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SUSTAINABLE PRODUCT-SERVICE SYSTEMS IN SMALL AND MEDIUM ENTERPRISES

From a case study on textile leasing to a Design Thinking Workshop for Sustainable Product-Service System Development



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sustainable product-service system development**

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*“Sustainable Design may be the key
‘Trojan Horse’ which allows design
graduates and design thinkers to find
space to change, for the better, the
services and products which society
depends on socially, environmentally
and economically”*

(De Eyto et al. 2008, p.341).

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Acronyms

B2B	Business to Business
B2C	Business to Consumer
BC	Business Consultant
C2C	Cradle to Cradle
CE	Circular Economy
CRM	Customer Relationship Management
D4S	Design for Sustainability
DBL	Deutsche Berufskleider-Leasing (German Workwear-Leasing)
DFG	Deutsche Forschungsgemeinschaft (German Research Foundation)
DT	Design Thinking
e.g.	exempli gratia
EC	European Commission
ECEI	European Commission Enterprise and Industry
EMF	Ellen MacArthur Foundation
EU	European Union
HiCS	Highly Customized Solutions
HLB	Hybrides Leistungsbündel (Hybrid Performance Bundle)
i.a.	inter alia
ibid.	ibidem
IPK	Institut für Produktionsanlagen und Konstruktionstechnik
IPSE	Integrated Product Service Engineering
IPSS or IPS ²	Industrial Product-Service System
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCE	Life Cycle Engineering
LeNS	Learning Network on Sustainability
MEPSS	Methodology for Product Service System development
MRO	Maintenance, repair and overhaul
NPD	New Product Development
OECD	Organization for Economic Co-Operation and Development
ProSecCo	Product-Service Co-design
PS	Product services
PSS	Product-Service System
S.PSS	Sustainable Product-Service System

SaaS	Software as a Service
SME	Small and Medium Enterprise
SusHouse	Strategies towards the Sustainable Household
SusProNet	EU Network on sustainable Product-Service Systems
TBL	Triple Bottom Line
TRIZ	Theory of Inventor's Problem Solving
WBCSD	World Business Council for Sustainable Development
WEEE	Waste Electrical and Electronic Equipment
WRAP	Working Together for a World Without Waste

1 INTRODUCTION

Waste is good material in the wrong place (Lutzenberger 1999). All recycling efforts recognize this drawback. The recovery of valuable elements from landfills gains worldwide economic feasibility due to resource scarcity (EMF & McKinsey 2012). Nevertheless, this end-of-pipe thinking does not solve the emergence of waste in the first place. Waste is inevitably a design failure of the product (McDonough & Braungart 2001). Current debates focus on product design and corresponding services to retain defined materials for circular production. Sustainability-sensitive politicians and entrepreneurs give a great deal of thought and action to resource efficiency and exploring new forms of energy (EC 2011), however, “less thought has been given to systematically designing our leakage and disposal” (EMF & McKinsey 2012, p.6) of valuable resources. This imbalance may be explained by the more obvious saving potentials of ‘low hanging’ efficiency measures in comparison to approaches, which try to transfer resources into closed loop systems. Nevertheless, an increased rate of recycling, reuse and re-manufacturing bears the potential of over 1 trillion USD per year by 2025 and 100,000 estimated new jobs within the next five years for the global economy, if companies would focus on building circular supply chains (EMF & McKinsey 2014, p.10). For these reasons, some legislators initiated regulative approaches to enforce circularity of material flows. The Waste Electrical and Electronic Equipment directive (WEEE, 2012/19/EU) prescribes targets for collection, recycling and recovery rates in the EU. In reaction to that, Germany wants to achieve a 65% recovery rate from 2019 onwards.

As a response to the given challenge, circular economy is an industrial system design concept that is restorative by intention and design (EMF & McKinsey 2012). It calls for a ‘resource revolution’ rather than ‘reducing environmental impact’, and tries to achieve this revolution by using the full potential of materials in closed loops instead of losing valuable resources in landfills. Walter Stahel was a pioneer for circular economy thinking (Stahel & Reday 1981/1976; Stahel 1982; Giarini & Stahel 1986, 1989). He described the vision of an economy based completely on the performance of products rather than their ownership (Figure 1).

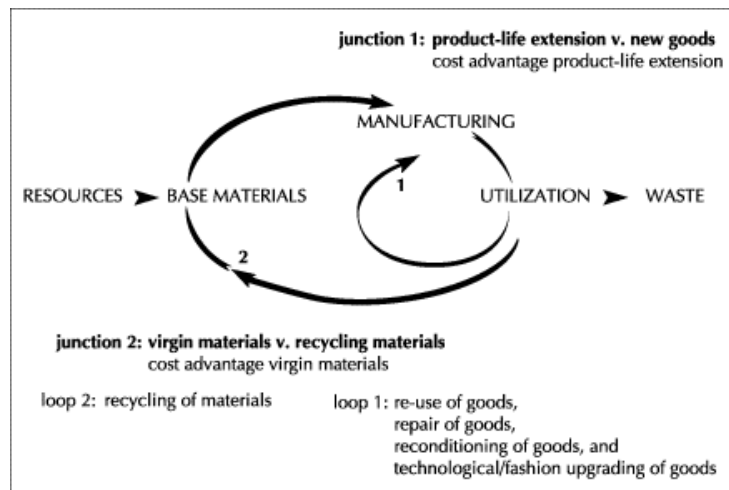


Figure 1: The vision of Stahel to close material loops: The figure illustrates loops of a self-replenishing, more sustainable service economy and the junctions between these loops and a linear economy (Giarini & Stahel 1989, p.56 with reference to Stahel & Reday 1981/1976).

Stahel highlighted the sustainability- and resource-efficiency-potential of just providing access to products. This can be seen as the roots of Product-Service Systems (PSS) (Tukker 2015, p.76; Stahel 2001). Within this concept, the provider retains ownership of the products and thereby the possibility arises to recycle and reuse materials in loops. The concept bears the potential to enhance competitiveness on the one hand and to contribute to sustainability on the other, then labeled sustainable Product-Service Systems, (S.PSS). This potential win – win situation is not self-evident. A satisfactory outcome can only be achieved by careful design of the PSS (Tukker & Tischner 2006b, p.1555). PSS have gained wide attention since the 1990ies in various research disciplines but not necessarily under the name of PSS¹.

Between 96% and 99% of all enterprises worldwide are of small or medium size (OECD 2002). Therefore, this study focuses on the application and development of S.PSS in SMEs as a reference framework. To convince practitioners of engaging in PSS businesses, Tukker and Tischner suggest developing a case base of successful PSS stories by highlighting the practicability and benefits in different branches (Tukker & Tischner 2006a, p.373). The present work investigates how

¹ Key words such as Industrial Product Service Systems (IPS²), Hybrid Service Bundles, Complex Service Solutions, Servitization, Service Economy, Performance Economy, Functional Economy, System Solution, Service Engineering, Service Design. Functional Sales, Integrated Product Development, Integrated Service Product (ISP) and Products to Services may likewise address the issue of joint product-service provision. Related fields of PSS research are Business Model Innovation, Circular Economy, Cradle to Cradle (C2C), Dematerialization, Remanufacturing, Vendor-leasing, Inverse Manufacturing and Design for Disassembly.

the initial implementation and ongoing development of an existing PSS has been managed within a SME and therefore poses the following research question:

1. What are promoting factors for long-term success and upscaling of sustainable Product-Service Systems in SME practice?

Aiming at further S.PSS implementation in SMEs, this thesis proposes Design Thinking (DT) as a methodological supplement to existing S.PSS methods to overcome challenges in the conventional design methods. DT is a user-centered iterative process, derived from the practice of an innovation agency, with the ability to quickly deliver applicable results through interdisciplinary teamwork. The second research question asks:

2. How can Design Thinking contribute to S.PSS development?

In response to these objectives the present thesis is organized as follows. First, literature on the potential contribution of SME and PSS to a sustainable development is reviewed to clarify the underlying concepts. Subsequently, findings in research regarding sustainable PSS in practice are presented together with an introduction to the field of practice, textile-leasing, which will be of further interest. This thesis moreover reviews literature on DT by highlighting the origin, key characteristics and its distribution in practice. Thereafter DT and PSS methodologies are put into relation. Secondly the research design, which addresses the two research questions, is described. On the one hand, internal and external factors contributing to the economic success of a SME from the textile-leasing sector are examined within a single case study. The case, which is further analyzed regarding its continuous innovation behavior and sustainability achievements, successfully offers workwear in a PSS business model in a network of SMEs since over four decades. On the other hand and on the basis of the former steps a methodological approach on how DT can contribute to S.PSS implementation within SMEs is developed. Thirdly, the findings on the case study and the workshop are presented in the results part of this thesis. Finally the concluding remarks and key findings are discussed together with possible limitations of the presented work and implications for further research.

2 LITERATURE REVIEW

2.1 Sustainability of Product-Service Systems and Small and Medium Enterprises

Computer-based projections of global population, industrialization, pollution, food production and resource depletion from the 1970ies led to the recognition that long-term economic growth is limited by the planet's finite resources (Meadows et al. 1972). The simulated scenarios predict a global collapse by the middle of the 21st century (Turner 2008, p.410). These simple but severe findings were published by the Club of Rome in 'Limits to Growth' and gained worldwide attention (Enquete Commission 1998, p.194; Held 1994; Scientific Service to German Parliament (WD) 2004; Grunwald & Kopfmüller 2012, p.24). Publications comparing the predictions from the 70ies with data from the year 2000 make clear that the global system is on an unsustainable trajectory unless there is substantial and rapid reduction in consumptive behavior supported by technological progress (Turner 2008, p.410; Meadows et al. 2004). Analysis of the planet's resource capacity and limits, which must be respected to ensure long-term social and economic development, adds to this dramatic prognosis. Three of the nine identified thresholds have already been irreversibly transcended (Rockström et al. 2009, p.475).

Various political institutions have since joined together to oppose the predicted irreversible depletion of natural resources and commit to sustainable global development. The World Commission on Environment and Development therefore defined sustainable development as:

"... development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

- the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and*
- the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs"* (WCED 1987, chap. 2, para. 1).

The narrow definition of sustainability by its physical boundaries still implies a social concern for intergenerational equity, which must logically be extended to intragenerational equity (ibid., chap. 2, para. 3). Sustainable development has to integrate economics and ecology in decision-making for environmental protection (ibid., chap. 2, para. 72; Barbier 1987).

The definition given by the World Commission on Environment and Development explains the conceptualized three-dimensionality of sustainability in *economic, ecologic* and *social aspects*. After the year 2000, the call for the integration of *culture* as a fourth pillar became stronger (Hawkes 2001; Nurse 2006; Stoltenberg 2010; Kopfmüller 2010). The relevant positions towards a sustainable development, published by the UNCED in 1992, were analyzed by the German social scientist Joseph Huber. He clustered and categorized the prevailing concepts into three strategies (Huber 1995a, 2000):

- ▶ *Eco-efficiency* is a concept, formulated by Schaltegger and Sturm (1989), addressing the industrial need to produce goods less resource intensively and to minimize environmental impacts of production (Ehrenfeld 2005, p.6). The Faktor X publications by von Weizsäcker and others suggest specific actions in different industrial sectors (Schmidheiny 1992; Fussler 1994; Schmidt-Bleek 1994; von Weizsäcker et al. 1995).
- ▶ *Consistency* addresses material and energy flows and the use of products. It questions the appropriateness of materials in production. Thereby solutions have to be found for each use-scenario with the intention of bringing material use of industrial society closer to nature's metabolism (Huber 1995a; Socolow 1994; Ayres & Ayres; 1996 Frosch & Gallopoulos 1989; Frosch 1997; Braungart & Engelfried 1992; Hofmeister 1998; Benyus 1997; Ayres and Ayres 1996; McDonough & Braungart 1998, 2002a).
- ▶ *Sufficiency* addresses individual consumption behavior. It is based on the growth and consumption critiques of the 1960ies and calls for renunciation of products and modest consumption (Huber 2003, p.217; Wackernagel & Rees 1997; Schmidt-Bleek 1994, Bringezu 1997, Peach 2005b, Jackson 2005).
- ▶ *Education for Sustainable Development (ESD)* is proposed in literature as a fourth strategy and engine for the realization of sustainable development (Stoltenberg & Michelsen 1999). ESD promotes the acquisition of key competen-

cies, encourages and empowers people to participate responsibly in the design of the present and the future (Stoltenberg & Michelsen 1999; De Haan & Harenberg 1999, 2001; De Haan 2006, 2008; Vare & Scott 2007).

Given the urgent challenges of sustainable development, a new field of sustainability science has emerged, investigating the fundamental character of interactions between nature and society. In order to address these dynamics, sustainability science differs in structure, methods, and content from science as we know it (Kates et al. 2001, p.641). Illuminating this contrast, Spangenberg (2011) offers a differentiation between a mono-disciplinary *science for sustainability* and an inter- and transdisciplinary *science of sustainability*. Science for sustainability is undertaken in a rather traditional disciplinary setting, but with an enlarged horizon and the dedication to make a difference (Spangenberg 2011, p.278). In contrast *science of sustainability* requires bridging concepts between different disciplines and searches for a generalizable scientific understanding of sustainability (ibid.).

Following the mindset of a science for sustainability, the concepts associated with each sustainability strategy are discussed by demarcating them from concepts of other strategies rather than promoting an integrative understanding (van Zyl 2010). Prominent examples in the German sustainability debate are eco-efficiency versus consistency (Braungart et al. 2007), de-growth versus consistency (Paech 2005a) and de-growth versus eco-efficiency (Jackson 2005).

In the 1990ies, the opportunities of 'environment-competitiveness' were highlighted by renowned management professors (Porter & Van der Linde 1995). The World Business Council of Sustainable Development (WBCSD) was founded in 1992 in order to elucidate reporting models, management strategies and business models adopted by international companies (Grunwald and Kopfmüller 2012, pp.8). Elkington translated the three sustainability dimensions into the business world. According to his managerial paradigm, businesses are sustainable when they live up to the 'triple bottom line' (TBL) of economic prosperity, environmental quality and social justice (Elkington 1997). After the introduction by environmental scientists, the business research community started to recognize sustainability-oriented approaches as independent fields of study e.g. sustainability management, sustainability accounting and sustainability-oriented product design

(Schaltegger 2005). One topic with in-depth study by EU researchers is the concept of sustainable Product-Service Systems (S.PSS).

In sustainability literature, the idea behind S.PSS can be found in performance ecology (Stahel 1982) or sharing economy (Heinrichs & Grunenberg 2012, Heinrichs 2013). Even the opponents of the business-oriented sustainability strategies utilized the idea by naming it differently and without reference to the existing research field of S.PSS. The consistency representatives Braungart and McDonough refer to ‘products of use’ in the ‘cradle to cradle’ concept. Paech, representing the sufficiency strategy, speaks of ‘dematerialisation’ (Paech 2005b), while the representatives of efficiency i.a. Lehmann and Schmidt-Bleek promote ‘use instead of owning’ and ‘result-oriented services’ in their factor X concept (Schmidt-Bleek 1994, Schmidt-Bleek et al. 2013; Halme et al. 2014, p.194). Consequently the field of S.PSS can be seen as the common denominator of the sustainability approaches (Figure 2).

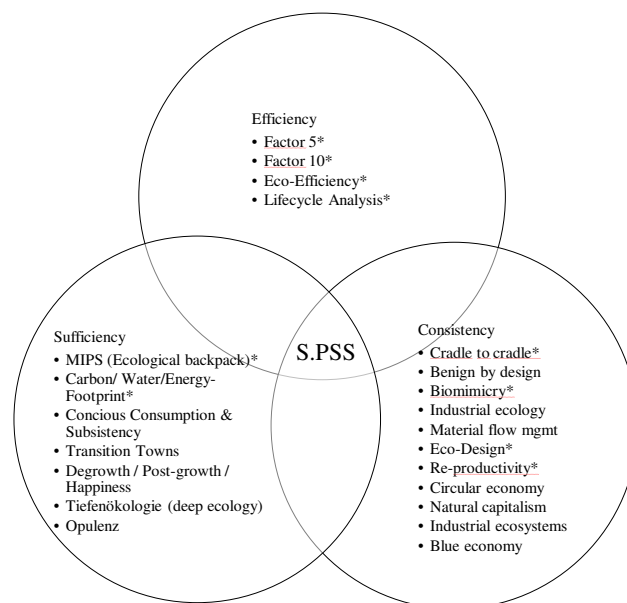


Figure 2: Sustainability strategies, the corresponding concepts and sustainable Product-Service System as a common denominator. (*) categorized by Huber in 1995a (own illustration).

This following chapter shows the relation of sustainability to i) product-service systems and ii) small and medium enterprises.

2.1.1 Sustainable Product-Service Systems (S.PSS)

The term of product-service systems (PSS) originated in northern European countries in the year 1999 (Baines et al. 2007, p.1547). PSS research further resonated with researchers in Asian countries, the United States, Canada and Australia. The maturation of the PSS research is indicated by a four- to fivefold increase of related papers in the last decade (Tukker 2015, p.79). As Goedkoop et al. (1999) state, a PSS can be defined as “a marketable set of products and services capable of jointly fulfilling a user’s need” (ibid., p.18).

Interest in PSS from the business community initially arose when possible product differentiation in mature markets became limited due to overall high quality standards (Pine and Gilmore 1999). In mature markets, designing and manufacturing products no longer serves as a main source of innovation and competitive advantage (Tukker 2015, p.77). To overcome price competition, companies offered integrated solutions and shifted towards an ‘experience economy’ with customized solutions to improve their position in the value chain, increase their innovation potential and enhance added value for their clients (Pine and Gilmore 1999).

The product- and service-ratio of a PSS can vary between high and low service shares. Therefore Tukker (2004) proposed a continuum between the extremes of pure product and pure service, further specifying three main categories and eight subcategories of PSS as shown in Figure 3. Analyzing the field of PSS research, Baines finds this approach consistent with Wong (2004) who sees PSS in a spectrum with pure products at one end and pure services at the other (Baines et al. 2007, p.1547).

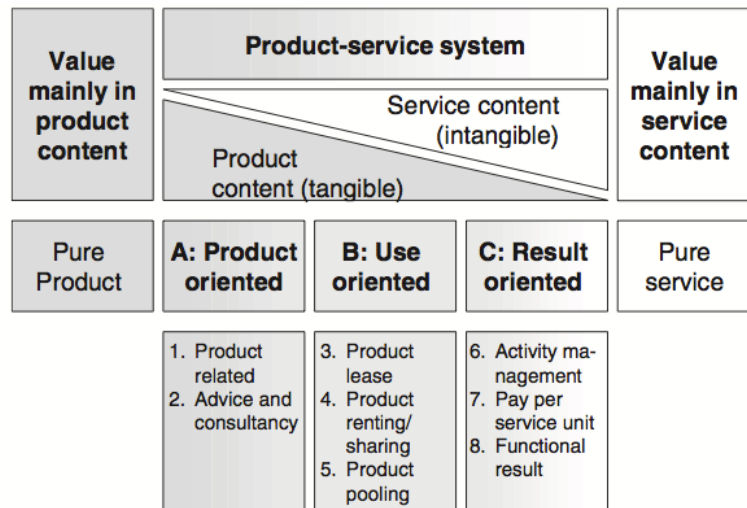


Figure 3: Main and subcategories of PSS that allow logical grouping of value proposition, including ‘non-material’ offerings such as (non-product related) advice and consultancy (Tukker 2004, p.248). However Tukker concedes the exception that this classification does not work for some products like software. The classification assumes by definition that ‘products’ have a material character (Tukker & Tischner 2006a, p.33).

Tukker explains the distinction between the three main PSS categories as follows. In *product-oriented services* the business model remains oriented towards the sale of products with some product-related services or consultancy added (Tukker 2004, p.248). *Use-oriented services* still contain large product share but instead of aspired sales, the provider remains in ownership of the product. This can be achieved through product leasing, sharing or -pooling (ibid.). At the service end of the continuum, *result-oriented services* are characterized by an agreement between client and provider on a final result without a pre-determined product involved. Third parties may as well deliver the result-oriented service and payment may be done per unit. A prominent example for a result-oriented PSS is ‘power-by-the-hour’ offered by Rolls Royce, which includes airplane engines as full-service package. As long as the functional result is achieved, the provider is free in the manner of delivery (ibid.).

The origin of the concept is highly scattered across different disciplines and research communities. Before the term PSS was coined by literature on dematerialization, remanufacturing and servitization existed independently from each other in different research fields. The concept has been approached from various research areas in the name of different concepts due to the earlier described diverse characteristics. Table 1 gives an overview of the multiple disciplinary approaches relating to aspects of PSS.

Table 1: PSS Related Research Areas (own table based on Tukker & Tischner 2006, pp.27; Thompson 2012, p.154; Wallin 2013, p.10; Boehm & Thomas 2013; Ceschin 2014; Tukker 2015; van Ostaeeyen 2014).

