective mapping tool is a first step towards the product-service promise and thereby creates an understanding of the providers' goal, the main needs and motivations of the user, who the users are and different thresholds, trends, limitations and conditions of the product-service. The tool also helps the team to prepare the field research (interviews) and what you want to examine exactly.

iii. Research questions

This tool builds further on the second tool (context and objectives mapping) by preparing the interview. It makes the team think about the type of user they want to query, the event stage (pre-event

period, event period and post-event period) regarding the context of the experience, other stakeholders and the activities that took place. Additional questions are considered up-front that the design team can ask when discussing their envisioned PSS experience with the user.

iv. Stakeholder interview

The research questions tool is used as guidance to interview the stakeholder. User, event stage and context are defined through the interview and serves to test previous assumptions. Doing so, new insights are identified related to the target audience. In the discussion related to the most positive and negative experiences, the additional questions helped discovering underlying reasons.

v. Persona dimensions

The persona dimensions tool allows design students to create personas through capturing the users' needs, identifying user attributes that affect your PSS. After identifying several attributes relevant to key stakeholders within the PSS, several combinations of these attributes are made. Selecting the opposite user attributes that affect the perception of the product-service combination, enables to determine realistic combinations of dimensions that can form a fictitious person.

vi. Persona template

Together with the persona dimensions tool, this template helps the design team to define the target audience and create different user perspectives, the goals and most important needs of the future product service system in later stage design.

vii. Actors map

It is important to get a clear picture of everyone involved and the role they play in the system. The actors map enables the designer to create a detailed mapping of the activities and actors that play in different event stages in the system. It allows them to identify the value exchange that takes place, which is crucial to combine relevant actions and actors into promising PSS combinations.

viii. Design challenge

This template helps to set more focus and determine what you want to design during the next phase, it is a rephrasing of the initial product-service promise into a design challenge. The design team can characterize their PSS with certain key values and decide on the boundaries of the project. A designer's approach using a diversity of visualization methods is then used to create a general identity of the envisioned product-service.

ix. Design requirements

The group determines the opportunities for innovation from the design challenge and translates them in requirements concerning context of use, interaction, rational and emotional objectives, services and product components. Afterwards the eight most important requirements are selected from this list.

x. Lotus blossom

The aim is to retrieve important characteristics through inspiring examples in different contexts and combine them with the eight most important requirements from the design requirements tool. The characteristics of the examples provide as input for a further product-service system definition.

3 CREATIVITY SUPPORT

3.1 Background

With a wide range of definitions and theories, there is no single agreed-upon methodology for recognizing and evaluating creativity. Thus making it particularly difficult to evaluate how well a tool that supports a designer during a creative process is actually helping a design team. Since the goal of our research was to understand which part(s) of the provided service design toolbox worked better than others, we chose to use the Creativity Support Index as a metric. The Creativity Support Index (CSI) [1] is a psychometric survey designed to assess the ability of a creativity support tool to support the creative process of its users. Its theoretical foundation is based on concepts from creativity and cognition support tools, which includes Schneiderman's design principles for creativity support tools (CST) [8]. The CST we refer to in this paper is the previously discussed PSS toolbox, i.e. the service design toolkit adapted with a specific PSS focus. The CSI consists of a standardized survey, which helps researchers and designers to evaluate the level of perceived creativity support, provided by a certain tool or method. The CSI survey is typically filled out after a participant has finished using a specific tool. The CSI consists of two parts: a rating scale section and a paired comparison section. The rating scale section, for which each agreement statement (Fig.) is answered by the participants on a scale of "highly disagree" (1) to "highly agree" (10), assesses 6 different factors; *Collaboration,*

Enjoyment, Exploration, Expressiveness, Immersion, and Results_Worth_Effort. The participants complete this section twice, using different statements for the same factors and without seeing factor names or knowing they are grouped. The higher factor score indicates that the tools better supports that factor, with a maximum number of 20. Afterwards, the participants also complete a paired-factor comparison section (Table 1), where each factor is paired against every other factor for a total of 15 comparisons. In these comparisons, the participant is asked which factor in a pair was the most important to them, for the activity that they just completed. This allows us to look at the reliability and similarity of the scores for each factor and across the different statements, resulting in (average) counts for the paired-factor comparison section. Within the scope of this paper, this score can be used as an indicator to the perceived overall creativity and its factors.