Research Area	Concept	Authors
Business Literature/ Strategy	Experience economy	Pine and Gilmore 1999
	Integrated Solutions	Davies et al. 2001, Brady et al. 2005 Markeset & Kumar 2005
	Functional Products	Fisher 1997, Alonso-Rasgado et al. 2004, Markeset & Kumar 2005
	Through-life management	Ward & Graves 2007
	Product Services (PS)	Mathieu 2001
Marketing	New product development (NPD)	Cooper 1988
	Service Design	Shostack 1984
Finance/ Banking	Service-dominant logic	Vargo & Lusch 2004
	Leasing	Dietz 1949
Engineering/ Manufacturing	Vendorleasing	Selmon 1988, Winders 1990
	Service Engineering	Tomiyama 2001, Bullinger et al. 2003; Aurich et al. 2010
	Industrial Product Service Systems (IPS ²)	Aurich 2007, Meier et al. 2010
	Integrated Product Service Engineering (IPSE)	Lindahl et al. 2006
	Hybrid Performance Bundle ²	Engelhardt et al. 1993
	Total Offers	Neely 2007
	Servitization	Vandermerwe & Rada 1989, Neely 2008
Information Systems Sustainability	Complex Service Systems Life Cycle Engineering (LCE)	Neely 2011a
	Cyber-Physical Systems	Boehm & Thomas 2013; Sha et al. 2009
	Performance economy	Stahel 1982 [1976]
	Natural Capitalism	Hawken et al. 1999
	Product of use (C2C concept)	Braungart & Engelfried 1992; McDonough & Braungart 2002a, Braungart et al. 2007
	Circular economy	Ellen MacArthur Foundation & McKinsey 2012, 2013, 2014, 2015
	Degrowth ³	Paech 2005b
	Use instead of ownership	Schmidt-Bleek 1994, Schmidt-Bleek et al. 2013; Angrick & Lehmann 2014
	Product-Service System	Goedkoop et al. 1999; Mont 2002
	Closed loop PSS	Mont 2002

Detailed reviews of PSS research exist within scientific publications for the periods before (Baines et al. 2007) and after 2006 (Tukker 2015). Tukker (2015) selected 278 relevant papers and used them to provide some quantitative insights on how research in the PSS field has developed in the last 15 years. He included only

² Translation from the German term 'Hybrides Leistungsbündel' (HLB)

³ Translation of the German term 'Postwachstum'

peer-reviewed publications in the formal literature, which does not include books and 'grey' research reports. This analysis is complemented by a paper, embedding PSS research in related research streams (Boehm & Thomas 2013).

In engineering literature the term PSS often relates to the B2C market with a focus on sustainability, while Industrial Product-Service Systems (IPSS or IPS²) aim to operate more efficiently regarding technical and economic aspects. In contrast IPS² is a subset of PSS, which represents PSS business-to-business (B2B) solutions (Müller & Stark 2008, p.1).

From the year 1998 onwards major research institutes launched the following PSS related research projects, mainly funded by the EU:

- ▶ SusHouse: Strategies towards the Sustainable Household, EU funded 1998-2000 (Vergragt 2000)
- ▶ ProSecCo: ProducteService Co-design, EU funded 2002-2004
- ▶ Innopse: Innovation Studio and Exemplary Developments for Product-service, EU funded 1997-2002 (Bitzer & Biernatzki 2004)
- ▶ HiCS: Highly Customerized Solutions, EU funded 2001-2004 (Manzini et al., 2004)
- ▶ MEPSS: Methodology for Product Service System development, EU funded 2002-2005 (van Halen et al., 2005)
- ▶ SusProNet: Network on sustainable Product-Service System development, EU funded 2002-2005 (Tukker & Tischner, 2006b)
- ▶ D4S: Design for Sustainability, A Step-By-Step Approach, UNEP funded 2005-2009 (Tischner & Vezzoli 2009)
- ▶ LeNS: Learning Network on Sustainability, funded by Asia Link Programme, EuropAid and European Commission, 2007-2010 (Vezzoli et al. 2014)
- ▶ Transregio 29: Dynamic Interdependencies between Products and Services in the Production Area, German Research Foundation (DFG) funded 2006- 2011 (Meier 2013)

Digitization is a trend supporting the PSS movement. Complexity of IT systems increases when connecting different life cycle phases. PSS connect product design, maintenance, repair and overhaul (MRO). The connection is hindered by

different data formats, steady demand for information or integration of new technologies (Uhlmann et al. 2015). The research field Life Cycle Engineering (LCE) accelerates the integration of new industry 4.0 solutions like cloud services, big data or cyber physical systems. In turn data on the usage of a PSS is central in competitive terms (Schultz & Tietze 2014, p.70). Long-term service contracts, continuously rising data collection and the digital connection of products enable the development of inhouse databases. Schultz and Tietze (2014) point out that the capability of handling big data and data mining is of growing importance also for innovation management. On the one hand, they argue, lead users for innovation processes can be identified from user profile databases. On the other hand, ideas for PSS improvements can be derived directly from the feedback data as well as the effect of adjustments can be digitally simulated. The mastering of such processes and the resulting range of enhancements results in information, that is not only valuable, but also difficult to imitate (ibid.).

Baines and others point out that “for some authors the concepts of PSS also embraces sustainability” (Baines et al. 2007, p.1543). As mentioned earlier Stahel (1982) and Schmidt-Bleek (1994) were pioneers in identifying the sustainability and resource benefits of the PSS concept (Tukker 2015, p.76). Some authors demand that a PSS must by definition be more sustainable than the competing product concept (e.g. Mont, 2004). Others define PSS simply as a combination of product and service and add the adjective ‘sustainable’ when the PSS is indeed more sustainable than the compared concept (Tukker & Tischner 2006b). In line with Mont, the two concepts are here forth used interchangeably in this thesis. To capture the multitude of definitions of S.PPS Table 2 is presented.

PSS breaks the tie between value delivered to the customer and the quantity of physical material needed to generate it. Dematerialization is often declared as an important aim for many S.PSS practitioners and researchers. Nevertheless Baines and others (2007, p.1546) point out that the term dematerialization does not appear in any of the definitions.

Table 2: Sustainable Product-Service System (Baines et al. 2007; Tietze & Hansen 2013, pp. 4)

Author	Definition
Giarini & Stahel 1986	A functional economy (...) is one that optimizes the use (or function) of goods and services and thus the management of existing wealth (goods, knowledge, and nature). The economic objective of the functional economy is to create the highest possible use value for the longest possible time while consuming as few material resources and energy as possible. This functional economy is therefore considerably more sustainable, or dematerialized, than the present economy, which is focused on production and related material flows as its principal means to create wealth.
Mont 2000	PSS is a system of products, services, networks of actors and supporting infrastructure that continuously seeks to be competitive, satisfy customer needs and have a lower impact than traditional business models.
UNEP: Manzini & Vezzoli 2003	Result of an innovative strategy that shifts the centre of the business design and sale of products only (physical) to systems offering products and services that are jointly capable of satisfying a given application.
Wong 2004	Product Service-Systems (PSS) may be defined as a solution offered for sale that involves both a product and a service element, to deliver the required functionality.
MEPPS: Van Halen et al. 2005	Result of an innovation strategy focused on the design and sale of a system of products and services that are jointly capable of fulfilling a specific customer demand.
SusProNet: Tukker & Tischner 2006a	Product-service systems (PSS) are a specific type of value proposition that a business (network) offers to (or co-produces with) its clients. PSS 'consists of a mix of tangible products and intangible services designed and combined so that they jointly are capable of fulfilling final customer needs'. The PSS concept rests on two pillars: <ol style="list-style-type: none"> 1. Inherently taking the final functionality or satisfaction that the user wants to realise as a starting point of business development (instead of the product fulfilling this functionality). 2. Elaborating the (business) system that provides this functionality with a 'greenfield' mindset (instead of taking existing structures, routines and the position of the own firm therein for granted).
Baines et al. 2007	PSS is an integrated offering of a product and a service that provides a value. Using a PSS offers the opportunity to decouple economic success from material consumption and thus reduce the environmental impact of economic activity.
McDonough & Braungart 2009 (cited as in Tietze et al. 2013)	'instead of assuming that all products are to be bought, owned, and disposed of by 'consumers', products containing valuable technical nutrients – cars, televisions, carpeting, computers, and refrigerators, for example – would be reconceived as services people want to enjoy. In this scenario, customers (a more apt term for the users of these products) would effectively purchase the service of such a product for a defined user period..., rather than the ... [product] itself'
UNEP: Tischner & Vezzoli 2009	System of products and services (and infrastructure), to jointly cope with the needs and demands of customers in a more efficient way with better value for both businesses and customers, compared to only offering products [...]. PSS can decouple the creation of value from the consumption of materials and energy and thus significantly reduce the environmental impact in the life cycle of traditional product systems.
LeNS: Vezzoli et al. 2014	an offer model providing an integrated mix of products and services that are together able to fulfill a particular customer demand (to deliver a 'unit of satisfaction') based on innovative interactions between the stakeholders of the value production system (satisfaction system), where the economic and competitive interest of the providers continuously seeks environmentally beneficial new solutions.
Boehm & Thomas 2013	A Product-Service System (PSS) is an integrated bundle of products and services which aims at creating customer utility and generating value.

Critical voices argue that the PSS concept is limited as it only delineates negative sustainability impacts of product innovations (Weaver et al. 2000; Blowfield et al. 2008; Paech 2005b, Hansen et al. 2009). Although efficiency improvements are beneficial, Hansen and others accuse such approaches to neglect the opportunity to address the “causes of such negative impacts – namely, the way current customer demands are fulfilled” (Hansen et al. 2009, p.639). Current western need structures and lifestyles are seen as one of the major causes for sustainability chal-

lenges (Belz, 2006). Innovations have potential for improving sustainability by developing alternative solutions to customer demands when actively challenging the prevailing consumption patterns e.g. how the need for mobility can be fulfilled in an alternative way (Hansen et al. 2009, p.639).

Practical applications of the PSS concept show that many firms are increasingly adding services to existing products (Neely 2011b). In China, the growth of servitization has risen from 1% in 2007 to approximately 20% in 2011 (Neely 2011b). The goal of more sustainable solutions is thereby largely not met (Vezzoli et al. 2015, Thompson 2012).

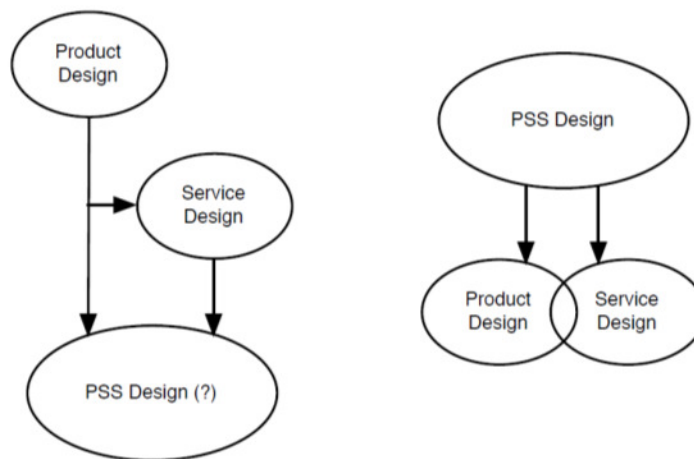


Figure 4: Many companies do not re-design their PSS for sustainability. (left) Manufacturing firms now commonly add services to existing products to arrive at product-oriented PSS. (right) To open up to more significant sustainability opportunities, firms should consider to move towards designing solutions at the PSS level first, and from there co-develop the products and services required (Thompson 2012, p.45).

Verkuijl and others (2006) point out that the design processes of product and service development are not automatically congruent with regards to S.PSS development (Verkuijl et al. 2006, p. 107). In her most quoted publication ‘clarifying the research area of PSS’, Mont suggests the following differentiators between product and PSS design (Mont 2002):

- ▶ Specifically between service and manufacturing organizations, a close integration of all actors of the network is compulsory for PSS. This integration is necessary to allowing the service mindset to drive manufacturing or design enhancements (Mont 2002, p.242).

- ▶ Take-back solutions and complementary network agreements should yield at maximum of closed material loops and coequal a minimum of transport emissions (ibid).
- ▶ The user should be informed about various use-scenarios of a single product. Information including economic and environmental differentiators could be provided at the point of sale to support a decision towards PSS (ibid).
- ▶ More sustainable ways of satisfying user needs should be prevailing in PSS marketing. Instructions for the most efficient use of the product should be embraced (ibid).

Regarding product design itself, insights on product design and eco design are rich, but there are gaps in integrating social aspects (Verkuijl et al 2006, p.106). Likewise the lack of cultural factors in SMEs is not taken into design processes (ibid). The known principles of sustainable products (Tischner 2001, pp. 263; Charter & Tischner 2001, pp. 118; Vezzoli & Manzini 2008) serve as blueprints for improved design. With the exception McDonough and Braungart's article on cradle to cradle (C2C) design reprinted in Charter and Tischner's reference compilation (2001), the eco-effective design principles regarding healthy and recyclable material definitions have not been considered in most PSS literature (apart from Mont 2002; Tietze & Hansen 2013).

Similar to the argument developed by Mont on closed loop PSS, Hockerts and Weaver (2002) use the extent to which the property rights of PSS remain with the user or provider as a measure to classify PSS (Tukker 2015, p.81). The authors aim to understand both, efficiency impacts and effectiveness impacts (consistency) of various PSS configurations (Hockerts and Weaver 2002). This thesis follows the PSS definition by Tietze, Schiederig and Herstatt (2013):

“An integrated offering of tangible products, intangible services and the enabling infrastructure providing a product-unspecific functional value. While the user and the offering firm engage into an enduring contractual relationship, the ownership remains with the offering firm with the user becoming the temporary proprietor enabling a high use-flexibility” (Tietze et al. 2013, p.52).

2.1.2 Sustainability-Oriented Innovation of Small and Medium Enterprises

Small and Medium Enterprises (SMEs) are defined by the EU depending on two determinants (EC 2015). The number of employees has to be below 250 and either the turnover has to be less than 50 million EUR or the balance sheet total has to be under 43 million EUR. It is notable that SMEs make up the majority of firms in the EU (ECEI 2010). Consequently SMEs produce a large share of environmental pollution on the one hand, specifically estimated 64% in the EU (Hillary 2000; ECEI 2010) and have great sustainability potential on the other. The latter perspective is justified by three folded SME specific advantages, a) lean organizational structures, b) strongly value-oriented through strong owner leadership and c) the ability for radical innovation enabling dominance in niche markets (Klewitz & Hansen 2014, p.59). Radical innovations have more potential to influence sustainable development of whole industries as they depart from current practice (ibid.). In conclusion, the overall economic share of SMEs, paired with the potential to perform sustainable by considering the TBL in the business model, raises the attention of sustainability scientists to analyze the role of SMEs for sustainability transformation (Schaltegger & Wagner 2011, Geels 2005). As early as 1962, Schumpeter coined the role of small enterprises as ‘creative destroyers’, changing the market by bringing more radical solutions than competitors and thereby shifting the baselines for market standards (Schumpeter 1962 cited as in Hockerts & Wüstenhagen 2010, p.482). The societal transformation of industries as a global goal (WCED 1987, chap.2, para.81) implies corporate innovative thinking on a regional level. Innovation can be defined as the implementation of improved products, processes and marketing methods in business practice, workplace organization or external relations (Klewitz & Hansen 2014, p.58). As described earlier, sustainability is multidimensional and deals complex systems (Meadows 1997, p.1). Innovations addressing wicket societal problems therefore have to pay tribute to this complexity. Hence, sustainability-oriented innovation (SOI) is summarized by Klewitz and Hansen as a research stream, evolved with a broader focus on environmental, social and economic dimensions than its initial conceptual origin, eco-innovation (Klewitz & Hansen 2014, p.57). In sustainability management Schaltegger (2002) argues that it is essential to diffuse SOI not only in the niche but also in mass markets, in order to substantially affect the transition to sustainable development (Schaltegger 2002). In contrast Hockerts and Wüstenha-

gen stress that new entrants, which they name ‘Emerging Davids’, are more likely than incumbents to pursue sustainability-related opportunities (Hockerts & Wüstenhagen 2010, p.481). In this regard Klewitz and Hansen point out, that large and small companies can engage in SOI, thus SMEs will innovate differently (Klewitz & Hansen 2014, p.58).

For more proactive SME behavior, Klewitz and Hansen argue that SME possess higher capabilities for more radical SOIs when changing their innovation process. They propose interaction with external actors such as customers, authorities and research institutes to ultimately increase the innovation capability (Klewitz & Hansen 2014, p.57). In many cases, radical innovation can only be achieved with business model innovation, such as the case of S.PSS. In SME such radical innovations often occur in cases of threads of organizational survival or succession to the next generation in family businesses (ibid, pp.71).

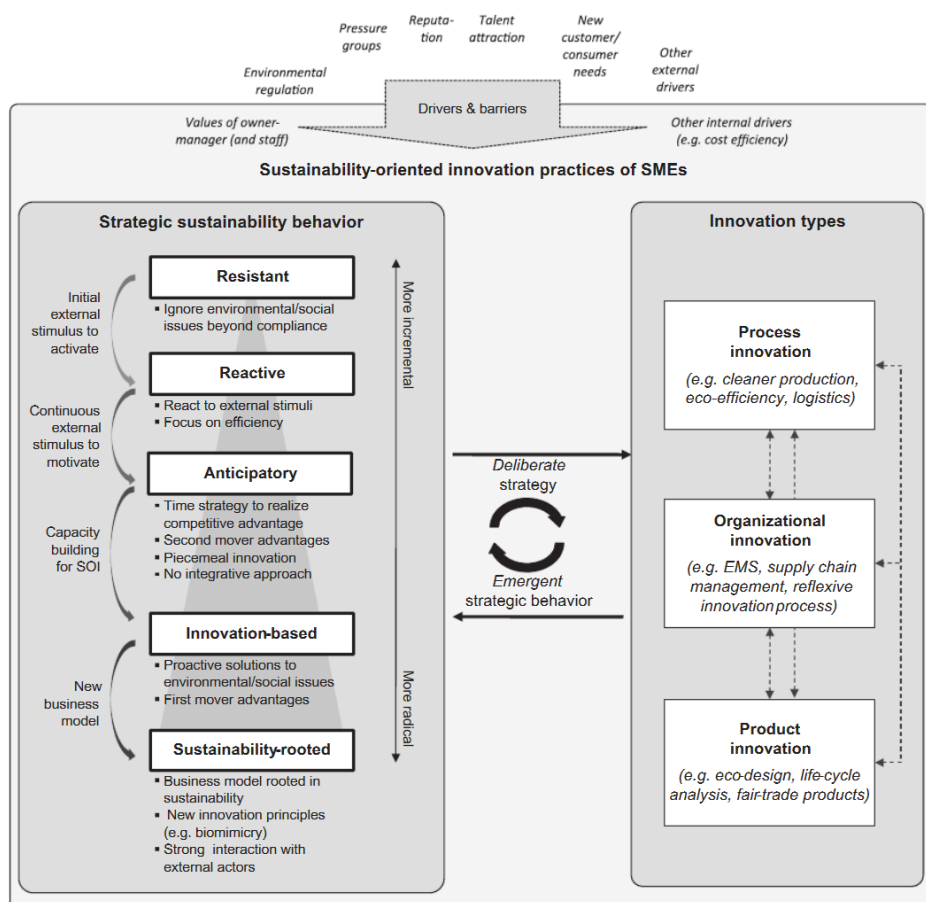


Figure 5: An integrated framework for SOI practices of SMEs (Klewitz & Hansen 2014, p.69)

Figure 5 displays their integrated framework on how SME innovate towards sustainability (ibid.). Klewitz and Hansen (2014) find that for *successful SOI in SME external barriers have to be overcome*, namely environmental regulations, pressure groups, reputation, talent attraction and customer needs (Figure 5, above). As an *internal driver* values of the owner manager and the staff were identified as critical for SOI. Klewitz & Hansen (2014) differentiate three types of innovation: process innovation, organisational innovation and product innovation (Figure 5, right). Action on one of these levels leads to changes on another level and therefore entails *continuous innovation processes* (ibid.). SOI such as S.PSS can be undertaken by SMEs with different *strategic sustainability behavior* between resistant and sustainability rooted (Figure 5, left).

Linking these SME innovation insights to our research field, it is notable that in-depth studies on SMEs embracing S.PSS are lacking, apart from Hernández-Pardo and others (2013). They explored the SME perceptions of S.PSS regarding sustainability awareness, use of information and communication technologies (ICTs), design process and business strategy in Columbia. Due to the different cultural setting the findings can hardly be transferred to German SMEs.

To sum up, innovation processes of SMEs shifting to PSS are of particular interest due to the high sustainability potential, recognized in both PSS and SMEs. Furthermore the competitive advantages of S.PSS might be especially interesting for SMEs, competing with highly professionalized corporations. Therefore it will be interesting to investigate, how to facilitate such innovation processes by simultaneously changing interrelated product, service and supportive structures. **This thesis further investigates how SMEs can successfully manage PSS implementation by learning from experienced S.PSS companies and the insights on innovation processes from SME research.**

2.2 Sustainable Product-Service Systems in Practice

This chapter reflects on S.PSS existing in practice and reviews internal and external success factors as well as continuous innovation behavior for long-term prevalence. It further analyzes sustainability criteria along the four dimensions for a strong holistic sustainability orientation of Product-Service Systems. Finally the market of textile leasing is explored within this context. The conclusion on the main outcome of the Sustainable Product Development Network (SusProNet), that developed 17 new PSS together with business partners, was:

*“Indeed, many firms do not even have structural routines for searching for innovations and new business models. The practice is that many firms, **particular smaller ones**, tend to be conservative and are not eager to even analyse the potential of novelties that at first sight seem a bit risky”* (own emphasis, Tukker & Tischner 2006a, p.373).

Regarding existing in-depth case studies on PSS, Grosse-Dunker and Hansen (2011) find that most studies analyze sharing options for mobility and the offering of technical equipment in B2C markets in developed nations. In their case study on an unsuccessful lending offer from Osram in Kenya they conclude, that the published cases mostly focus on the integration of existing products or technologies into a PSS, as *“there is virtually no research on cases where the product innovation joins the introduction of the PSS”* (Grosse-Dunker & Hansen 2011, p. 41). Baines and others find a very diverse range of practice examples, mostly demonstrating economic success and emphasizing sustainability gains in their literature review (Baines et al. 2007, pp.1548). They found almost 150 examples of separate PSS. The range in practice is very diverse, from the provision of ecologically grown vegetables, to a description on how DuPont has shifted its flooring systems from selling floor coverings to providing total servicing to customers. Schultz and Tietze (2014) give an additional overview of practice examples (Table 3).

Table 3: Selected PSS examples from different application fields (own translation; Schultz & Tietze 2014, p. 59)

Application field	PSS designation	PSS description	Provider example
Office services	Flexible workplace solutions	Flexible full- or part-time offices available in various cities via membership.	Regus ('Businessworld'); Marriot ('Workspace on Demand')
Office services	Document management	Use contracts for printers and copy machines in companies including consumables. After using up a quota, billing per print.	Xerox (,Managed Print Services')
Chemical industry	Mobile industrial water purification	Container-based, mobile solution for the purification of waste water for companies and municipalities.	Grundfos (,BioBooster')
Energy	Solar driven 'Off-Grid Lighting'	Portable electric lamps for rural regions in developing countries that are charged at "Energy Hub" for a fee using solar energy.	Osram (,Lake Victoria, Kenya')
Energy	Solar panels	Design, financing and operation of solar systems including remote monitoring.	SunEdison (,Solar Energy Solutions')
Industrial service	Textile management	Textiles (workwear, cleaning wiper, towel rolls, mats, etc.) are delivered to the customer, picked up, washed and cared for, maintained and replaced when worn.	MEWA (,Textile Management')
Industrial service	Fluid management system	Design and operation of fluid systems (incl. Maintenance, equipment and documentation management and disposal) through on-site service staff.	Castrol ('ILS Fluid Management Systems')
Industrial service	Industrial abrasive/solvents	Cleanings with solvents in a closed circuit. Reuse by recycling the materials used.	Surface Preparation ('Abrasive Lease & Recycle Programs'), SafeChem ('COMPLEASE Chemical Leasing')
Information and Communication Technology	'Software as a Service' (SaaS)	Use of software that is provided on servers of a provider and does not have to be installed on the local PC.	Google ('Google Docs'), Amadeus ('Amadeus CRS'), GMX ('Media-Center')
Agriculture	Mobile Services	Compaction of crop waste into pellets with a mobile plant that the operator brings to farms.	Bundesverband der Maschinenringe (German Federation of machinery rings) ('Mobile pelleting plant')
Aerospace	Aircraft engine maintenance management	Leasing of aircraft engines, including service packs and sensors for remote monitoring.	Rolls Royce ('Corporate Care', 'Power-by-the-hour')
Medical technology	Tele medicine	Overall system for remote monitoring of heart failure patients.	Vitaphone ('Vital Data Management Systems')
Medical technology	Mobile medical services	Mobile diagnostic centres for occupational health studies in business or checkups in collaboration with hospitals.	GE Healthcare ('Mammography on the Road'), Medicina Digital Corporativa
Mobility	'Free floating' Car- and Bikesharing	Telematics-based utilization rates for distributed fleets.	Daimler AG ('Car2go'), BMW ('Drive Now'), Hertz ('Hertz on Demand')
Paper production	Industrial recycling	Take back and reuse of industrial products.	Polyplank AB ('Core plugs' for paper production)
Advertisement	Outdoor advertising	Street furniture is provided municipalities, cities. Refinancing is carried out by outdoor advertising.	JCDecaux (,Street furniture')

In a special issue of the *Journal of Cleaner Production*, prominent PSS researchers ask: 'Why have Sustainable Product-Service Systems not been widely implemented?' (Vezzoli et al. 2014). They criticize that the given emphasis in research does not reflect in the results of adaption and upscaling of PSS practice. Tukker suggests in the same issue to stimulate a wider diffusion of PSS by improved insights onto how the risks of a transition from a product-centered to a PSS-centered firm can best be managed (Tukker 2015, p.88).

Ceschin argues in this regard that S.PSSs are often developed as a niche innovation. In order to upscale them, the actor network plays a central role (Ceschin 2013, p.84). Tukker and Tischner recommend to develop a transparent case base, by working out the PSS concept “*for different sectors, different cultures, with different consortia of companies and so on*” (Tukker & Tischner 2006a, p.373). This would create hands on insights on drivers and barriers on the basis of tested success examples. To convince SMEs of PSS implementation, “*it is particularly such recognizable success stories from other businesses that help to make firms less skeptical about novelties and make them see how the concept could be beneficial for them*” (ibid.).

2.2.1 Success factors of S.PSS

Mont (2008) detected a set of *internal drivers* for long-term success of PSS in practice (Mont 2008, pp. 57). First of all, a committed top management and the presence of a catalyst, promoting the PSS concept internally, drive a successful PSS implementation (ibid.; Ryan et al. 2011, pp.77). Among others, Mont (2004) and Grosse-Dunker and Hansen (2011) point out that the phase of development determines whether a PSS becomes success story (Mont 2004; Grosse-Dunker & Hansen 2011, p.50; Cavalieri & Pezzotta 2012, p.278; Ryan et al. 2011, p.216; Alix & Vallespir 2010, pp.644; see also chapters 2.1.3 & 2.3.3). Even if external market pressures trigger the change to a PSS, economic savings can be linked to environmental improvements (Mont 2008, p.57). Another internal driver for PSS prevalence is that contracting enables clearer cost structures and long-term planning for the providing company (ibid.). Mont describes two further PSS aspects related to possible savings. First she explains that by extending the product life, costs associated with resource management can be reduced and secondly, risk management through professional handling might reduce compliance costs (ibid.). Managing resources and processes that aren't core activity of the customer can be seen as a further opportunity for PSS success (ibid. 2008, p. 57). Tukker (2015) moreover finds, that the focus on product availability for clients supports long-term success of PSS (Tukker 2015, p.76).

As the implementation of a PSS is considered a system innovation with high complexity for the company, *overcoming internal barriers* is key to long-term

success (Mont 2008, pp.58). A main barrier to manage a PSS is the required internal knowledge on PSS delivery, as knowledge capabilities between producing and managing services are significantly different (ibid.). The PSS providing department have to possess both, technical knowledge of the product and relationship management skills (Tukker 2015, p.85). For the latter, competences on customers processes have to be developed, either by training the staff or by recruiting additional personnel (ibid.). Mont calls the traditional business mindset “*the most critical barrier for a producer to start providing functional sales*” (Mont 2008, p.60). Existing internal company functions may hinder PSS success, as for instance product units sold no longer serves as a success measurement. Pricing immaterial services, particularly those that highly depend on knowledge, bears a burden for PSS implementing enterprises (ibid.; Baines 2007, p.1550). After the implementation process companies may face the problem of an internal competition between traditional sales and service-oriented solutions. This internal barrier corresponds with the unwillingness to change the own business for suiting customers’ needs (ibid.; Maxwell et al. 2006, p.1476). Other obstacles found on the operational level are reliable supportive systems for condition monitoring and managing the product at customer sites (Mont 2008, p.60).

Based on a data collection of Swedish companies, Mont (2008) further identified the following *external drivers*, positively influencing the success of PSS. The growing environmental awareness leads to a greater demand on information regarding the product supply chain (Mont 2008, p. 56). Therefore a LCA perspective can set the basis in PSS development for approaches minimizing the environmental impact (ibid.). Correspondingly, stringent environmental regulations, for instance take-back legislations, may serve as a driver turning functional sales into a competitive advantage. Moreover services can be developed as corporate responses to health and safety regulations (ibid.). From a market perspective, B2B customers demand diverse services as a possibility to externalize ecologic responsibilities in a cost-effective way. Cost reduction is a convincing argument for B2B-customers (ibid., pp.56). Even though market drivers differ considerably from sector to sector, competition could lead to new opportunities for improvement (ibid., p.57). Monts’ findings further suggest that, in comparison to private customers, business customers prefer services over ownership as a general external driver for the B2B market (ibid., p.61).

From her empirical study Mont also deduces the need for *overcoming external barriers* in the PSS implementation phase (Mont 2008, pp.58). Companies declared a lack of market demand as the main barrier for PSS success (ibid.) due to existing customers' habits (Ceschin 2013, p.75). This is in accordance with Baines (2007) who argues, by reviewing PSS literature, that most authors see the cultural shift from owning a product to meeting needs through a PSS as the main barrier to PSS adoption (Baines 2007, p.1550). Especially low-value products are difficult to introduce to the market (Mont 2008, pp.58). For B2B customers, not fully understanding the PSS contract, paired with the desire to preserve competencies in-house can be hurdles to engage in PSS relations. Externalizing responsibility and ownership of the product within a service contract can lead to a reduced care for products (ibid.). For delivering PSS, businesses have to overcome weak relations along the value chain, strengthening the sense of commonly delivered customer value. The high complexity and the variety of stakeholders involved in PSS value proposition can result in a barrier for newcomers, if companies are unwilling to share market experience. A company might struggle achieving credibility from potential customers, being simultaneously understood as a producer and provider of service and information (ibid.). Once this necessary credibility is created it remains a sensitive issue, entering customers' facilities during service delivery (ibid.).

It requires time and money to make use of the mentioned internal and external drivers to facilitate change processes within the company and to absorb the risks stated as internal and external barriers (Baines et al. 2007, p. 1550). Especially SME with limited capacities have to use resources effectively to handle the complexity of shifting products and service propositions internally and externally at the same time (Hernández-Pardo 2013, p.25).

2.2.2 Continuous Innovation of S.PSS

Process-innovations often originate from intra-organizational learning processes (Nilsen & Ellström 2012, p.156). Hence the employees of an enterprise, in connection with its customers, are the most typical origin of service innovation (ibid., p.447). Therefore it is seen as a success factor to involve frontline personnel with hands-on expert knowledge in the creation of new services (de Brentani 2001,

p.182). Next to creating services, employees convey the distinctiveness and benefits of service propositions to the customers (Tukker 2015, p.85). Tukker (2015) thus suggests as a key success factor for the introduction of new service offerings and integrated product development, to consider the internal organization and to consistently integrate and coordinate the enterprises departments (ibid.).

Publications in innovation management stress the relevance of user integration for traditional product development (Gemünden 1981; von Hippel 1988, 2001; Franke & Piller 2004; Piller & Walcher 2006; Schreier & Prügl 2006; Neyer et al. 2009). Especially lead users can become the source of innovation because of their self-interest in the expected benefits of the innovation outcome (Skiba & Herstatt 2012, p.239). In PSS research, authors likewise emphasize the importance of integrating users very early into the development of PSS (Hansen et al. 2009; Manzini et al. 2001). Grosse-Dunker and Hansen highlight “*the requirement of new methodologies for the design and development of user-tailored PSS (Morelli 2002, Baines et al. 2007, Manzini & Vezzoli 2002). Further research should look at processes of open innovation and customer integration (e.g. Halila & Horte 2006; von Hippel 1988)*” (Grosse-Dunker & Hansen 2011, p.50). The tight integration of diverse stakeholders within development processes of products and services is widely recognized as a major success factor (Franke & Piller 2004; Piller & Walcher 2006; Reichwald & Piller 2006, p.133). Company stakeholders exceed the mentioned employees and users, such as the firms’ technological network leading to a cross-disciplinary setting that is correlated with promising results (Gemünden et al. 1996).

Findings from practice-based innovation supports the perspective that a certain degree of cognitive distance, including novel information from other perspectives, enables the creation of new innovations (Uotila et al. 2012, p.33). Uotila and others characterize and reflect on different types of distances in innovation networks by referring to Harmakorpi and others (2006). Geographic distance between actors for instance does not coercively stimulate innovations, but it can facilitate social proximity (ibid.). Proximity however reduces the uncertainty within economic activity, assists problem solving and enables interactive learning for innovation (Boschma 2005; cited as in Harmaakorpi & Melkas 2012, p.444). Therefore, an organizational network should embrace both, strong and weak links between multiple actors as radical ideas are often triggered by trust in relationships (Uotila et

al. 2012, p.33), while disjuncture can also lead to learning and innovation (Darsø & Høyup 2012, p.151).

2.2.3 Sustainability in S.PSS

By definition sustainability characteristics have been discussed during S.PSS explanation from a resource perspective. Here sustainability potentials are systematically further examined within the categorization of the sustainability dimensions: economic, ecologic, social and cultural aspects sphere, which a S.PSS ideal-typically can embrace.

Economic sustainability is reflected by the increased profitability, decoupled from productivity and the competitive market position of PSS (Vezzoli et al. 2014, p.113). Maxwell and others (2006) stress the economic assertiveness of PSS by highlighting the competitive advantage in saturated markets and the cost benefit from eco-efficiency (Maxwell et al. 2006, 1472). Achieving an added value for both, the PSS providing company, for instance by offering second-hand products for need fulfillment and for the client through intangible benefits, as time savings, is a key characteristic for Product-Service Systems (Vezzoli et al. 2014, p.113). For economically sustaining, PSS have to cope with market threats in the long-term like changing trends and customer needs or threatening legislation. For overcoming macro-economic effects like monopolistic structures, competencies can be provided by cooperating in strategic partnerships (ibid.).

Regarding the *ecological dimension*, S.PSS can minimize the environmental impact of consumption through alternative scenarios of product use (Mont 2002, p.239). The argument of dematerialization is connected with the provider maintaining product ownership, enabling the re-use of components in next generations and the closure of material cycles (ibid.). The molecular re-design of raw materials can further contribute to product circularity (Tietze & Hansen 2013, p.3; Lindahl & Sakao 2013, pp.441; Braungart et al. 2007, p.1338). Reducing raw material input, by reusing products or materials from products, reduces the material intensity (ibid.) and increases overall resource productivity (Mont 2002, p.239). Dematerialization consequently leads to a reduction or elimination of generated waste (Maxwell et al. 2006, p.1472). However, Sustainable PSS need to be eco-efficient in distribution, through low energy requirements and reduced emissions

of pollutants (ibid.). Achieving biocompatibility by eliminating the usage of hazardous substances within the products, will ultimately lead to toxic reduction (Maxwell et al. 2006, p.1472). The system life of the product part can be optimized for instance through adaptable products with upgradability options or by services facilitating the shared use of the products (Vezzoli et al. 2014, p.121).

Ecologic detoxification strategies also impact the *social dimension* of S.PSS, providing health and safety benefits to the S.PSS company employees, to employees within the supply chain and to end users (Maxwell et al. 2006, p.1472). Social commitment of S.PSS providers is mainly reflected within working conditions locally at the PSS provider and on a global level at sub-contractors sites by supporting health and safety issues, equity and equality and opposing child labor, discrimination and inadequate wages (ibid., p.1474). Van Halen, Vezzoli and Wimmer argue within their methodology for product-service innovation that S.PSS can contribute to the domains of living, working, healthcare and consumption and thereby “*have an impact on society at large and ultimately on the sustainability of our planet*” (van Halen et al. 2005, p.36). The sustainable design orientation toolkit (SDO), providing guidelines for product-service design, suggests further criteria for the socio-ethical dimension. Social cohesion by favoring and integrating the weak and marginalized can be improved by S.PSS (Vezzoli et al. 2014, p.113). Another social aspect is that S.PSS enable easy responsible and sustainable consumption by externalizing the responsibility of sustainability issues to the professionalized PSS provider. Moreover S.PSS rather valorize local resources, also positively influencing the social well-being of communities opposing impoverishment (ibid., MEPSS SDO 2012; van Halen et al. 2005).

Service-oriented solutions have to be tightly linked to the *cultural* context and habits of the target group, such as overcoming a broad throwaway-mindset and fostering a collective living and sharing acceptance, with respect to the regions historic development (Mont 2008, p.62). Osrams’ failure introducing off-grid lighting in Kenya further underlined that cultural habits have to be considered and integrated during PSS design (Grosse-Dunker & Hansen 2011).

2.2.4 Field of Practice: Textile-Leasing

The concept of textile leasing refers to the distribution of pre-financed textiles with regular payment for the products and additional laundry, maintenance and logistic services (Böttger 2007, p.21). With the difference to other leasing concepts, textile leasing contains elements of financing the product and the compensation of the service performance, both contained in the weekly payment (ibid., p.60). The concept of textile leasing was invented in the United States and was introduced to the German market in the late 1950ies (AlSCO 2015).

Böttger (2007) has analyzed market structures and developments of textile leasing in Germany on the basis of data from 1994 to 2005. In the overall branch of textile care in Germany, the number of competing enterprises continuously decreased by 26 % since 1994. The same applies to the sub segment of textile leasing with a 23 % decrease of companies, indicating that rental textiles are still better performing than the overall branch. Opposing enterprise decline, the total turnover of textile care has increased since 1994, leveling at three billion EUR since 2000 (Böttger 2007, p.23). The textile leasing sector in Germany likewise registered a steady growth with an increased turnover from 1,5 billion EUR in 1994 to over 2 billion EUR estimated in 2005. In the meantime volumes in the laundry segment continuously decreased by 9 % within the considered time frame (ibid, p.34, p.38). This disequilibrium is underlined by the finding, that only 1,2 % of the companies, coming from textile leasing, created over 54% of the total turnover in the textile care market. In 2004 an average textile leasing provider generated an annual turnover of 7.2 million EUR in comparison to an average laundry with 0,57 million EUR and dry cleaning enterprise with 0,22 million EUR. Within the of market textile leasing, workwear holds the greatest share with a revenue of 980 million EUR (ibid., p.18 & p.49). Measured by product value, pants and overalls depict the largest part with over 45 % of the workwear segment (ibid., p.84). With a proportion of over fifty percent in workwear leasing, customers from industry are the biggest purchasers, followed by the craft and healthcare sectors (ibid., p.85). Böttger estimates an employment rate of approximately 42,000 workers in the German textile leasing sector (ibid., p.17). Textile leasing providers moreover relied on an average of 24 suppliers of which half were regular suppliers (ibid., p.157).

From his economic findings Böttger concludes that, driven by competitive forces, textile leasing in Germany has changed considerably from small and medium-sized service providers to large companies such as Bardusch, AlSCO and Boco. Settled SME react to this development by joining forces and cooperating in marketing and purchasing. Nevertheless, the process of consolidation is expected to continue, forcing SME without strong service and distribution structures to either give up or to merge to larger structures (Böttger 2007, p.35). Numerous institutions and associations exist, representing the German textile service industry (ibid., p.257). Since 2013 the association WIRTEX specifically represents textile leasing companies and annually publishes the 'WIRTEX industry compendium'. Their more recent figures support the presented data from Böttger, stating an actual turnover of 3.2 billion EUR in the textile service market (Wirtex e.V. 2015a). Justifying the success of textile services, Böttger (2007, pp.59) finds a set of advantages and disadvantages of textile leasing in comparison to self-sufficiency by the customers. Advantages are:

1. *Concentration onto the core business*, as responsibility for textile availability and condition are externalized to professional and efficient handling.
2. *High product quality*, as textiles used within PSS are considered to be of higher standard, especially if complying to regulations regarding security and hygienics
3. *Cost advantages*, due to better market prices textile leasing providers can achieve scaling effects. A high profile in product-service performance can diminish this advantage.
4. *Liquidity advantages in textile leasing* relate to the purchase of textiles, which is financed by the service provider and thereby saves the customers equity capital.
5. *Advantages in punctuality* compared to self-supply, due to regular delivery times of the provider.

Possible disadvantages for customers of textile leasing are (Böttger 2007, p. 60):

1. *Contractual binding*, is seen negatively because the service contract limits the scope of individual decisions, making a shift to a different service provider or back to self-sufficiency difficult.

2. *Costs*, as textile leasing is not necessarily related to savings. If only low maintenance or logistic standards are required self-supply may achieve results at lower costs.

In a ‘strategic analysis of the textile service industry in the United States’ (Ferencz 2007, p.33) a strong environmental trend is recognized pushing textile leasing. Governmental institutions support this megatrend by stronger demanding environmentally sustainable products and services (ibid.). Ferencz further sees the increased outsourcing by the healthcare industry and a continuous shift of clothes into the leasing sector “to extend a decade-long trend of stronger growth in the textile services industry as compared with the U.S. economy” (ibid.).

Textile leasing matches the given definition of PSS (Tietze et al. 2013) by offering tangible products paired with intangible services to deliver a functional value with the support of the necessary infrastructure. Therefore the involved parties engage in long-term contractual relationship with the PSS provider remaining in ownership of the textiles. In PSS research product related attributes such as durability, flexibility, modularity, and ease of use are highlighted as characteristic features, which do not necessarily apply to the clothing industry (Armstrong et al. 2015, p.31).