3.2 Creativity support index results

Table 1. CSI results for the rating scale and paired-factor comparison section

Creativity support factors	Factor scores related to the PSS toolbox in descending order of agreement		Factor scores (relative importance for PSS design) corresponding paired-factor comparison counts	
	/20	(based on two rating scales)	/5	
Collaboration	12,65		1.75	(low importance)
Exploration	12,06		4.34	(more important than any other factor)
ResultsWorthEffort	11,70		2.79	(moderate importance)
Expressiveness	10,92		2.60	(moderate importance)
Enjoyment	10,69		0.99	(low importance)
Immersion	8,02		2.52	(moderate importance)

The average participants' agreement on the factor '**Collaboration**' shows that the PSS toolbox enables the participants to share ideas, designs and work easily in team. However the paired-factor comparison for 'Collaboration' indicating that users see the factor as less important in creativity support in general.
In the rating scale section, the creativity support factor '**Exploration**' indicates that participants agree that the PSS toolbox provides the necessary support for creativity through different ideas, outcomes and possibilities. The rating scale factor score corresponds with the score it received in the paired-factor comparison section. This result is important because the creativity support factor 'Exploration' receives the highest paired-factor comparison count from the users, who chose this factor as more important than any other factor.
'**Results_Worth_Effort**' has a similar - but slightly lower - score than the previous creativity support factors. It shows that participants were satisfied with what they got out of the PSS toolbox. Correspondingly, the users find the amount of effort required for the same amount of work with the usage of tools in general, of moderate importance.
On '**Expressiveness**' participants were still satisfied with the outcome, but agree that the PSS toolbox provides only moderate support in their creativity. The paired-factor comparison shows a corresponding score, nonetheless users still search for something that better expresses their thoughts.
Participants score '**Enjoyment**' of the PSS toolbox as fairly moderate, but this is analog with the score in the paired-factor comparison section. The creativity support factor 'Enjoyment' received a visibly lower count and seems inferior to any other factor.
To close, the users were not satisfied with the way they were engaged in the use of the PSS toolbox. However, the creativity support factor '**Immersion**' gives a count of moderate importance, meaning that they want tool(s) to provide reasonable creativity support to users engaged in PSS design.
We asked all student groups to complete the CSI questionnaire on three moments during the project and usage of the toolbox. This allowed us to have a better consecutive view on the usage of the individual tools, templates and posters after the students used them in the design process. Figure 2 combines the agreement statements and the paired-factor comparison into CSI scores and gives an indication of the total creativity support. As the design process and the introduction of tools progresses, the CSI scores have an upward tendency. This allows us to reflect upon how well the toolbox and its individual tools support creativity for the particular task the design teams was engaged in or had to perform.