In the textile sector the throwaway mentality and an excessive consumption behavior paired with the emotional role of clothes indicating social status leads Armstrong to finding that:

“the clothing industry is product-focused. Though traditional services have long supported the use and maintenance of clothing products, these services have not necessarily been utilized as a method to achieve dematerialization, longevity or sustainability for that” (ibid., p.31).

These apparently contradicting particularities of PSS in the textile leasing market raise the interest for further investigations. Moreover the complaint of PSS research, asking why this concept has not been widely implemented in practice and the conflicting finding of growing and saturated markets in textile PSS give reason for a closer examination. The described distinct feature of the German market, forcing textile leasing offering SMEs to collaborate in networks and the considered high ecological potential further raise curiosity on the sustainability of these business models. We therefore raise the first research question as follows:

What are promoting factors for long-term success and upscaling of sustainable Product-Service Systems in SME practice?

For the investigation of cases, Baines is concerned that, “authors (...) appear to be attracted by the novelty, completeness, and environmental benefits of schemes, rather than in-depth assessments of implications to competitiveness” (Baines 2007, pp.1548)

2.3 Design Thinking for S.PSS Development

Recent literature highlights user acceptance and satisfaction as key issues for a research agenda aimed “at the wider diffusion and implementation of Sustainable Product-Service Systems” (Vezzoli et al. 2015, p.9). The authors of this thesis propose Design Thinking (DT) as coined by IDEO as a methodology, capable of delivering such quality. The following chapter presents the potential contribution from DT methodology for S.PSS development. For this purpose, the origin of DT is explained, the process is described generically and its rapid adaption in practice is shown. Existing PSS development methods are examined against this background.

2.3.1 Defining Design Thinking

Design Thinking is a flexible innovation process consisting of three to six steps, depending on the author (Plattner et al. 2009, p.113).

“[It] can be described as a discipline that uses the designer’s sensibility and methods to match people’s needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity.” (Brown 2008, p.2).

Terry Winograd, Larry Leifer (ID Two) and David Kelley (David Kelley Design) founded the innovation agency IDEO as a merger in 1991 and developed DT from their daily practice (Brown & Wyatt 2010). Terry Winograd became widely known for his attempts of ‘bringing design to software’. In 1996 he edited a book bearing this exact title (Winograd et al. 1996). IDEO commercialized the DT approach and has since been hosting the ‘Design Thinking Research Symposia’ (SAP 2012). Inspired by their lecture the SAP founder Hasso Plattner financed the

first Hasso Plattner Institute (HPI) of Design in 2003. At the so-called ‘d.school’, located at Stanford University, the DT principles are taught to interdisciplinary student teams (d.school HPI Potsdam 2015a). As a second ‘d.school’, the HPI in Potsdam, Germany, started its curriculum in October 2007 (ibid.; FAZ 2008).

Worldwide DT training centers are emerging. The latest are the d.schools at the Communication University of China (CUC), founded in 2012 (d.school HPI Potsdam 2015a) and the government-supported DT program ‘Genovasi’ in Kuala Lumpur in 2013 (Genovasi 2015). Besides the mentioned d.schools, several universities offer DT as executive workshops such as the Hochschule St. Gallen and the Harvard University.

It has to be clarified that the term Design Thinking is used with different connotations. Johansson-Sköldberg and others (2013) reviewed the theoretical perspectives behind DT. For the business world they point out that DT seems to be a new concept since the publications of popular books from the IDEO founders and current CEOs (e.g. Kelley & Littmann 2001, 2005; Brown & Katz 2011), whereas the characteristics of the adopted designers’ practice have been at the center of attention of design research for at past 40 years.

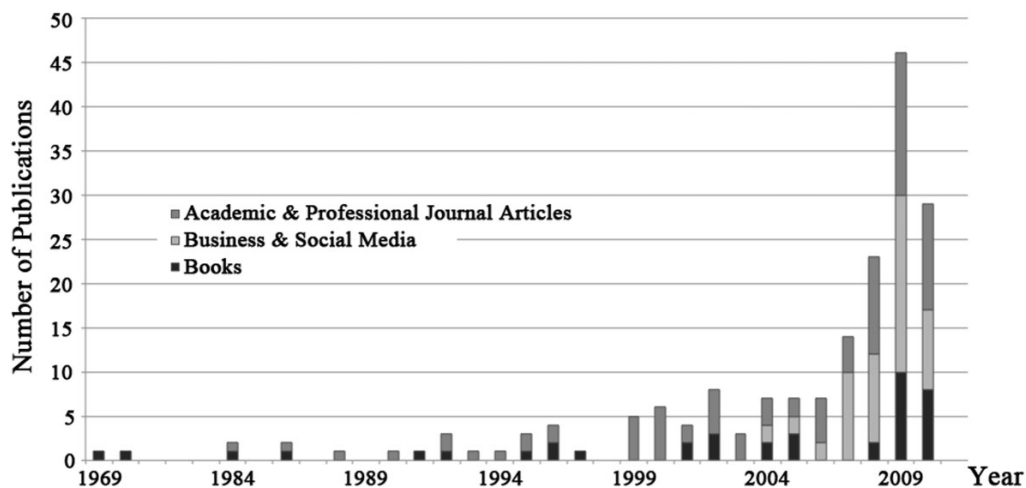


Figure 6: The development of the broad field in a timeline of publications. The DT literature is clustered by type: books (black column), substantial articles in academic (peer-reviewed) and respected practitioner journals (dark grey column), and short pieces in the business press and online media (light grey column). The figure illustrates that DT gathered popular media attention starting around 2004 and peaked in 2009 (Johansson-Sköldberg et al. 2013, p.123).

Within the literature review over 80% of the examined 168 documents related to DT were published after the year 2000 (Figure 6; Johansson-Sköldberg et al. 2013, p.121). Johansson-Sköldberg and others summarize that publications in books play a central role in the maturing field. Early publications tend to be theo-

ry-driven relating to a discourse on ‘designerly thinking’ which derived from the design research field. The recently published books are mainly guidelines for practitioners on ‘how to do DT’ (ibid.). These books represent the second discourse ‘DT’ coined by business application (ibid.). In this management discourse, three different sub-discourses of the DT are recognized (ibid, p.128): 1.) The way of working with design and innovation by IDEO (Kelley & Littmann 2001; Brown 2008), 2.) an approach to vague organizational problems and crucial skill for managers (Dunne & Martin 2006; Martin 2009), and 3.) a part of management theory (Boland & Collopy 2004). In this thesis the authors refer hereinafter to the first of these interpretations.

In 2009 the DT Research Program was initiated in order to conduct scientific research on the IDEO inspired DT - so to speak with the aim to analyze the innovation process retrospectively (Meinel & Leifer 2011, pp.xiii; Plattner et al. 2011, 2012a, 2012b, 2014). The methodology is still further developed in practice by innovation agencies and d.schools. This is why the main characteristics of the concept are still frequently explained with different emphasis as illustrated within Figure 7-12. DT research finds that the transfer of divergence and convergence thinking from the design domain to business context in interdisciplinary teams might be one of the explanations for the hype about DT (Lindberg et al. 2011, p.5). In contrast to predominant problem-solving patterns, DT is elucidated by the dualistic approach between the problem space (Newell et al. 1959; Newell 1979) and the solution space (Figure 7; ibid.). In other words, half of the process is explicitly dedicated to understand the problem to be solved. The underlying theory emphasizes empathy and user-centeredness through active listening and qualitative interviewing. After structured brainstorming for solutions, the teams test the ideas with potential users. In an iterative approach, also deriving from designers practice, the interdisciplinary teams rework their ideas several times (Plattner et al. 2009, pp.113). IDEO uses the picture of broadening and narrowing thinking to explain the underlying process (Figure 10) and emphasizes the three main stages, ‘inspiration’, ‘ideation’, and ‘implementation’ together with the iterative nature as visualized in Figure 8. The d.school Potsdam highlights three key characteristics of DT: people, place and process (d.school HPI Potsdam 2015c). Whether applied in higher education or in companies, DT is always exercised in teams, consisting of three to five interdisciplinary members, with a shared mindset such as high

failure tolerance. “This trend moves visibly from an individualistic way of thinking to a we-culture of mutual creation” (d.school HPI Potsdam 2015c). The advantages of team collaboration lie in faster reactions, the better use of collective intelligence and outcomes of greater sustainability (ibid.). The term ‘creative confidence’ (Kelley 2013) underpins the encouragement of creativity in the group without prejudging the outcome. Several qualitative and quantitative DT studies verify that the capability of ‘creative confidence’ is learnable (Rauth et al. 2010; Jobst et al. 2012).⁴ A workplace surrounding with flexible and adaptable working material supports the teamwork. Ideas are captured on walls and interior, such as whiteboards via sticky notes. Digital infrastructure and prototyping material supports the creative environment (d.school HPI Potsdam 2015b). The teams apply the process in an iterative manner, meaning that the steps of DT can be repeated recursively without chronological order. Figures 9 and 12 demonstrate this non-linearity.

⁴ Parallels can be drawn to the aim of Education for Sustainable Development (ESD 1 and 2) to enable the development of capabilities (Vare & Scott 2007).

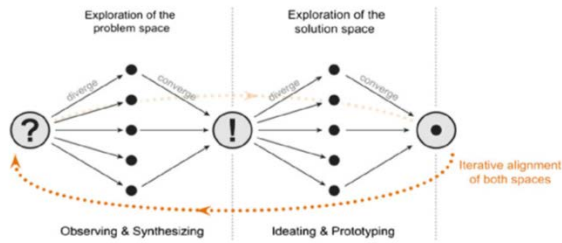


Figure 7: This illustration accentuates that DT aligns of both, the problem space, first coined by Newell et al. (1979), and solution space iteratively (Lindberg et al. 2011, p.5).



Figure 8: The current CEO of IDEO explains the design process in the Harvard Business Review metaphorically as a system of three spaces rather than a predefined series of orderly steps. The continuum of innovation is formed by related activities in the inspiration, ideation, implementation spaces. He highlights that DT can feel chaotic to those experiencing it for the first time (Brown 2008, pp.5).

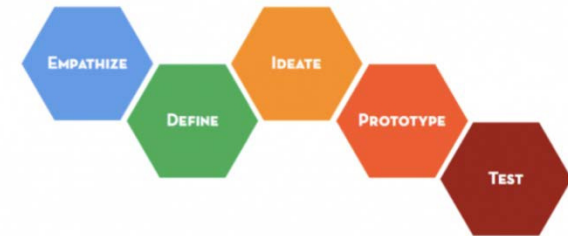


Figure 9: The illustration by the d.school Stanford highlights the non-linearity of the process. All steps can be 'puzzled' in changing order (d.school Stanford 2015).

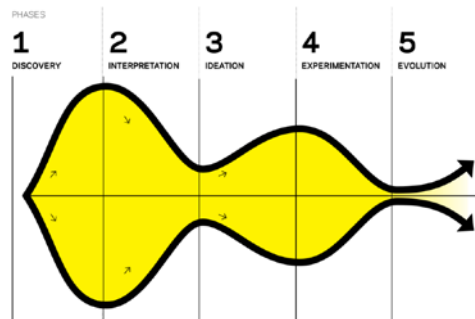


Figure 10: This later illustration by IDEO demonstrated the convergence and divergence that stands characteristic for a design process. Here the next iterations of the methodology are explicitly displayed as fifth step, 'evolution phase' (IDEO 2012, p.15).

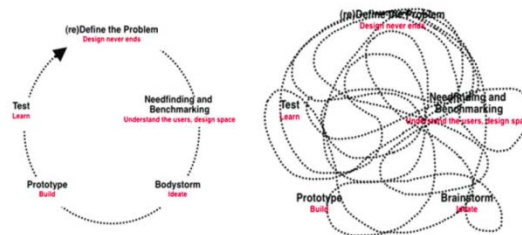


Figure 11: DT is commonly visualized as an iterative series of five major stages. (left) This illustration by the Stanford Potsdam DT Research Program presents the standard form. (right) The illustration comes closer to reality. Creative confidence is required to elect the right inflection points, that requires practice and is learnable (Meinel & Leifer 2011, p. xiv)

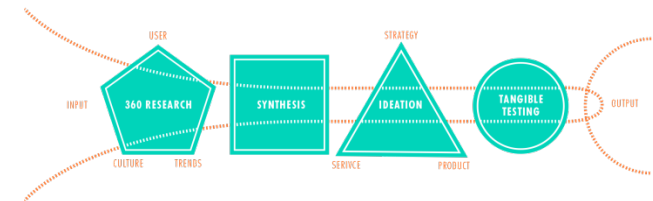
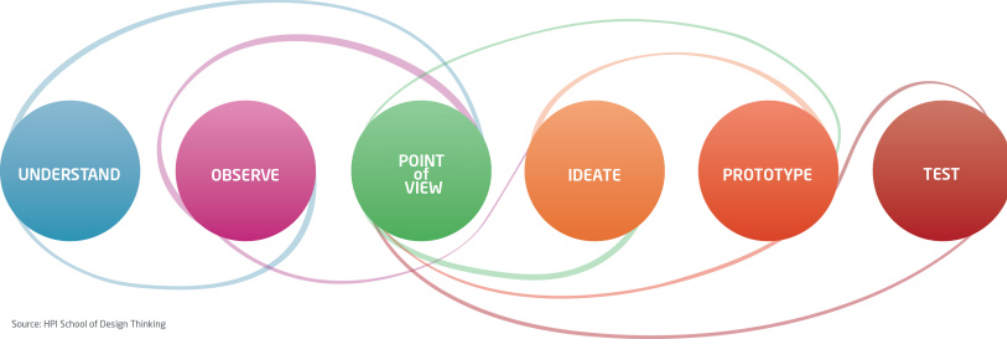


Figure 12: The DT illustration by the Berlin based DT agency Dark Horse, one of the most successful spin-off of the d.school Potsdam graduates from class of 2009, underlines the different character of the steps and translates the design phases back to business language (Dark Horse 2015; Tagesspiegel 2014).

The authors follow the ‘interpretation’ of the methodology as taught at d.school Potsdam. Table 4 depicts the Potsdam specific six-step DT process with its corresponding descriptions and methods.

Table 4: DT steps as followed by d.school Potsdam (d.school Potsdam 2015c; SAP 2012; K12 Lab Wiki 2010; Plattner et al. 2009).

<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Design Thinking steps and iterations</p>						
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Description</p>	<p>The challenge is specified and defined from a user perspective. The team synchronizes its interdisciplinary understanding of relevant words and understands the real problem beyond the task.</p>	<p>Search for rich stories and observations in the field. To conduct interviews with users in the real setting is essential to DT.</p>	<p>Interpretation transforms user stories to valuable insights.</p>	<p>Generation of many ideas without constraints. A prepared brainstorm session with and a clear set of rules can yield hundreds of fresh ideas.</p>	<p>Building Prototypes means the translation of critical functions of an idea to tangible artefacts as well as learning and synchronizing within the team while building them.</p>	<p>Testing the prototype to receive direct response from the user in order to improve and refine an idea further.</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Pool of Methods</p>	<ul style="list-style-type: none"> - Assume a beginners mindset - Facilitated discussion of the challenge - Mindmap on wording of the challenge - I wish, I like, what if 	<ul style="list-style-type: none"> - What? How? Why? - Interview (for empathy) - Extreme users - Analogous empathy - User camera study - Cultural probes - Story share-and-capture - Storytelling 	<ul style="list-style-type: none"> - Empathy map - Journey map - Persona - Point-of-view : “We met” “We were amazed to realize” “I wonder if this means” - Why-how ladder - Point-of-view madlib: user needs to user’s need because surprising insight - Point-of-view analogy - Point-of-view want-ad - "How might we" questions 	<ul style="list-style-type: none"> - “How to” questions - Brainstorm rules - Brainstorming (+ selection) - Bodystorming - Reverse questioning - Powers of ten - Stoke/Warm ups - Impose constraints - 2x2 matrix - Dotmocracy 	<ul style="list-style-type: none"> - Prototype for empathy - Prototype to test - Role play - User journey - Shooting video (+ editing) 	<ul style="list-style-type: none"> - Testing with users - Prototype to decide - Identify a variable - User-driven prototyping - Wizard-of-Oz prototyping - Feedback capture grid

The first two DT phases of understand and observe help participants to develop a sense of empathy on the DT challenge. To *understand* participants immerse into the challenge by talking to experts, and conducting research on the issues at question. Hereby, a common background knowledge is established. In the *observe*

phase the teams experience how people behave and interact. Therefore Design Thinkers go into the field and observe physical spaces for questioning practitioners on opinions and behaviors, while observing reactions. In the define phase, the team members reflect on the gained practice insights and concentrate on becoming aware of user needs. The question of “How might we ...” is used to define a *point of view* (POV), giving name to this process step. The POV is a single statement combining the user, need and insight within one sentence. It ends with a suggestion about how to make changes that will have an impact on peoples’ experiences. To *ideate*, the teams are challenged to brainstorm and generate a spectrum of ideas on the user need. As the most possible quantity of ideas is encouraged, wild ideas are welcome and no one’s input is rejected. Within a prototyping session a rough and rapid solution for a selected idea is crafted. A *prototype* can be a sketch, a model, or a cardboard box as a way to convey a critical function quickly. Finally the *test* provides the teams with feedback on their prototype. The purpose of testing is learning what does and doesn’t work in practice and to use the feedback for further iterations of the process (IDEO 2012, pp.24; Plattner et al. 2009, pp.110).

2.3.2 Fast diffusion: DT in Practice

In contrast to PSS application (Vezzoli et al. 2015), the methodology of DT has been highly adopted by practitioners within the past five years. Within a German newspaper article, Professor Uebnickel from St. Gallen University estimates that half of the DAX companies (German Stock Index) have already adapted DT (Süddeutsche Zeitung 2014). Among them are companies such as SAP, Siemens, Deutsche Bank, Deutsche Bahn, BMW, Daimler, VW, Charité and Janssen-Cilag (d.school Potsdam 2012). The companies either train their employees -as SAP did for instance with 4000 employees (SAP 2012), establish DT enabling office spaces (Bahnmobil 2015; Spiegel Online 2015; Handelsblatt 2015) or create task forces to integrate DT into their daily business routines (Siemens 2015).

Companies that incorporate DT in their processes often share a certain mindset or are systematically cultivating a more creative and human-centred company culture (Jones 2008, pp.13). Jones explains from a management theory perspective that innovative, human-centered firms are characterized by a design paradigm. This is

in contrast to the prevailing traditional economic management paradigm of not endorsing a collaborative work mode, connected to abductive thinking (Jones 2008). The American management professor Oster however argues that both paradigms can be integrated, by highlighting that the approaches answer different management questions. “While the scientific method of management espoused by Frederick Taylor (...) provided a key framework for **how** work should be done, DT answers **what** should be done” (emphasize as in original, Oster 2008, p.111). From his perspective “the idea of DT may be the single most important business concept to emerge from the 20th century” (ibid.). In the United States large companies share this enthusiasm, as significant investments and organizational changes by successful companies like GE, Procter & Gamble, and Maytag prove the willingness to exploit the gains of design methodology and mindset (Burney 2006). Some companies even actively promote DT. Cisco for instance presents a video, explaining their DT philosophy (IBM Think Academy 2014) and SAP shares DT insights in blog entries (SAP 2012). The application of the methodology “helps [to] derive a solution that meets user needs and at the same time generates revenue that drives business success” (SAP 2012).

As DT is not a panacea. A number of limitations exist to the methodology. First to mention, decision making in DT workshops is not based on empirical evidence (Oster 2008, p.113). This opposes the prevailing logic of quantitative market research. Despite the aim of economic feasibility DT outcomes do often not include elaborated business models (ibid.). The question of how to make an idea profitable is postponed to a secondary step in downstream iterations. Regarding sustainability, DT workshops lack any inherent normative framework (Ketchie et al. 2013, pp.10; Brown & Wyatt 2010). Johansson-Sköldberg and others additionally criticize that DT is sometimes misunderstood as a ready-to-use toolbox. They argue that applying DT methods requires knowledge and simultaneously the skill to judge when to use which. These competences have to be trained in the same manner that designers acquire them during their education (Johansson-Sköldberg et al. 2013, p.131; Meinel & Leifer 2011, p.xiv).

2.3.3 Existing Methods for S.PSS Development

Key references for existing methodologies on PSS development specific methods are Tukker and Tischner (2006a, pp.134), Morelli (2006), Baines et al. (2007), Aurich et al. (2010), Vasantha et al. (2012), Vezzoli et al. (2014) and Tukker (2015, p.84). In the following, an overview of PSS methodologies is given, the characteristics are highlighted and shortcomings are set into relation with Design Thinking.

Tukker summarizes that in the period from 2000 to 2006, a variety of guidelines for PSS development were published, many of those by sustainability research (2015, p.82). He outlines that methods are mostly tools and worksheets: a) on idea generation and creativity enhancement, b) on economic, social and environmental evaluation, c) on the visualization of the S.PSS via a storyboard or a system map, d) on the description of the PSS business model in terms of technical and organizational architecture, and e) on revenue streams, including networks to deliver the PSS (ibid.). Baines et al. (2007) identify a second methodologic stream in Concurrent Engineering and Lean Product development methodologies i.e. identification of customer value, early involvement of the customer in the system design, effective communication, information sharing, and continuous improvement. A cross-analysis conducted by the SusProNet project finds that most of the methods available in 2006 had three main blocks in common (Tukker&Tischner 2006, pp.146): First, an analysis of the current product portfolio and markets, second, PSS idea generation, including selection, refinement and evaluation and third, the implementation phase. Baines and others (2007) summarize that the presented methodologies have a strong generic flavor in common. Further he claims a lack of critical and in-depth evaluation of the performance of the existing methods tools in practice (Baines et al. 2007, p.1550).

Similar to DT the PSS development *process is considered iteratively*: Despite the three earlier described blocks “methods show a healthy sensitivity to the fact that PSS design is not usually a linear process” (Tukker 2015, p.82). Presented methodologies e.g. by Tukker & Tischner (2006a) take into account the repetitive proceeding and do not necessarily start with a top down strategic SWOT analysis.

In PSS methods and in DT *user needs* are in the focus of attention: Baines highlights that successful PSS must be designed at the systemic level from the user

perspective and require early involvement with the customer. This provokes changes in the organizational structures of the provider (Baines et al. 2007, p.7). “A company must move from ‘product thinking’ to ‘system thinking’, and break-down the ‘business as usual’ attitude” (ibid.). Despite the shared opinion on the importance of identifying user needs, PSS literature does not provide applicable tools. Tukker and Tischner (2006a) for instance, suggest the project team to define relevant market segments and underlying client needs via the tool ‘market segmentation criteria’ (a spreadsheet with questions to discuss in the team) and ‘persistent questioning approaches’ (no tool provided; ibid, p. 378).

Likewise in line with DT, the *modularity of the development process* is highlighted: Building on the aforementioned, Tukker argues, the methods would consist of the phases in product and service design, as well as a set of standardized tasks to be executed in each phase. This modularity would have the advantage of enhancing the speed of PSS development, allowing for new and unexpected PSS combinations without major design and testing needs. Hence, potentially high costs of customizing offerings in a non-linear and trial and error nature of PSS design are mitigated (Tukker 2015, p. 83).

PSS methods *lack communicability and testability* in contrast to DT: Schultz and Tietze (2014) point out that intangibility is reflected by the lack of communicability and testability, not only in the adoption process, but also affects the entire innovation process negatively. The lack of verbalization and communicability of customer needs hinders the integration of customers in the early phase. Gate decisions on the continuation or termination of projects can only partially be corrected by objective data. In later stages, the testing of PSS is related to the characteristics of the products and to the customer perception of the entire provider constellation. For the latter, however, the appropriate test methods are missing (ibid., p 62).

Unlike DT *multidisciplinarity is demanded but not enhanced* in PSS design. Vasantha and others point out that the necessity to incorporate multidisciplinary approaches within design methodologies is mentioned but not incorporated in the PSS design process (Vasantha et al. 2012, p. 650).

In the field of PSS research, DT has so far only been mentioned a few times in grey literature:

- ▶ Grant Young from the Australian innovation agency Zumio describes the opportunity to fuse DT and Sustainability within an essay (2010). He dedicated one chapter to PSS in which he concludes:

“DT sees the relationship between the firm, the customer and the object as the locus of value-creation, where ‘value is co-created in practice’. This suggests that DT – especially as manifested in the emerging area of service design – can play a positive role in the identification of opportunities for the design of PSSs” (Young 2010, p.22).

- ▶ In a conference paper for the Third Nordic Conference on Service Design and Service Innovation ten Bhömer and others (2012) report on two executed co-design workshops. Although DT does not namely appear in this paper, the workshop operationalization shares many characteristics of a DT process, as stakeholder integration, visual mapping and low-resolution tangible prototypes.
- ▶ A research group from Fraunhofer IPK (Institut für Produktionsanlagen und Konstruktionstechnik – Institute for Production Plants and Construction Technology) and the TU Berlin (Technical University of Berlin) collaborated with the DT agency Dark Horse (Futur 2013). Together low-fidelity prototyping methods, for visualizing and testing the material and immaterial part of first PSS ideas, were developed.
- ▶ Guanzhong and Xin introduce MATTEROLOGY, a Chinese method for sustainable DT to teach PSS to design students (Guanzhong & Xin 2014, p. 399). Here DT is understood as a mindset of designers, rather than an operationalized innovation methodology.
- ▶ Similar to the suggestion of DT is the recommendation of Rovida and others (2009) that adopt the ‘Theory of Inventor’s Problem Solving’ (TRIZ) as a methodology. Thus the paper does not offer applicable tools, the authors conclude that TRIZ is a well-known tool that “may help lowering the barrier to adoption of a PSS-oriented thinking, supporting ‘traditional’ manufacturing firms in making smoother the transition” (Rovida et al. 2009, p.10).

The authors see the main potential contribution of DT for S.PSS in four points: First, DT could strengthen bottom-up knowledge sharing techniques by its work-

shop character. The authors argue that a bottom-up integration of employees in the innovation process would prevent the ‘not-invented-here (NIH) syndrome’ (Hussinger & Wastyn 2015). Second, the corner stone of DT to ask the user, rather than to anticipate her/his need, strengthens the empathy of the employee. Inherent to DT is also the question for the underlying need. This answers a call raised by Hansen and others to extend “the principle of customer orientation (...) to not only understanding, but also innovating current ways of fulfilling customer needs” (Hansen et al. 2009, p.693). Third, in line with Baeck & Gremett (2011), the authors argue that DT is a more creative and user-centered approach to problem solving than traditional design methods and existing PSS Development tools: "DT defies the obvious and instead embraces a more experimental approach" (Baeck & Gremett 2011, p.231). Fourth, the authors acknowledge that DT has a high adaption power of its own. Linked to the common features of existing PSS development methods, DT is most likely to provide obvious benefits.

Summarizing the key findings from this literature review, it was shown that DT has the potential to provide companies with user-centered ideas, in a fast and low cost manner compared to normal R&D activities. Especially for SME these benefits are promising. Consequently, the second research question raised is:

How can Design Thinking contribute to S.PSS development?

3 RESEARCH DESIGN

The research design consists of three main steps (Figure 13) discussed within this chapter. Addressing the first research question, a case study of an SME was conducted to identify success factors for PSSs on a regional level. Secondly, the authors developed a DT workshop for S.PSS implementation. To further improve the workshop approach a third step towards retrieving expert feedback from academia and practice was taken. Insights were integrated within an iterative process.

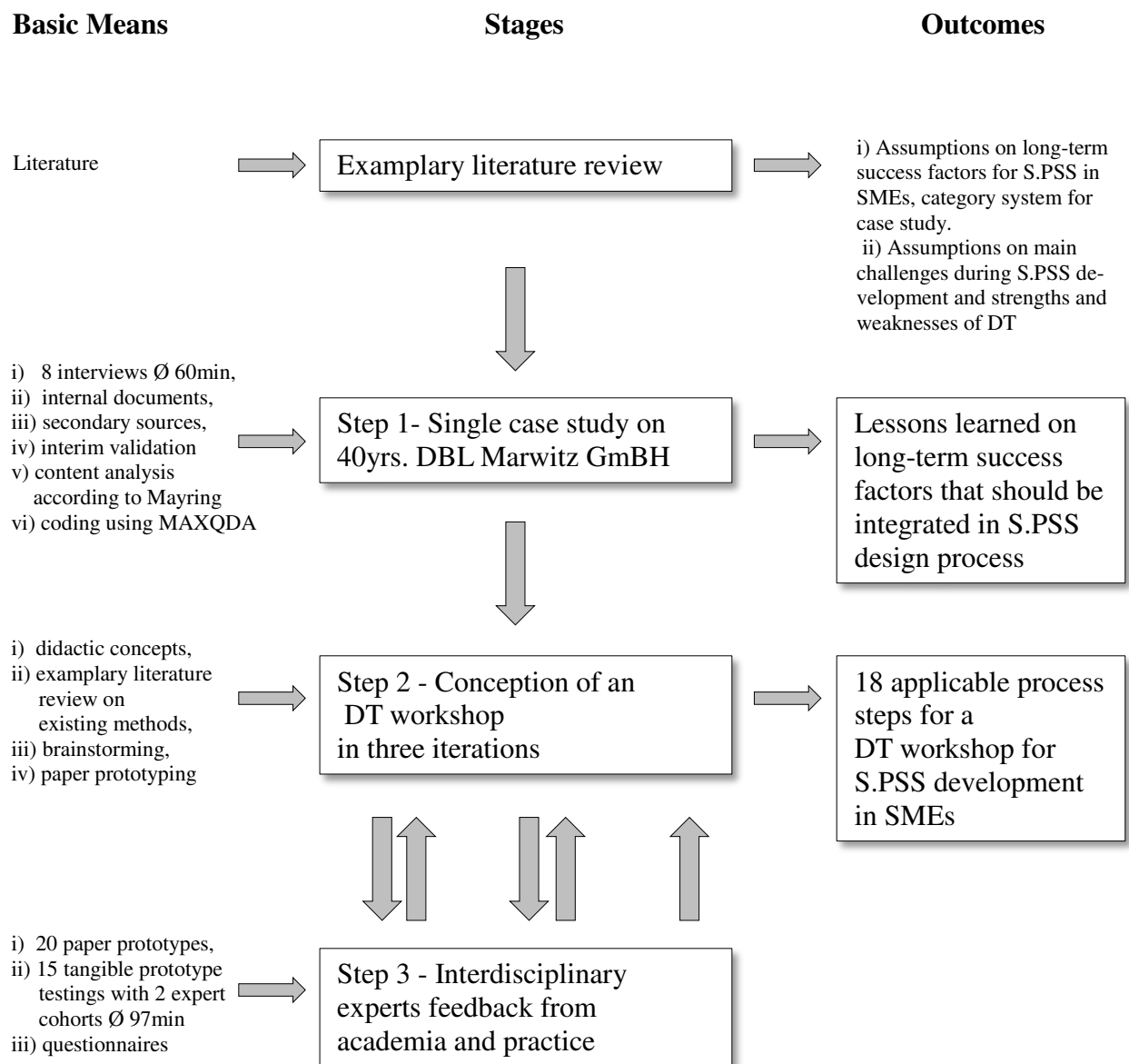


Figure 13: The applied three-step research design.

3.1 Case Study

A single case study was conducted, investigating a long-term successful PSS in the textile rental sector. Yin reflects on the case study as a research method that is used in many situations to contribute to our knowledge of individual, group or organizational phenomena (Yin 2009, p.4) and draws on a definition from the 70s:

„The essence of a case study, the central tendency among all types of case study, is that it tries to illuminate a decision or set of decisions: why were they taken, how were they implemented, and with what result (Schramm 1971, p.6).“

Schramm himself stresses the benefit of case study research because of the realistic and holistic quality, specifically its ability to report on findings as a whole and to put separate findings into context and proportion (Schramm 1971, p.39).

Still, case study research is discussed controversially in literature, as skepticism regarding theory, validity and reliability is repeatedly formulated (Flyvbjerg 2006, p.4; Stoecker 1991). Especially single case studies are criticized for being inferior to multiple case studies (Stoecker 1991, pp. 90), because the absent control over variables abolishes the scientific value of the findings. Critics argue that securing scientific evidence involves, making at least one comparison (Campbell & Stanley 1963: p.6). Opposing this criticism, proponents argue that single case studies are inevitably multiple because diverse evidence is linked on set variables in many different ways (Flyvbjerg 2006, p.19; Ragin 1992, p.225). In fact a single case study can be a very powerful example (Siggelkow 2007, p.20), especially if the selected case represents an extreme or a unique case (Yin 2009, p.47). Eysenck describes vividly that “sometimes we simply have to keep our eyes open and look carefully at individual cases - not in the hope of proving anything, but rather in the hope of learning something” (Eysenck 1976, p.9). Flyvbjerg adds from an epistemological perspective that it is only because of experience with cases that one can move from beginner to expert status. Especially in the field of human affairs all knowledge appears to be context dependent on which theory can subsequently build on (Flyvbjerg 2006, pp.35).

The authors follow this beneficial perspective on case study research with multiple objectives. Primarily, the conducted single case study aims at the identifica-

tion of context dependent success factors for S.PSS business operations on distinct levels. It specifically targets, the initial implementation process and the ongoing development and innovation processes of the enterprise. Moreover the company's sustainability orientation is investigated. Therefore the case study was designed to be exploratory by asking *why* the PSS was designed in the current manner and descriptive by addressing *how* the long-term success was achieved and *what* experiences were made during the process on different levels.

3.1.1 Case Sample

The case-selection was aimed at finding an either extreme or paradigmatic case sample. Flyvbjerg explains that extreme cases can provide insight on especially good or bad examples, enabling researchers to understand the limits of theory (Flyvbjerg 2011, p.307). Unlike this, paradigmatic cases highlight more general characteristics of scientific concepts as a practical prototype and reference point for researchers (ibid., p.308). Both approaches enable the authors to contrast theory with practice for identifying consistencies and deviances. Although single case studies cannot confirm theory, they can illustrate how theoretical constructs appear in practice (Siggelkow 2007, pp.21). Case study insights can be linked to context variables, thereby creating a holistic picture.

Decisive criteria were formulated; the case sample had to match. Due to the thesis' funding by the Innovation-Inkubator Lüneburg, which supports local structural development, the regional scope was assigned to the administrative district of Lüneburg in Lower Saxony, Germany. As indicated by research question one, a further objective was to find an SME, successfully operating a PSS business model on the long-term. This long-term success characteristic was specified by ten years plus market persistence. Moreover a company with an explicit sustainability orientation was favored.

Through filtering and scouting the base of the thesis was found: DBL W. Marwitz Textilpflege GmbH, which distinguished itself as an appealing research objective, met the requirements. First, DBL Marwitz is situated in Lüneburg, matching the convergence area. Secondly, the company has been operating the business with rental work-textiles in B2B contracts since 1972, outreaching the minimal company existence by a fourfold. Economic success is further suggested by an annual

turnover of 16 million EUR with a balance sheet total of 11,5 million EUR in 2014. Business activities are multifaceted, including the sourcing and ownership of workwear as well as logistics, specifically delivery and pickups at customer sites. Moreover, customization, washing, maintenance and monitoring security legislation also belong to the area of operations. These multifaceted services, externalizing all customer efforts concerning employees' garments thirdly classify business activities as a result-oriented PSS. Fourthly, DBL Marwitz is engaging 180 employees and is thereby categorized as an SME. Finally, the company's sustainability orientation is indicated in two factors. First, the company's external communication proclaims optimized logistics, the use of especially durable fashion and employing environmentally efficient washing processes regarding water and energy. Second, the senior owner managers were awarded in 2013 for outstanding social engagement, a substantial contribution to the economic development of the region and salient family successor handling (RW-Textilservice 2014). Additionally to the thereby fulfilled sample criteria, Marwitz operates in a network of 17 associated but independent family-businesses, merging under the common name of DBL (Deutsche Berufskleider-Leasing GmbH - German Workwear Leasing). Through this association the DBL SMEs can commonly cover the German market.

In line with Flyvbjerg (2011), this leads to the situation of a simultaneously paradigmatic and extreme case. This is not contradictory but beneficial as selection categories are not exclusive and versatile cases are most likely to reveal valuable insights (Flyvbjerg 2006, p.17). On the one hand DBL Marwitz is paradigmatic through its long-term PSS success. The 43-year history of operating the textile-leasing business model is expected to bring forth characteristics consistent with B2B specific insights from PSS literature. On the other hand the case of DBL Marwitz is unique by operating business-activities in the DBL network. This strategic cooperation qualifies Marwitz as an extreme case, specific for German medium-sized companies and deviant from any familiar cases. The combination of long-term success and collective market appearance makes the case of DBL Marwitz particularly worth investigating.

3.1.2 Data Sources

Multiple data sources were used, as case studies typically employ diverse data collection methodology like interviews, questionnaires, and observations (Eisenhardt 1989, p.534). Yin (2012, p.10) supplements the list of common sources by written material like documents, archival records and physical artifacts. For this case study the authors chose to rely on interviews, internal documents, secondary sources and an interim presentation (Table 5). The data collection was conducted between July 2014 and June 2015.

Table 5: Case study data sources

Type of Data	Description	Time frame
Interviews	8 semi-structured interviews 2 informational interviews	November 2014 - January 2015
Internal document	Organigram	November 2014
Secondary sources	Market studies provided by the company DBL Marwitz website screenings DBL Association websites screenings Corporate videos Media coverage	July 2014 – May 2015
Internal validation	Three hour interim presentation and discussion with four managers	June 2015

A set of two informational and eight semi-structured *interviews* with management and leading staff served as a major data source for the case study (Table 6). The received qualitative data from interviews is inevitably subjective and biased by the interviewee. One perspective on this issue is that the bias in interviews contaminates the data. The contrary position suggests that the narrative reality is generally built by individual perception (Holstein & Gubrium 2010, p.163). The authors follow the latter argumentation. Interviews were explicitly chosen because of their special ability to incite the production of narratives that address issues relating to particular research concerns (ibid. p.157). In this case the managements' perception of PSS success factors, innovation behavior and sustainability performance was questioned. To increase internal validity of the findings, comparative samples were used for the semi-structured interviews, addressing the topics of interest to employees in different functions of the entity as suggested by Miller and Glassner (Miller & Glassner 2010, p.147). Additionally the authors split between interviewing and documentation during the interview sessions for a diverse picture on the generated data.

The informational interviews served as a first face-to-face introduction, contained mainly insights on general company structures and lasted 60 minutes in average. An overview is given in table 6. Semi-structured interviews were conducted by using a guideline for addressing the research objectives systematically (Appendix 1_1). The interview guideline was further tailored to each interviewee's individual expertise, position and temporal affiliation. By addressing each research objective within multiple open-ended questions, in-depth interviewing was achieved. This method is particularly useful for examining the social world from the participants perspective (ibid., p.137). Depending on position and insight of the interviewee, the semi-structured interviews took between 50 and 90 minutes (Table 6). Post scriptum to each interview, the authors documented the main impressions in order to catch the atmosphere as suggested by Lamnek (2010, pp.335).

Table 6: Conducted case study interviews

Code	Name of Interviewee	Position of Interviewee	Duration of Interview	Type of Interview	Informational Interview
Int.0*	Mr. Perczynski Mrs. Voigtländer	Executive Manager ¹ Human Resources	01:04:00**	Face-to-face	Yes
Int.1	Mr. Hischemöller	Owner Manager, Executive Manager DBL	01:22:06	Face-to-face	No
Int.2	Mr. Perczynski	Executive Manager	01:02:44	Face-to-face	No
Int.3	Mrs. Voigtländer	Human Resources	00:49:48	Face-to-face	No
Int.4	Mr. Czyborra-Rätsch	Head of Sales	01:03:00	Face-to-face	No
Int.5	Mrs. Perczynski	Owner Manager	01:04:07	Face-to-face	No
Int.6	Mr. Gruhn	Head of Service	01:04:58	Face-to-face	No
Int.7*	Mr. & Mrs. Hischemöller Senior	former Owner Manager	01:16:55	Face-to-face	No
Int.8	Mr. Koch	former Head of Sales	01:26:09	Face-to-face	No

Notes: * Two interviewees were questioned simultaneously. ** Additional on site-tour in facility two.

An organization chart, displaying the company's internal department structures, was the only *internal document* analyzed (Figure 20). This overview proved to be very helpful in order to select the key positions for in-depth interviewing. Further, various *secondary sources* were incorporated for analysis. First of that, Marwitz provided two studies, illustrating the market development of textile leasing in Germany. Second, the websites of Marwitz and the DBL association were

screened for information, which was beneficial for interview guideline preparation. The same applies to the third source, two company videos, explaining the offered services from an internal and external perspective. Fourth, the media coverage from regional newspapers found online, revealed insights on the companies historic development.

Finally an interim presentation for *internal validation* of the case study findings, followed by a discussion was held at the companies' sites. This gave the authors the opportunity to verify first results and to fill informational gaps.

3.1.3 Data Analysis

All interviews of the case study were recorded with explicit permission of the interviewees, using a Zoom H2 portable stereo recorder (Appendix 1_3). The recorded audio files were then transcribed with f4 and f5 software (Appendix1_7). With the support of MAXQDA 11 software, a structured content analysis according to Mayring (2015, pp.103) was conducted, employing the written sources (Appendix 1_8, 1_9). Even though Mayring has only published in German, his approach was applied here due to its prominent status in research⁵. Mayring moreover provides a precise operational sequence as a guideline for researchers in contrast to rather vague concepts published by Anglo-American authors. Silverman for example underlines the broad acceptance of content analysis as a method for textual investigation. Nevertheless he only dedicates a three-paged chapter and a generic model to the topic (Silverman 2011, p.64).

A single case cannot prove but only falsify a theory (Siggelkow 2007, p.21). Qualitative case studies thus serve for generating hypotheses and exploring the limits of existing theories. Consequently the structured content analysis by Mayring suits as a methodology for data analysis, as it explicitly enables the categorization of new findings (Mayring 2015, p.82). This process follows an abductive logic. This means practically that analysis starts with deductive categories, derived from theory and then integrates inductive categories. The latter are developed from data screening during the process of analysis.

⁵ Between 4299 - 8712 citations depending on the edition of publication (Google scholar as of 02.06.2015).

The analytical approach applied for this thesis is visualized within Figure 14, depicting the procedure of a structured content analysis within ten steps.