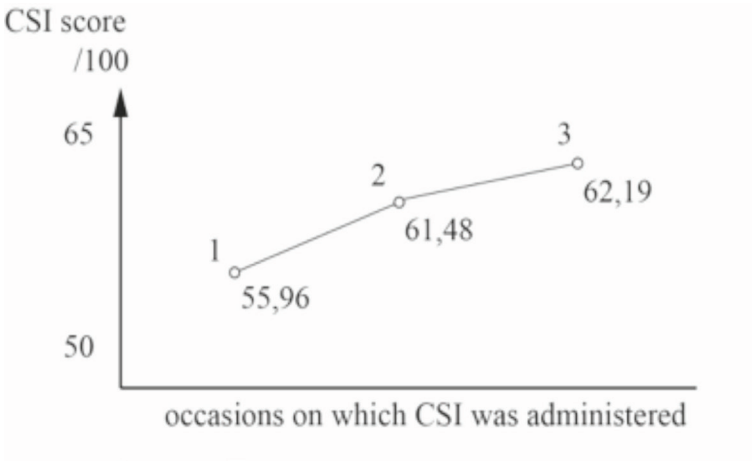


Figure 2. CSI (total) scores

3.3 The PSS tools in relation to creativity support

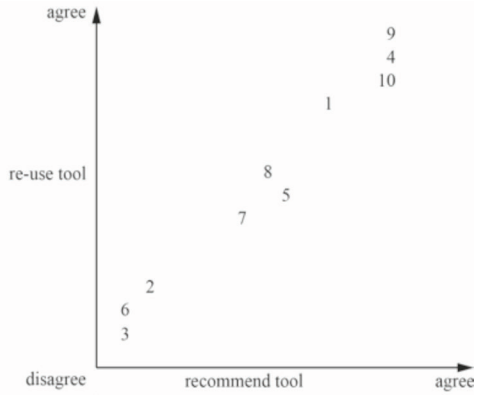
Table 2 provides a clear image on the participants view on the individual tools within the PSS toolbox, which are ranked in descending order of creativity support. Adjacent to the ranking - that also serves as legend - the graph represents a graphical ordering of the individual tools in terms of participant agreement on re-usage and recommendation to others. Besides an obvious correspondence between re-usage and recommendation, the participants follow a tendency to rank the PSS tools in a similar way.

Table 2. PSS toolbox; ranking, re-use and recommendation

(1) Participant ranking of PSS design tools in descending order of creativity support

4	Stakeholder interview
9	Design requirements
1	Stakeholders experience journey
8	Design challenge
10	Lotus blossom
5	Persona dimensions
7	Actors map
2	Context & objectives
6	Persona
3	Research question

(2) Legend to the graph; PSS design tools' re-usage in relation to recommendation



4 DISCUSSION

The scores are dependent on both individual preferences, as well as the individual's level of expertise with each of the tools. Therefore we formed groups of three who filled out the questionnaire. As they had to discuss each answer in group, we were avoiding individual preferences. At the moment the project took place, the toolkit was not yet published. This gave us confidence that none of the participants had experience with the provided tools. Another type of expertise could also impact the results, namely the level of expertise in the domain. Again, individual differences should be averaged out since the groups all consisted of three first master students in product development with a similar educational background.

Where the design teams took the survey at three occasions, the results showed a slight increase in the total CSI score. We acknowledge that the results might be biased for following reasons:

1. Only nine of seventeen groups administered the CSI tool as required (some of the participants did not save the survey, did not fill out the whole survey, etc.) and on each of the three occasions.
2. The results might go up because of increased knowledge in the design and its process.
3. The toolbox' tools introduced during the later stages of the design process have a more tangible outcome, and could therefore provide higher creativity support scores.

An additional note that should be made is that a CSI score for a creativity support tool (the service design toolkit) is not necessarily representative of the whole CST. It reflects upon a CST being used during a particular task or activity, by a particular type of user.

5 CONCLUSIONS AND FUTURE RESEARCH

With regards to the creativity support factors, the PSS toolbox stimulates group dynamics and co-creation sessions with future users and potential service providers. Tools such as the Stakeholders experience journey (tool 1) and the Stakeholders interview (tool 4) prove their importance to the CSI factor 'Collaboration'. The uniform but open structure of the PSS toolbox demonstrated to be relevant for a wide range of design challenges in different domains (CSI factor: Exploration). E.g. the Lotus blossom (tool 10) showed to be more supportive in 'Exploration' than the Actors map (tool 7). Finally, higher ranked tools like the Design requirements (tool 9) and the Design challenge (tool 8) relate output and effort to the corresponding CSI factor 'Results_Worth_Effort'. The lower scores on the CSI factors 'Expressiveness', 'Enjoyment' and 'Immersion' indicate that it is not enough represented in the tool and provides room for improvement. The PSS toolbox may need to invest on ways to improve creativity and expressiveness with the tool and enhance the workflow and absorption in the activity to ensure that the tools are used on a more regular basis.

Besides creativity support, the PSS toolbox was evaluated on the specific goals of each tool. We specifically focused on what part(s) of the toolbox worked better than others and if steps or even specific tools were missing. In addition, we related the skills and design outcome of the project to the creativity support and evaluation of the toolbox to better prepare future generation designers for challenges that come with designing these product service systems. The findings of this additional research step still required further analysis in order to be fully compared to the research presented in this paper. Additional future research aims to test, validate and finally refine the PSS toolbox in an organizational context, with companies that are making the transition to integrate products and services.

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