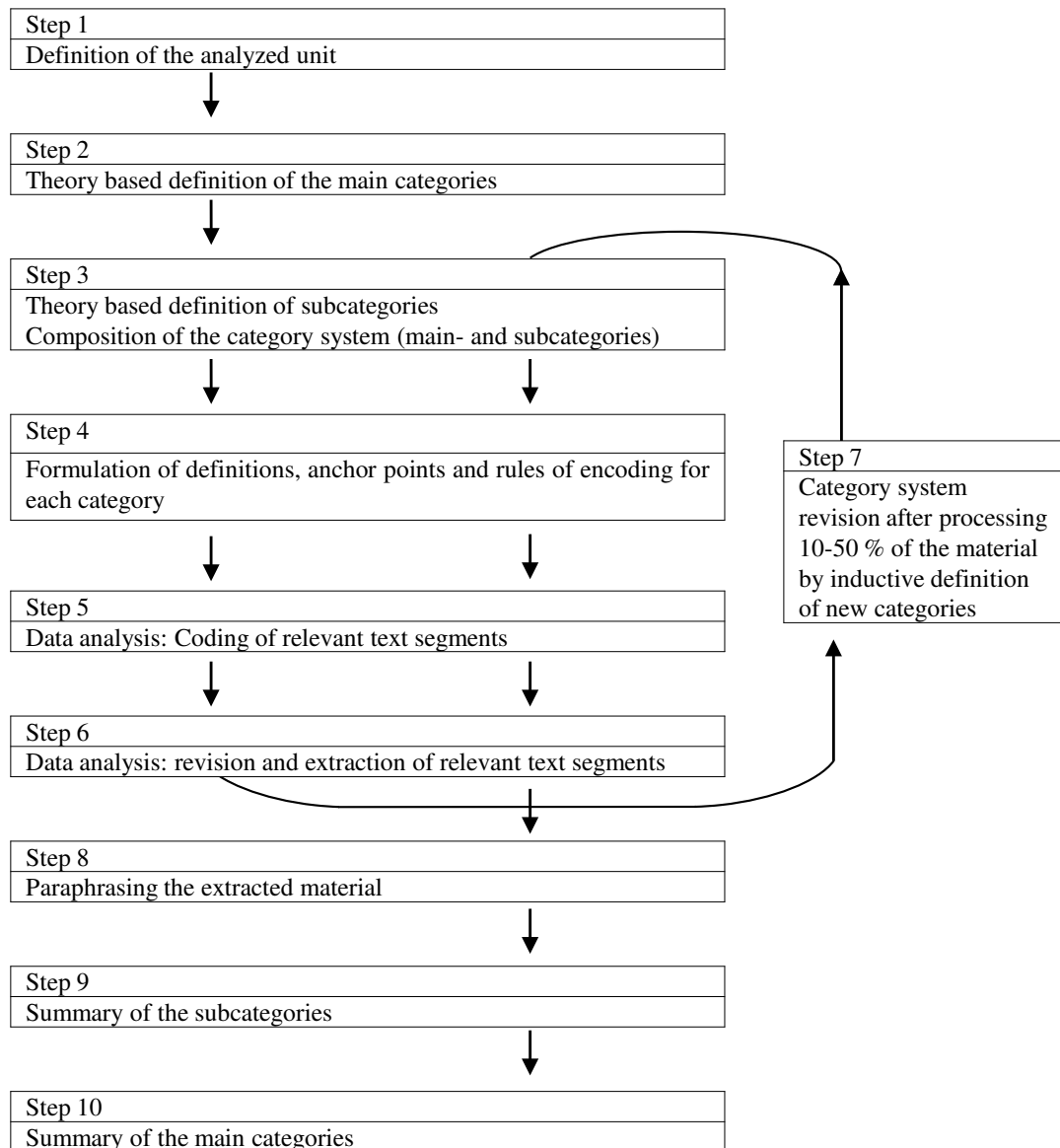


Figure 14: Process steps of the structured content analysis (own illustration based on Mayring 2015, p.86, p.98, p.104)

Case selection already defined the unit of analysis (Step 1) and the research question set the main categories of investigation (Step 2) in the first place. Purpose of this case study was to investigate success factors, innovation behavior and sustainability characteristics of the PSS operated by DBL Marwitz. Organizing the interview guidelines in the same manner resulted in pre-structured data sets. Subcategories were derived from literature (Step 3), finalizing the category system with main- and subcategories at this stage. These precise citations from literature, underlying the subcategories, were helpful for the textual differentiation of the

subcategories (Step 4). During the actual data analysis (Step 5) the data set was sequentially screened and assigned to the subcategories. Both authors commonly coded the entire data and discussed cases of uncertainty for assuring reliability. During coding many text segments were assigned to multiple subcategories, leading to a total of 827 codes. Sections without significance were not coded. MAXQDA enabled the easy extraction of the so far coded material for a first revision (Step 6) after half of the material was processed (Figure 14). This revision revealed the need for further case-specific modifications of the category system, classifying insights in the best possible manner. Therefore further inductive subcategories were added to the category system (Step 7), thereby finalizing it (Appendix 1_2). Both authors then again categorized the data. After the data analysis, content of all categories was extracted and paraphrased (Step 8). On this basis, main- and subcategories were summarized (Step 9, Step 10), leading to the case study results presented in chapter 4.1.

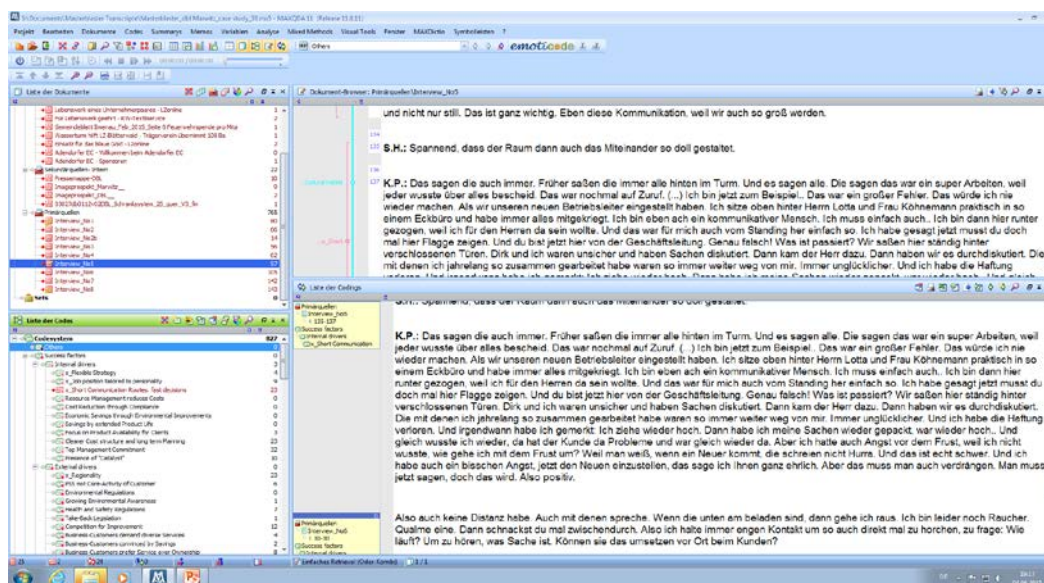


Figure 15: Example of the coding process using MAXQDA 11. (upper left) documents of analysis, (lower left) main categories and subcategories, (upper right) color-coded primary data, (lower right) list of codings organized by subcategories.

To ensure scientific standard, emphasis on stringency was put during data collection and analysis. Selecting the case by criteria set explicitly for analyzing the area of interest contributed to quality in the first place. Further, multiple sources were employed and analyzed for a holistic picture. As an adaption to the case, interviewees were selected and question guidelines customized according to their position and expertise. For strengthening reliability, the case study was conducted and documented in most possible operational steps, as suggested by Yin (2009, p.45).

Most importantly, the steps of data evaluation were applied by strictly following the scientific method of qualitative content analysis by Mayring. Moreover, the collected data was multiply scanned because of the iteration in coding, thereby further contributing to reliability. Intercoder-reliability was additionally assured by the judgments of both authors. Regarding criticism against qualitative research, this intersubjectivite agreement between researchers, guided by the scientifically defined categories, brings the results closest possible to objectivity. The described reliability standards also serve as a precondition for validity. Feedback on first results was received during an interim presentation. The step of including feedback represents a communicative validation to avoid hasty interpretation by the authors as suggested by Mayring (2010, p.109).

3.2 Conception of a Design Thinking Workshop for S.PSS Development

Within this chapter the authors derive insights on workshop development from theory and show how the Design Thinking workshop for sustainable Product-Service System development was designed within three subsequent steps. First, an exemplary set of existing methods was derived from a literature review and summarized. In a second step new methods were invented or adopted to match the process of Design Thinking in a brainstorm session. Finally the filtered methods were crafted as tangible paper prototypes.

Looking at the theory behind workshop development, the pedagogue Ulrich Lipp and the business consultant Hermann Will (2008) define a ‘workshop’ as a work meeting in which participants devote time to a specific topic (Lipp & Will 2008, p.13). They argue that all workshops have necessary characteristics that work on a specific task outside the daily routine and takes place within a group setting. Furthermore, four features apply to most workshops: a) The participants are experts or affected persons. b) A moderator has the lead as expert for collaborative methods and group dynamics. c) The time constrain is not too limited. d) The outcomes last longer than the workshop (ibid.). The strengths of workshops are that they facilitate the concentration onto one topic and activate power reserves in the short term. Moreover workshop outcomes are group results with the positive side effects of cross-department exchange and the facilitation of collaborative skills (ibid., 2008, pp.16).

In accordance with Seifert (2011, pp.85) the authors had to 1. define workshop goals, 2. create a dramatic composition, 3. think about organizational preparation, 4. introduce to the topic, 5. guide the discussion, 6. clarify content questions in cases of uncertainty and 7. visualize and document the outcome.

As a first step, the workshop goals were defined according to the research question of how Design thinking can contribute to S.PSS development. As described earlier (chapter 2.3.1), Design Thinking has the ability to quickly develop user-tested ideas. Hence, the authors chose to develop a Design Thinking workshop with the outcome of two tested sustainable product-service systems concepts

The overall aim of the workshop is four folded and can be summarized as follows:

- 1) Familiarize the SME with the innovation method Design Thinking and PSS
- 2) Achieve a strong identification of the employees with the PSS outcome
- 3) Achieve a strong user orientation of the innovation outcome
- 4) Achieve a strong sustainability orientation of the innovation outcome

Design Thinking was chosen as a methodological approach to meet both, the self-defined workshop goals and the three main development challenges from S.PPS literature: user need identification, multidisciplinary employee integration and fast prototyping and testing (chapter 2.3.3).

It is notable that these goals open a wide range of classifications for the planned workshop, such as a PSS innovation workshop, a transdisciplinary sustainability workshop, action learning, a co-creation workshop, collaborative team work, user-centered design interaction, business model innovation or an education for sustainable development session. Notwithstanding that each of these categories could be a distinct theoretical approach to the development process, the authors focused on the former as a respective elaboration in detail would expand the scope of a master thesis.

From an education perspective the principles of constructivist didactics (Reich 2008, 2012) were followed by designing all input sessions as experienceable as possible. The basic assumption of constructivist didactics is that reality builds on

subjective (constructed) perception. A constructivist-oriented teaching is in this sense, the following assumptions:

"If we come to see knowledge and competence as products of the individual's conceptual organization of the individual's experience, the teacher's role will no longer be to dispense 'truth', but rather to help and guide the student in the conceptual organization of certain areas of experience" (von Glasersfeld 1983, p.41).

In contrast to conventional 'top-down didactic', cooperation, communication and interaction are used to define and solve problems. Negotiation plays a major role in this process (Reich 2008). Another theoretical background is Creative Problem Solving coined by Osborn and Parnes (Noller et al. 1976) which can be seen as one of the didactical roots of the Design Thinking methodology itself. Osborn, the father of brainstorming, also taught design students and brought creativity techniques into academic curricula. The underlying theory of divergence and convergence created an awareness, which sharpened the researchers' view on intertwining different method steps.

3.2.1 Literature Review on Existing Methods

An exemplary literature review on existing methods for S.PSS Development and Design Thinking was conducted in line with Rubin et al. (2010, p. 236). The search for PSS documents was operated using Scopus and google scholar databases with the search string (Kitchenham 2007) (**Product-Service System or PSS AND (sustain* or Sustainability) AND (tool or method* or framework)*) as well as reference chasing. Supplementary, content experts recommended publications. In the field of Design Thinking only few peer reviewed publications could be found next to the omnibus volumes of the HPI-Stanford Design Thinking Research Program. Therefore the search scope was broadened to popular business magazines and online research on the websites of leading Design Thinking agencies and d.schools, providing educational material to the public in an applicable format. The authors examined a total of 101 documents on PSS and 52 on Design Thinking which were obtained, saved digitally and included for the workshop development literature screening. Regarding the PSS, sources the selection was narrowed down to 40 papers by manual exclusion criteria 'method' or 'tool'. Out of these,

seven Systematic Literature Reviews (SLRs) with lists of existing PSS methods were identified as key references (chapter 2.3.3). “Key references are those that have directly influenced the study being proposed or conducted” (Rubin et al. 2010, p. 236). In terms of the Design Thinking literature 13 applicable methods were used for the conception of the workshop. After individually condensing the most relevant existing methods on sticky notes, the authors started the conception on a self-moderated workshop day by mutually presenting the findings within prepared pitches (Figure 16).

3.2.2 Brainstroming

The authors brainstormed, building on the existing tools found in literature. Therefore a tight timeframe, so called ‘timeboxing’, was scheduled giving 5 min for each of the Design Thinking steps, divided in 2 min of silent and 3 min of loud brainstorming.



Figure 16: Collected PSS Development and Design Thinking methods from literature on color-coded sticky notes: (orange) existing PSS meta-concepts/methodologies, (yellow) existing PSS development method, (pink) existing Design Thinking method, (green) own method/tool building on existing ideas.

From a theoretical perspective, brainstorming can be sub divided into two phases: first the ideation of ideas and second the filtering and modifying of the best ideas (Plattner et al. 2009, p.121). In the first phase of brainstorming, premature evaluation is accused to be the major hindrance to creativity. Therefore Osborn introduced the brainstorming rules to think broadly early on and save critique for later (Osborn 1963 quoted as in Dow et al. 2012b, p.130). “Immediate feedback sets

the focus on refinement, whereas postponing critique until after creating multiple designs encourages more divergence” (Dow et al. 2012b, p.130). To counteract the impulse of criticizing instantly, the research team deliberately pre-scheduled ‘flash lights’ (Reich 2007) to think each produced sticky notes further as a team as displayed in Figure 16. With a clear cut after time run up, the research team decided in dialogue which methods to combine to a workshop. In this discussion decisions were biased by the finding on the PSS drivers and barrier from literature and the observations and first lessons learned during data collection on the case study.

3.2.3 Building Low-Resolution Paper Prototypes

In order to exploit the potential of first ideas, it is important to bring them into a tangible and testable format. Iteration is central to learning and motivation (Dow et al. 2012b, p.127). Hence iterative prototyping “oscillates between creation and feedback: creative hypotheses lead to prototypes, leading to open questions, leading to observations of failures, leading to new ideas, and so on” (Dow & Klemmer 2011, p.112). In design literature prototyping is likewise praised as it “entails repeatedly trying ideas and getting feedback” (ibid, p.111). A variety of prototype techniques exist applicable for different purposes in design theory, as visualized in Figure 17.

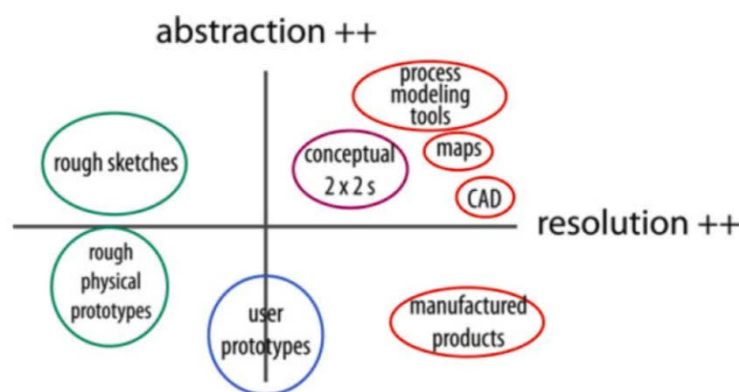


Figure 17: Exemplary selection of prototype techniques clustered by abstraction and resolution (Edelman & Currano 2011, p.64).

The authors decided to follow the approach of ‘rough’ or ‘low-fidelity paper prototyping’. Low-fidelity prototypes, illustrated as rough physical prototypes, are especially applied in the field of human-machine interaction because of multiple strengths (Virzi et al. 1996, p.236, Snyder 2003). They are an efficient way for exploring the design space (ibid.) and are predictive of preferences about the actu-

al product (Wiklund et al. 1992). Low-fidelity prototypes moreover enhance user participation in the design process (Muller 1991), enable the visualization of possible design solutions (Moggridge 1993) and thereby provoke innovation (Wulff et al. 1990). It is obvious that prototyping has an internal and external function: Within the research team prototyping enables a focused communication and thereby facilitates decision-making (Meinel & Leifer 2011, p.xv; Dow et al. 2012a, p.48). In the testing phase the user is confronted with a rough but precise idea that makes it easy to criticize constructively.

Bringing the ideas from brainstorming to testing, twenty-two rough paper prototypes have been created, capturing the first conceptualization of a Design Thinking workshop for S.PSS development. In other words, the ideas from the sticky notes were sketched and handcrafted on paper in order to visualize a workshop scenario of an employee team.

“For the early phase of the process techniques, such as paper models or rough prototypes, are quickly realized and offer an easy way to make an idea testable” (Jobst & Meinel 2014, p.108).

Building on the insight from the Design Thinking a time constraint of 30 min (Dow & Klemmer 2011) was chosen to turn each sticky note into a multilayered collage. Within that timeframe each author sketched multiple prototypes for each idea individually. In a second step first results were presented to the research partner and further developed as suggested by Dow and others (2012a, pp.62). Design research points out that comparison enables people to focus on key similarities (Gentner & Markman 1997), to acquire the underlying principles (Colhoun et al. 2008; Gentner et al. 2003) and sharpen categorical distinctions (Boroditsky 2007).

ing that it meets usability criteria (Rubin 1994, p.25 cited as in Corry et al. 1997). Dumas and Redish (1993) coined it as "a systematic way of observing actual users trying out a product and collecting information about the specific ways in which the product is easy or difficult for them" (Dumas & Redish 1993, p.12 cited as in Corry et al. 1997). They further characterize usability tests as follows: Researchers watch real users conducting real tasks with the ultimate goal of improving product usability. Lessons on problems and recommendations for future changes can be subsequently drawn from these observations (Dumas & Redish 1999, pp.22).

During usability testing researchers should behave as reserved as possible to avoid misleading results on the prototype. "What is required is a usability test, not a selling job" (Gould & Clayton 1985, p.302). The testers were therefore encouraged to be critical and have the major share in the conversation. DT corresponds to this with the rule 'show, don't tell' for prototype testing. Consequently the prototype was designed as self-explanatory as possible with complementing visual and written explanations.

These explanations were presented on 22 pages, each depicting one workshop-step. This enabled the experts to skip back and forth and scribble feedback onto the sheets, making the conceptual ideas tangible for feedback. Meinel and Leifer (2011) state in their DT research program that "making ideas tangible always facilitates communication". Tangible prototypes are naturally used in DT processes, but the particular quality, that "prototypes are communication media" was only brought to discussion recently (Meinel & Leifer 2011, p.xv).

Regarding the level of abstraction, literature recommends low-fidelity models, such as rough paper prototypes, because they allow designers and users to focus on high-level interaction and information architecture, rather than on details or visual style (Corry et al. 1997). Building on this insight, the presented paper prototype was intentionally "roughly drawn" to visualize and evaluate the critical function and not the visual appearance. DT research underpins rough prototyping for two reasons. First, it stimulates a more honest feedback as testers do not hide judgments out of politeness. Second, testing a rough first version saves the designer effort in later adjustments. Nevertheless one has to be aware that "*discovery is not an automatic consequence of experimentation; the way people frame*

problems makes some insights salient and hides others” (Dow & Klemmer 2011, pp.112).

3.3.1 Sample Criteria

Qualitative research is determined by the unpredictable nature of the data (Saranakos 2012, p.183). Therefore the principle of typification is most important when selecting the interview partners. In this context typification implies that the sample follows ‘typical’ features of research (Lamnek 2010, pp.163). Accordingly the area for examination defines the characteristics of the sample criteria, the so-called theoretical sampling. Following this principle, experts for prototype testing were selected due to their fields of expertise in DT, Product-Service Systems, business-consultancy and sustainability sciences (Figure 19).

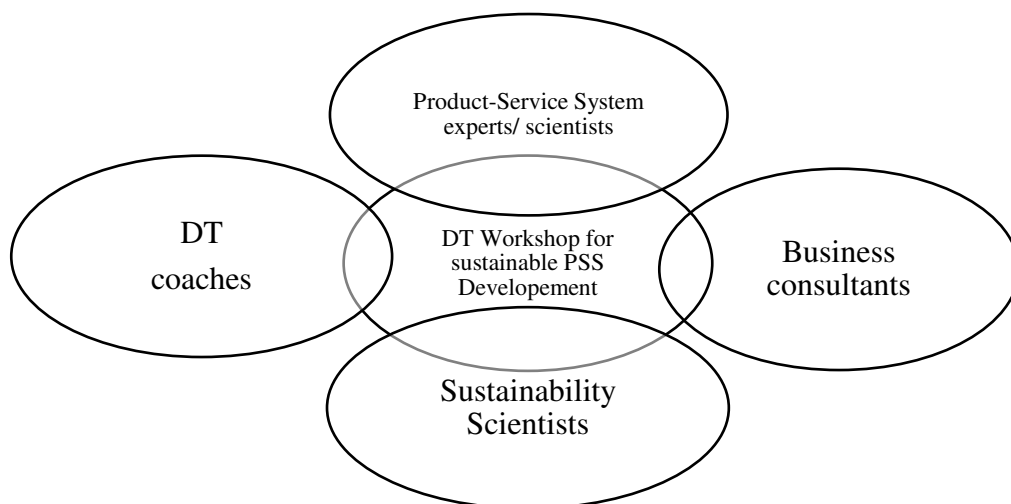


Figure 19: The four fields of expertise were identified as selection criteria for the expert feedback selection. By relying on these four fields of expertise, the authors assured multi-perspective insights on the question how DT can contribute to S.PSS development. This approach also became necessary, because experts covering multiple or even all fields of expertise are very limited. Fostering applicability of the final results, contributors from both, academia and practice were questioned. Here, business consultants and DT coaches were expected to deliver valuable practice-insights from group dynamics and the possible levels of workshop complexity. Product-Service System researchers and sustainability scientists in contrast were expected to give feedback on the operationalization of theoretical approaches.

3.3.2 Data Sources

In qualitative research, the guiding paradigm of inquiry is the major determinant for the sample size (Lamnek 2010, pp.384). Literature on narrative interviews suggests a sample between twelve and thirty interviews for the saturation of information (Glinka 1998, pp.29). The literature on tangible prototype testing does not provide such estimations. The authors therefore aimed at a minimum of twelve testers and ended up with a total of twenty experts involved in the evaluation process (Table 7). A fast adaption of prototype feedback is suggested for low-fidelity prototype testing (Takayama & Landay 2002, pp.661). Glinka likewise recommends to first conduct a small amount of interviews for an insight into the possible variation of dimensions (1998, p.30). One might waste time on doubling outcomes, if conducting too many interviews within the first iteration. A total of 15 *tangible prototype tests*, conducted within three iterations, served as the main data source for later analysis (Appendix 2_1, 2_2). The tests lasted 97 min in average, during which the experts were asked to loudly articulate thoughts on the comic-like illustrations of the presented material and scribble their feedback onto the sheets. Additionally five *interviews* with an average of 66 min were held due to time constraints, not allowing in-depth prototype testing. Still the authors wanted to capture the interviewee's feedback and therefore only addressed the main topics of interest. The paper prototypes also served as a support for illustrating certain issues in the interviews, but were not entirely evaluated. The majority of the prototype-tests and interviews were conducted by the two authors. Meanwhile tasks were split between explaining the intention behind certain conceptions in cases of uncertainty and capturing spoken word in protocols.

To furthermore capture feedback, a *questionnaire* guided the assessment process. According to the questionnaire-characteristics, simplicity, uniqueness and neutrality (Scholl 2003, pp.149; Raab et al. 2009, pp.105), experts rated each process step by marking a line between the poles of plus and minus. By rating the workshop steps on a line of ten centimeters without given categories, the authors aimed at best possibly transferring a qualitative gut feeling into a quantitative judgment for later comparison. Because experts can thereby rate intuitively instead of preset categories, this approach allows a perceptive differentiation within millimeters (Albers 2009, p. 69).

Table 7: Evaluation process of the DT workshop

No.	Name	Position	Field ¹	Date	Location	Duration	Type of Inquiry ²
0	Peer Priedwich	Leuphana University, Head of Regional Networking, Leuphana Professional School	BC	04.03.2015	Leuphana University, Lueneburg	2h15min	Pretest
<i>First Iteration</i>							
1	Robin Mehra	Tiefenschärfe, Co-Founder; Coach at d.school Potsdam	DT	09.03.2015	Tiefenschaerfe, Berlin	2h	Testing
2	Bettina Michl	Tiefenschärfe, Co-Founder; Coach at d.school Potsdam	DT	09.03.2015	Tiefenschaerfe, Berlin	2h	Testing
3	Dr. Arist von Hehn	Teach For All, Co-Founder & Vice-President - Strategy & Governance	BC	09.03.2015	Private Setting, Berlin	1h20min	Testing
4	Dagmar Rissler	Dagmar Rissler personal.team.entwicklung, selfemployed; RaumSieben, Founder	BC	11.03.2015	raum sieben, Hamburg	2h	Testing
5	Henning Prox	Prox Beratung-Training, selfemployed; Travel Beyond, CEO	BC	11.03.2015	raum sieben, Hamburg	2h	Testing
6	Dr. Doroteya Vladimirova	University of Cambridge, Lead Researcher, Industrial Sustainability	PSS, SS	17.03.2015	IfM University of Cambridge	1h	Interview
7	Dr. Florian Urmetzer	University of Cambridge, Senior Research Associate, Cambridge Service Alliance	PSS, BC	18.03.2015	IfM University of Cambridge	45min	Interview
8	Veronika Schubring	Projekt:raum Rostock, Co-Founder; Freelance DT Coach	DT,SS	25.03.2015	projekt:raum, Rostock	2h15min	Testing
<i>Second Iteration</i>							
9	Prof. Ursula Tischner	Econcept, CEO, S.PSS Lecturer	PSS, SS, BC	30.03.2015	econcept, Cologne	3h	Testing
10	Gabriele Duchek	C3 consulting coaching concept, Founder	BC	07.04.2015	C3, Rullstorf / Lueneburg	1h45min	Testing ³
11	David Lam	Schlange&Co, Consultant for Corporate Responsibility	SS, BC	27.04.2015	restaurant, Hamburg	1h30min	Testing
12	Dipl.Ing. Konrad Exner	TU Berlin, Phd Institute for Machine Tools and Factory Management	PSS, DT	04.05.2015	TU Berlin, Berlin	2h20min	Testing
13	Dr. Arndt Pechstein	Co-Founder Biomimicry e.V. Germany; DT Coach at d.school Potsdam	DT, SS	04.05.2015	d.school, Potsdam	2h5min	Testing ³
14	Pascal Gemmer	DarkHorse, Co-Founder	DT, PSS	04.05.2015	Dark Horse Büro, Berlin	1h30min	Testing ³
15	Johannes Puschmann	bettertoday.de, Partner ; DT Coach at d.school Potsdam Professional Track	DT	05.05.2015	St. Oberholz, Berlin	1h10min	Testing
16	Friedrich Grosse-Dunker	DarkHorse, Co-Founder; Sustainability Scientist	DT, SS	07.05.2015	Berlin	55min	Testing
17	Prof. Cornelius Herstatt	TU Harburg, Professor Technology and Innovation Management	PSS, SS	27.05.2015	TU Harburg, Hamburg	1h30min	Testing
18	Prof. Nancy Bocken	TU Delft, Associate Professor Industrial Design Engineering	PSS, SS	24.06.2015	London, Circular Economy Summer School	35min	Interview ³
19	Bill Burnett	Stanford University, Executive Director d.school Stanford	DT, SS	24.06.2015	London, Circular Economy Summer School	55min	Interview ³
20	Prof. Fabrizio Ceschin	Brunel University London, Lecturer Design for Sustainability within the School of Engineering and Design	PSS, SS	30.06.2015	Brunel University	2h 15min	Interview ³

Third Iteration

Notes: ¹ Fields of Expertise: PSS: Product-Service System expert; BC: Business Consultant; SS: Sustainability Scientist; DT: DT Coach
² Testing: Tangible Prototype Testing; Interview: Informal Interview
³ Conducted by only one author

3.3.3 Data Analysis

The tangible prototype tests were conducted within three iterations (Table 7). In each loop the workshop design was further modified. The experts were instructed to speak out loudly whatever came to their minds while reading and interpreting each workshop sheet. The feedback was then directly self-captured on the process sheets and protocolled by the authors.

As a first step, a pretest was conducted with the first version of the workshop. This provided valuable insights on both, the practicability of the workshop prototype at testing and a first feedback on the presented concept. Pretesting has led to two main modifications of the questionnaire. First, the evaluation was separated from the workshop illustrations onto an extra sheet that displayed all process-steps. This external overview later proved to be helpful for experts navigating through the sequence of the workshop and making comparative judgments. As a second modification, evaluation criteria were reduced from four to the single dimension of purposefulness for the overall aim. This dimension was only supplemented by a best guess regarding the time needed for conducting each step in practice (Appendix 2_3). The pretest showed the need for clarifications in illustrations and explanations. These insights lead to a revision within the first iteration.

The result was then evaluated within six tangible prototype tests and two informational interviews. Based on this feedback the workshop steps were edited within the second iteration. Therefore the questionnaire ratings indicated which process steps were perceived below the average. Improvements were integrated by specific modifications or an exchange in sequence. Simultaneously the coding of the case study was finalized. These insights on factors for successful PSS implementation have led to additional adjustments of the workshop within the second iteration. For a more concise illustration the workshop and its setting were specified and the graphic characters were modified. Additionally a final step was added, rounding up the workshop (4.2.19). Again, questionnaire ratings indicated process steps to rework or remove.

The second iteration was ninefold prototype-tested and discussed within three interviews, before the final workshop design was crafted in the third iteration. The interviews primarily served to discuss the broader context of the DT workshop and its placement within academic debates.

Feedback cumulated to overall 330 prototype-pages with handwritten notes, 15 evaluations sheets and 24 pages of observation notes. The combination of tangible prototype testing and questionnaire-ratings ensured the interpretation of the qualitative feedback. One could argue that the rating is highly subjective depending on the benchmark determined by the tester's first rating. This shortcoming was neglected by arguing that the questionnaires purpose was to indicate necessary improvements of workshop steps instead of quantitatively evaluating the process.

The workshop was evaluated on a theoretical level only⁶. Not bringing the concept into practice is justified by three reasons: a) The initial thought was to co-develop the DT workshop for S.PSS development with experts before applying it at an immature stadium. Tangible prototype testing facilitated an elaborated discussion, integrating experiences and adding to a holistic picture of the methods described in literature. b) The authors argue that the workshop was developed for an application in different fields. Hence a broader concept is needed as a starting point, which can later be customized to the requirements of a specific SME. c) Scientifically evaluating a 18-step workshop exceeds the limits even of a collaborative master thesis, especially if also conducting a case study.

⁶ Tests of single workshop elements were conducted at the regional company network „Rohstoffquelle:Produkt“ within two workshops (12.05.2015 and 16.07.2015).

4 RESULTS

4.1 Case Study Summary: DBL Marwitz GmbH

The case of DBL Marwitz GmbH has a 200-year history, operating the family-owned business in 6th generation. When a fire destroyed the previously owned tannery in 1823, family Marwitz decided to shift to the laundry business as the then innovative technology of the steam engine prevailed. In 1900 Marwitz moved to Lüneburg for promising markets. Demand rapidly decreased in the 1970s when private laundry machines were becoming affordable. The possibility of washing at home thereby put pressure on the laundry market. At that time the Marwitz-business contained a laundry, a delivery service, fifteen owned stores in the area of Lüneburg and additional service points in local supermarkets. Marwitz recognized the need for further development.

„When the market for laundries collapsed, one had to consider how to proceed. Then it was about work textile leasing, which was totally exotic in ‘71” (Int.1, para.9).

Textile leasing had been newly introduced to Germany by corporations, offering the leasing of work clothes in combination with laundry, maintenance and delivery service. To compete in the new market the DBL (Deutsche Berufskleider-Leasing GmbH⁷ - German Workwear Leasing) was funded in 1971 as an alliance of laundry SMEs. The DBL is a strategic cooperation of family-owned businesses operating in economic and legal independency. The alliance was triggered when a supra-regional customers from food and automotive industry demanded service in areas, the addressed SME could not supply itself. For service providers with limited delivery range contracts of greater dimension were only manageable in collaboration with partners. Therefore owner managers of six family-run laundries from northern Germany decided to cooperate in the market of textile leasing. By strategically dividing geographic spheres on the map, exclusive territories for business activity were established between the companies. In this process of division the area of northern Lower Saxony between Hamburg and Hannover, considered to be a broad and economically weak territory, had to be covered by a service provider. Hence, the DBL initiators integrated Marwitz in their network, covering

⁷ Until 2003 DBL operated as: Deutsche Berufskleider- und Textil-Leasing GmbH

the required segment and matching the common feature of a family-run business. By further including associate partners, the DBL stepwise expanded over entire Germany and the new federal states after the German reunion in 1989. The DBL Group now commonly offers a defined standard in service, workwear leasing, rental floor mats, sales of security products, and shirt service. Customers range from industry to craft sector, trade, health care and restaurant and hotel industry. The red button was introduced as the shared DBL logo in 1977, redefined in a new corporate identity in 2011.

Marwitz joined the DBL Group in 1972, a year after its initiation and further operated as DBL W. Marwitz Textilpflege GmbH. The business model then successively shifted from a service provider for private customers to a PSS with work textile leasing in a B2B market. Initially the prior owner manager had to be convinced, making the necessary investments for developing the business model towards textile leasing.

“Investments had to be made. If you want to rent out workwear, you have to buy workwear in the first place” (Int.7, para.31).

When first regional leasing-contracts were signed with car dealers, a small subunit for the workwear business was installed next to the ongoing laundry business. A first stock for product storage and spaces for sewing and patching was installed.

“And then the leasing segment slowly spread across the entire company. The other parts got pushed away and leasing steadily spread” (Int. 7, para.115).

The slow but steady growth of rental textiles enabled financial investments for further structural development. First additional space was required for product storage. Therefore a warehouse for new and used work textiles was built, soon followed by a new staff cafeteria. When the fifteen laundry service stores had ultimately lost profitability in 1989 the decision for their closure was taken. By then the company's main income was generated through textile leasing. Continuous company growth, outreaching the internal capacities, repeatedly lead to spatial problems. This caused management to cancel a major laundry contract with the German army. In the early 90ies, the decision for expanding to new company sites was taken. A double property was bought in Lüneburgs industrial area and facility two was built. The purchase of a large plot of land proved to be farsighted for

Marwitz, as this enabled owner managers to build facility three in 2001 and a fully automatic sorting plant in 2013. Facility one further operates the smaller proportion of textiles from hotels and gastronomy. The company's logistic capacities are expected to reach limits within the next three years, most probably leading to investments in new company sites.

Subsequent to the firm's mentioned geographical development, staff had to be hired for managing the additional tasks. Today's senior manager served as a catalyst during the introduction phase, promoting the idea of textile leasing and spending half of the day acquiring customers. When his capacities reached their limits a first salesman was hired. He later became head of sales, when additional sales agents were employed. The sales team was trained in cooperation with the DBL partners. Insights on workwear collections and the peculiarities of textile leasing were systematically shared within the DBL. During the entire phase of initialization and growth, process knowledge from the DBL partners, who had likewise undergone these processes, was consulted and proved to be very helpful. Personnel for the maintenance and the repair of worn out clothes was needed and successively employed. With continuously growing customer structures, professionalization in customer support became likewise necessary. Hence the head of service position was created, bundling all employees with continuous customer contact in one department. This resort includes the areas of service in house, service in field and logistics, entitling fleet personnel as service-drivers. Logistics are contained within the field of service, as the former fleet manager became head of service and widened his area of responsibility. Thereby a clear internal structural division from service to sales and accounting was achieved. After acquisition, the service team is responsible for customer satisfaction. Clients have a personally addressable contact person from the service team to whom they can relate. Service employees in house back the service-team, answering incoming requests and noting reclamations. Marwitz employs about 180 employees in total, lead by three key positions, one managing partner, one managing director and one partner. Figure 20 shows internal staff organization.

W. Marwitz Textilpflege GmbH - Organigram

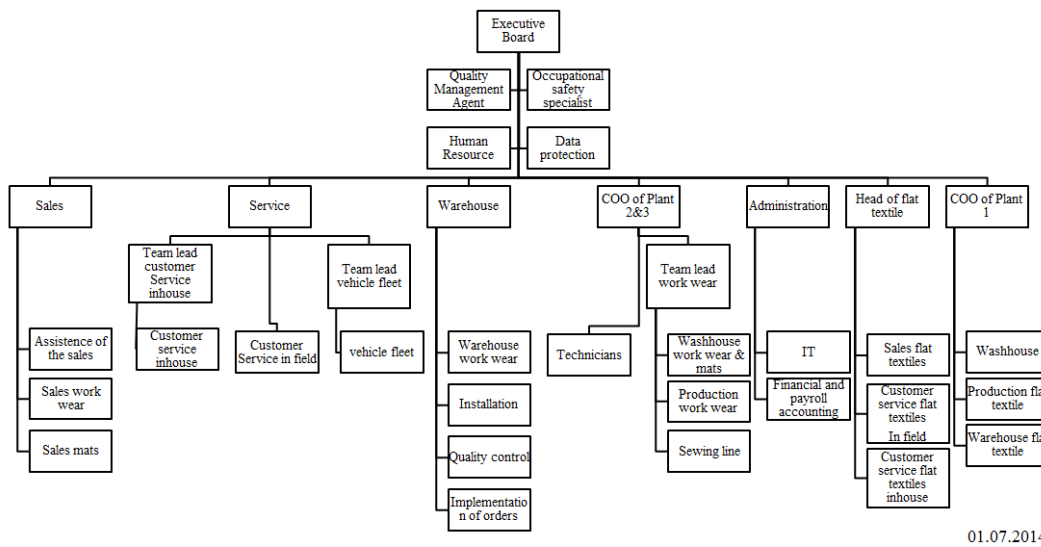


Figure 20: Organigram as of 01.07.2014 (own translation of internal document provided by DBL Marwitz GmbH).

Laundry operation has become a minor part of business activity, next to product maintenance, collection and delivery. Within textile leasing, operations have not changed as much as their communication. Until the 1990s the leasing of work-wear had to be explained to customers whereas leasing nowadays needs no further explanation. Now the overall service is put into focus, delivering a carefree package from assistance in selection to individualization, washing, maintenance and logistics.



Figure 21: DBL Service cycle (screenshot from image video; DBL 2013)

The digitalization of work processes, namely the customer relationship management and the product management system, has led to a professionalization of business activities. On the one hand speed in customer contact has increased and the economic evaluation of processes and customers was enabled on the other hand. Computerized documentation and transparency has led to the reconsideration of business practices. The replacement rate of damaged textiles for example is now calculated in detail according to the contract scope in contrast to a former service flat rate. Customers are now classified internally into A, B and C categories according to their profitability. Warehouse management likewise profits from automated processes in the sorting plant. Internal communication also became more systematic through electronic support. For nevertheless maintaining the personal contact between departments and hierarchical levels weekly meetings have been institutionalized.

“Don’t tell my wife, because she always complains. She says we don’t talk enough with each other anymore. And I say: Yes, but now we speak about the important and not the unimportant issues” (Int.2, para.36).

Marwitz today generates an annual turnover of 17 million EUR with a proportion of 12,4 million EUR from rental textiles. The company supplies 2600 customers, daily managing 17.000 parts. The catchment area of DBL Marwitz covers parts of Lower Saxony, Mecklenburg-Western Pomerania and Saxony-Anhalt. Due to the weak market penetration, strong sales and regional competencies, the management predicts further company growth. The profitability of flat textiles from gastronomy and hotels however was questioned in the interviews because of strong seasonal fluctuations. The closure of facility one, where flat textiles are handled, was announced during this inquiry for 2016 (Landeszeitung 2015). Executive management expects the market of workwear leasing to offer future economic opportunities. This prognosis is justified by the ongoing trend to supplement private clothes with professional workwear. Additionally the acceptance of rental textiles is spreading, causing a shift from purchase to leasing contracts.

The success of Marwitz is reflected in the development of the DBL Group, commonly managing 60.000 customers and a total of 2.750 employees. Cumulated income steadily increased from ten million DM in 1975, to 65 million DM in 1986 and 300 million DM in 1996. The turnover amounted 246 million EUR in

2014. The DBL Group comprises twelve independent SMEs with twenty-four company sites and a head office in Zirndorf, Germany. After its initialization, the DBL network soon started strategically collaborating and operating by self-set rules. An executive manager was employed whose position is today collaboratively held in part time, by three CEOs from the associate SMEs. Moreover committees were formed with the board of directors as the most important panel discussing strategic development. The second most important panel is the meeting of sales managers. They meet most frequently on both national and regional levels, discussing trends and new customers wishes for further portfolio development. Moreover committees for coordination of marketing, advertisement, finances and IT have been installed. This institutionalized network of corresponding fields of duty within the DBL results in a valuable exchange of practice insights from the individual companies, leading to a better overall standing in the market (DBL 2014c).

4.1.1 Success Factors of DBL Marwitz GmbH

The success of DBL Marwitz is multifaceted within the 43-year history of textile leasing. According to the methodological approach success factors were analyzed in categories of both internal and external drivers on the one hand and the way internal and external barriers are overcome on the other. The following success factors have to be viewed coherently, as they influence each other.

Internally the *flexibility in strategic decision-making* was identified as a major success factor. External consultants were surprised by the quick decision on investing into a fully automatic plant once the proposal was fully elaborated together with the operational officer. When the top management agrees, ideas are quickly executed. This factor is supported by the network structures of the DBL as members try different options and successful ideas spread across the network.

Short communication routes for fast decision-making within Marwitz and the DBL support the former. Company size and the family business structure allow quick reaction and decision-making.

„That is an important value within the company, the proximity between management and the employee” (Int.3, para.10).

For establishing the short routes, management remains directly addressable for personnel of all levels. Moreover the communication routes are adapted to decision-making structures, allowing decisions on sub-management level. For further advice, knowledge resources within the DBL are quickly addressable.

Within the few leading positions of the company, *work spheres are customized to the personality of the employee*. The steady company growth gives management personnel the opportunity to divide new tasks according to preferences and abilities. The first creation of the sales- and service manager positions matching the individual competences, highlights this driver.

Company development was supported by the *presence of a catalyst*, taking responsibility for specific topics. The initial engagement in textile leasing was only enabled by the effort of the senior manager. Another example is the computerized product- and customer relationship management that was developed with personal dedication of an executive manager by Marwitz. Without the same commitment from an internal catalyst, DBL partners fail to implement this system successfully.

Taking the responsibility for steady improvement within complex business-structures requires a *high management commitment*. The executive managers try to balance between consultancy for individual decision-making and providing structure through decisions. The management's dedication also reflects in the voluntary engagement in DBL committees.

A *clear cost structure for long-term planning* is a strong internal success factor. Three-year contracts give financial security and detailed customer analysis, ranking A, B and C customers, ensures profitability. Surprisingly small businesses from the craft-sector with only few employees are most profitable and A-ranked. Many small contractors enable the spread of fix costs. Big customers operate professional purchase departments and are thereby tougher in negotiating prices but ensure a high utilization rate. Hence a diverse structure of many small and few big customers proved to be most beneficial.

For overcoming internal hurdles, continuous *investments for products and production sites* are seen as an important factor. The last three generations of owner managers were reported to willingly invest into business development. For textile leasing, every leased product has to be bought by Marwitz in the first place. The

purchase of several parts-per-employee of the customer leads to big investments, which are then converted into customer-contracts.

For successfully operating the PSS, internal *competencies regarding products and services* are fundamental. As knowledge for delivery and laundry existed prior to the PSS business model, competencies for purchase, patching, maintenance and warehouse management had to be developed. This product-specific knowledge is easily accessible through the close contact to the DBL and the suppliers. The leasing part of the business-model was adapted from existing leasing contracts and with additional help from lawyers.

For growing the company, *additional personnel recruitment* was essential. Further staff was employed step-by-step, whenever capacities in production, sales or service were overreached. Most recently the position of a personnel officer was created to disburden the management. Recruiting new employees for leading positions has been difficult in the past as personnel usually has a long company affiliation and therefore knows routines better than the new managerial staff. Particularly social competencies are seen as a factor for employment in leading positions for a successful integration into company structures.

Further, long training periods for newly hired staff have been installed. In customer contact, *trained middlemen* are essential for professional contract procession. Therefore sales trainings are executed on DBL level. Likewise on a technical level, staff is exchanged for familiarization with machines between DBL partners. Moreover an evaluation of personnel is conducted on a yearly basis to figure where qualification programs are wanted and needed.

Most important for creating value are *competences on customers' processes*. Next to sales conversations, Marwitz learns from experiences at customers' facilities. Furthermore signs of product usage as smell, dirt or abrasion give insights on customers' processes and the necessary frequency of replacement. The long personal contact between employees and customers is of great value for Marwitz. Comprehending and anticipating customers' wishes provides further sales arguments.

Close *relations along the value chain* to both designers and customers are maintained as a business success factor. The supplier contacts were established during PSS introduction, because of the comparably large amounts of purchased goods the retail market was not used to provide, if bought at once for leasing. Further

agreements were taken to omit single packaging of large purchase volumes. The close relation to product providers has led to commonly developed collections in cooperation with DBL customers. The DBL plays an important role for the suppliers to receive customer feedback. Further, the DBL holds an exclusive contract for textile leasing with a well-known workwear producer.

For overcoming potential *internal conflicts between sales and service*, a tight cooperation between the departments was established. During institutionalized meetings, portfolio development is discussed in coordination with the warehouse capabilities and profitability. Unlike the departments' separation in customer contact, collaboration between service and sales is essential for purchase and portfolio management. Perceived customers' wishes and trends are regularly discussed between the two departments. The integration and exclusion of products from the portfolio is strategically decided between the heads of the departments. An observed demand from service can thereby quickly serve as an argument in sales. For quick decision making on sub-management level, the heads of service and sales are authorized as procurators. Rules for product introduction have been established, ensuring a minimum quantity and constant quality resisting industrial washing programs. As both departments strive for customer satisfaction the owner managers add an economic perspective to major decisions. Further key functions for decision making are held by the plant managers of both facilities, paying attention that the intended development matches Marwitz's internal capacities.

All departments have internalized a *service mindset*, putting customer satisfaction in the center of attention. The management does not favor top down decisions. Instead a collective decision process towards the best service-solution is envisioned. In supra-regional contracts the DBL has set rules for customer contact, achieving a common standard in service delivery. The service mindset is furthermore reflected in the company's structures, bundling all activities with customer contact within a single service department for improved performance. Marwitz differentiates from competitors through high quality services. Not offering pooled flat textiles although the market trend suggested, illustrates the company's serenity to offer high standards and only change if profitability obliges to.

The *problem of pricing immaterial services* is solved through a clear cost structure, calculated with EDP support. The prices are regularly adapted as smaller

factors are recalculated individually. In customer contact the service part of business activities has to be explained in greater detail.

Externally, the company's rooted identity in *regional structures* is regarded a major success factor. Being small and medium sized, family owned and from the region serves as a sales argument for local SMEs, sharing the same values. Marwitz sources credibility from its 200-year history, being well known from the former laundry business. Being situated in Lüneburg, a city with 74.000 inhabitants, personal contacts to the community are easily established. The owner families and employees engage in local associations or sport clubs, building personal contacts in the municipality. Outside an estimated radius of 50 km Marwitz is perceived as DBL. Regional commitment is moreover reflected in environmental and social engagement.

Despite stronger *market competition*, the DBL businesses have commonly always achieved a top three ranking. The DBL association allows benchmarking on a national level with competitors, and on SME level between DBL partners. Marwitz has the highest market penetration within DBL, explained by less competition in the rural region. For competing businesses, the DBL is hard to monitor because of the many SMEs individual offers. The associate DBL partners always have parts in their portfolio bigger competitors fail to offer. A further advantage is that the DBL commonly employs a bigger sales team than any competitor. Thereby smaller sized customers can be reached.

In work textile leasing, the *offer does not affect the core competence of the customer*. Thereby the product is of rather low value for customers. Marwitz uses the externalization of minor issues as a sales argument. Clients save time and effort in purchasing and maintenance and thereby money below the line.

Success in sales mainly depends on the communication of the leasing-contract to *convince customers by savings*. Marwitz argues, when buying work textiles, the investment falls flat service after a while, which the maintenance service can compensate making leasing more cost effective on the long-term. As businesses may purchase workwear for saving leasing costs, this argument is also used in the opposite way. Leasing contracts in comparison allow a reduced capital tie-up. This highlights the importance of clients' distinct *B2B contract understanding*, explained by the sales team. The cost structure has to be communicated in detail,

because laundry has become a minor part of business activity and most service aspects remain invisible for the client. Within the concluded leasing contracts, financial risks like the replacement frequency have to be negotiated as a reference point.

An increasing standard in *health and safety regulations* also contributes to the argument of externalization. In many branches, regulations and their amendments apply to employees work textiles for ensuring labor safety and hygienic standards in production. Moreover, in certain areas, the exchange rate or laundry temperature for workwear are prescribed by legislation. Monitoring and fulfilling regulations is a strong sales argument for Marwitz, as the determined replacement of reflection stripes for employees in traffic for instance, extends the competencies of many SMEs. The fulfillment of hygienic standards moreover serves as a door opener for sales conversations.

Marwitz sells the externalization of all workwear issues within a carefree contract. The customers' employees are well dressed at all times. Since Marwitz offers individualized solutions, *customers demand diverse services*. Therefore products are customized, matching the clients' corporate identity. Customization moreover is a very profitable part of the business. The sales argument of customized workwear only applies to small sized customers. Bigger customers, operating on a national level, have contractually determined clothes without any need for personal individualization.

A further external driver is the broad acceptance of leasing in general, which has established itself. Utilizations of *services are preferred over owning* nowadays. Many family-owned businesses are transferred to the successor generation, who is more likely to be interested in leasing options than the older generation. Management reported that leasing and internet-purchase are the two growing segments within the market of work textiles. Both trends are connected to convenience and low organizational efforts.

For Marwitz, *customer credibility* is essential, trusting the delivery of services within the long-term contracts. The personal customer contact, the regional prominence and punctual delivery are factors contributing to a liable image. Customers only infrequently request *environmental issues* in terms of eco labels. Hence, these only serve as a minor sales argument in the branch.

Customers not at all requesting work textile leasing independently, reveals the external barrier, *lack of market demand*. For overcoming this hurdle, Marwitz has built a strong sales team continuously cultivating the market. Information on health and safety legislation helps to create new markets.

Problems with low value products occur, as these play only a minor role for customers. DBL vendors have to first raise attention and then explain the customers' benefits of textile leasing. Further, the externalized ownership paired with the low value of the textiles leads to a *reduced care for the product*. Cases of chopped pants or textiles used as rags were reported. Marwitz reacts to this by personally contacting customers and recording replacement rates within the leasing contracts.

The continuous *portfolio management*, conducted between sales and service departments, was reported as a major success factor. The task for Marwitz is to simultaneously offer a diverse portfolio while minimizing providers. On the one hand customer requests have to be best met by providing different options while on the other hand fewer different items are favored due to spatial limitations of the warehouse. Portfolio management is a process of continuous adaptation; sourcing clothes for branches from craft sector, to sales and food industry or business outfits for higher positions. When purchasing, *product quality* is the most important criterion. The self-interest of Marwitz is to lease especially durable products that are best manageable for service maintenance and resist industrial washing programmes.

“That means we first try to buy goods of extremely high quality so that they have a long lifetime. Because the longer the product functions and satisfies the customer, and as a customer we see the single wearer not even the boss of the company, the more money we can earn and indirectly we spare the environment, because it simply goes that many month, years and washing cycles later into recycling or into deposit” (Int.1, p.31).

Broad learning from the DBL network is very important for Marwitz. Overall success is achieved by repeated learning from success and failure. Together the DBL SMEs have a big knowledge resort, shared within the network. Learning structures and DBL culture have slowly developed towards open communication and mutual learning.

4.1.2 Continuous Innovation Behavior

Regarding the business model of DBL Marwitz since 1972, only the portfolio further developed. New products or collections were repeatedly introduced, while the service aspects of washing, maintenance and logistics remained. Hence, innovation solely occurred on the product side of the product-service system. Still three exceptions from work textile leasing are found in the business model. Firstly floor mats which are offered in leasing contracts with washing and replacement service. Secondly, the sale of various security equipment, and thirdly the offered facility management with hand washing products, which are both strategical matches for the professionalization towards health and safety regulations.

Changes in the PSS portfolio are primarily a reaction to perceived customers wishes rather than innovation understood as entirely new inventions or ideas brought to the market. The starting points for portfolio enlargements are specific market demands or differentiation in reaction to competitors. The difficulty for Marwitz is the recognition of such market demands. As a service provider for work textiles, Marwitz does not affect the customer's core business and is thereby hardly recognized. Regular inquiries on customer satisfaction deliver only poor insights for further improvement. Customers have purchased a carefree service and therefore only communicate about their needs if inconveniences occur. The task of service and sales staff is to be sensitive about customer demands and to further discuss ideas with the heads of the departments or management for quick reaction.

“We are a middle class company - in the best sense of the expression. Short routes, clear decisions, competent contact persons - that is how we understand modern service provision” (DBL brochure, appendix 1.5.6, para.485).

The high commitment of leading staff, trying to fulfill demands, has proved to be essential for quick adaption. Furthermore the clear SME structures paired with the family-owned rational of freer decision making allow rapid reaction to perceived wishes. Customers are also receiving numerous settlement offers and report the competitors' market behavior to sales and service staff, who can thereby monitor and identify market trends.

“We are not the inventors in the market. But we are rather the flexible, who can react quickly to things, quickly realizing them and making them maybe even more delicate and better, than the one who invented it. That is where we see our strength“ (Int.1, para.7).

Especially personal long-term relationships to suppliers have been valuable for portfolio management. Work textile manufacturers rather monitor global and market trends and can thereby add a bigger picture to Marwitzs’ regional perspective. Furthermore the close contact to suppliers is essential when reacting to market demands. Marwitz has to figure first whether customers wishes can be fulfilled either by products from suppliers or by own efforts and second whether the figured solution meets the quality requirements of textile leasing. If suppliers provide diverse solutions, these can be passed on and offered to customers.

Within the DBL network the affiliated SMEs can rely on a diverse supplier network. A DBL partner has developed fire-resistant welding suits in cooperation with a producer and a client. This case illustrates the DBLs important role as a mediator for supply and demand between user and producer. Moreover the beneficial association within the DBL becomes evident. On the DBL level a product design challenge for different producers was posed leading to an exclusive result, differentiating the DBL portfolio on the market. SMEs don’t have the capacities to operate an innovation department next to the daily routines and hurdles. Within the DBL all members commonly achieve a better standing in the market.

“We engage within the network of the DBL to build up the strengths of a big company outwards. That means that, by being many contractual facilities, we have a different standing than a company with 200 employees would present on the market” (Int. 4, para.19).

For sharing knowledge personnel is released to work in DBL committees. Most important for innovation, the head of sales committee works on bundling customers’ wishes and evaluating their market potential. Only if a total profit of two million EUR plus seems achievable, the DBL commonly engages in cultivating new markets. DBL members solely engage in specific efforts regarding products, processes or services because of their own conviction and without the networks support. Thereby diverse practice knowledge of different approaches is generated and shared between the associates. All DBL members can rely on each other’s experi-

ences, exchange ideas without hierarchy and enable everybody to learn from success and failure. This DBL advantage has been recognized and institutionalized through the committees and regular company tours in different facilities as a source of inspiration on work processes. Employees have a specific contact person of corresponding positions in DBL companies for quick consultation. This structure facilitates learning processes for example regarding technical systems or the PSS supporting system. If that help on different levels remains insufficient external expertise is acquired. External advisors and engineers were consulted when Marwitz planned and installed the new sorting plant.

Next to the recognition of customer demands Marwitz also takes proactive steps in portfolio innovation. Broader trends in workwear and fashion are monitored on the one hand. Stricter standards in upcoming health and security regulations are observed on the other hand. Insights from both are incorporated into sales arguments.

4.1.3 Sustainability Orientation

Marwitz communicates its sustainability engagement modestly because of possible counterproductive misinterpretations. Sustainability is seen as a buzzword being used in a fashionable manner and poorly to delimit from true social or ecologic commitment. The company has a strong intrinsic sense of responsibility towards its employees and the municipality and therefore does not feel the need for external profiling. Therefore specific sustainability certification is neglected. The company holds DIN EN ISO 14001 and DIN EN ISO 9001 certificates for environmental and quality management. Due to Marwitz, laundry services in Germany automatically operate sustainable by following the legislation.

Textile industry generally suffers a weak reputation as scandals regarding child labor and health and safety regulations revealed poor work conditions. These issues however occur at production sites overseas. Differentiating from such practices has become important for Marwitz. The company therefore relies on textile providers from Europe, preferably Germany and Denmark. These suppliers, nevertheless producing overseas, are expected to sufficiently monitor work conditions in the supply chain as approved by certificates. Hence auditing by bigger custom-

ers secures the company's image. Smaller customers rather focus on product quality.

Corporate donations of DBL Marwitz are not strategically placed to raise attention but given to institutions with personal relation to the company, where a maximum of impact is expected. Examples are donations to a women's shelter, support of a tree plantation initiative for water regeneration and volunteer fire departments employees engage in.

Economic sustainability has been widely discussed within the reflection of internal and external success factors. To mention here from sustainability viewpoint is, that savings in water, electricity and fuel have led to investments and behavioral adaption towards efficiency. The market of leased workwear is perceived as marginal in relation to the overall textile industry though. Therefore possible influence towards further environmental or social development in the textile sector is neglected.

Regarding *environmental sustainability* interviewees found it difficult to ultimately balance the overall performance, as considerations between social and ecological issues are difficult to illustrate. When planning the new sorting plant, for example environmental concerns were not central in decision-making. Also the factor of avoided surface sealing in that case is hardly illustratable.

Maritz's central environmental argument is the product durability and the thereby achieved long period of use. Clothes used in textile leasing have to resist industrial washing programs and are therefore quality tested. Despite the more intensive handling, industrial washing was described as more resource efficient than household laundry. Product durability is mainly achieved through mixed synthetic fibers. Cotton suffers a weak image due to its lower durability and the environmental impacts during cultivation. Through repeated maintenance and repair some parts have been over ten years in use.

Logistic frequently recalculates the most economic routes for delivery thereby also reducing emissions. By collaborating within the DBL, the environmental performance profits from the smaller radius of delivery, compared to competitors. Considerations of biodiesel for propulsion failed as the vehicles insurance coverage could thus not be further guaranteed.

DBL partners individually handle ecologic efforts at production sites. Some are taking stronger action than others, relying on renewable energy or operating own sewage plants. Marwitz uses recuperators for heat recovery in the washing process. Detergents are also efficiently used through computerized application. The responsibility for efficient machines is externalized to the producers. These are expected to further develop and push resource-efficient technology by competing on the market. In the laundry sector, water as a resource linked to core business activity, is very present although the absolute usage is not higher than from other branches.

Individualized workwear with several parts for replacement leads to huge amounts of disposed textiles. These are so far either sold in foreign countries or incinerated. Bio-compatibility of the products has been recognized as a problem but circular approaches as Cradle-to-Cradle are still at the very beginning.

Due to a heritage of carcinogenic perchlorethylen from dry-cleaning, ecological efforts are not offensively communicated by Marwitz. The pollution on old company sites is currently restored under governmental control.

Social sustainability is primarily aspired by good working conditions for the employees. Marwitz's employee structure encompasses all levels of qualification, from academics in management to trained technical professions and unqualified personnel in production. For the latter, Marwitz offers the possibility of long-term employment with reasonable payment. Wages are always higher than the lower branch average and in most times over the upper branch average and thereby above minimum wage.

Low fluctuation rates within the firm lead to long periods of employment. Many employees have a twenty or thirty year history of company affiliation. Hence work conditions have to be adapted to elderly employees in the future. The bonus wage system in production for example is putting pressure on elder personnel physically not able to earn the extra reward. This raises conflicts in teams with differing capabilities or ambitions. Provisioning in sales however seems to work as a motivator and steering instrument for the personnel. Professionalization in health management is achieved through a qualified worker in safety issues, made necessary by currently 180 employees. Technical development of machines and

work processes raises the complexity of jobs in production, leading to problems with a deaf-mute employee in facility one.

The management is very committed to provide an enjoyable work atmosphere. This social commitment particularly showed when the new sorting plant was installed. From the beginning employees were assured, that the technical professionalization would not lead to a reduction of work places. Most important criterion in planning was the most silent operation of machines for a commode work sphere in the new facilities. During the installation, plans for shift work were designed especially suitable for mothers working in production.

The management's high commitment is evident but neither documented nor externally communicated. The efforts shall not be seen as legally binding through textualisation. CEOs want to maintain flexibility, reacting to upcoming hurdles individually. Helping employees in cases of financial difficulties or nursing cases in the family are examples of such individual support. As a further example, employees were conveyed to DBL partners when moving. Managerial staff principally tries to keep a sympathetic ear for the workers. Flexibility regarding job-sharing or home-office is not as present though, as this only becomes possible in leading positions.

The senior managers couple was honored for their lifetime achievement and successfully transferring the business to the younger generation. The price also emphasized outstanding social commitment in the region.

Moreover, a nearby daycare facility providing lunch and homework attendance for children and a children's orphanage receive financial support. Marwitz regularly offers internships to the teenagers. Instead of recruiting personnel for further employment, this relationship is primarily maintained to provide daily routines and insights of the work sphere to the juveniles.

The *cultural dimension* is reflected in both, the company's internal and external positioning. Internally, the match of leading personnel to the company's culture was mentioned as the main criteria in recruitment. Externally, Marwitz identifies with the municipality by being a regional family owned service provider. Regional commitment explicitly proved in not shifting the facilities to Bremen when the opportunity arose. This mindset is moreover reflected in the continuous adaption to customer's culturally varying wishes.

4.2 Evaluated Design Thinking Workshop for S.PSS Development

Based on the six-phased DT process (chapter 2.3.1), adaptations were made, as the inclusion of further methodologies. The aim was, as indicated by research question two, to create an applicable DT Workshop for sustainable Product-Service System development. For achieving explicitly sustainable PSS outcomes, the ‘Impact’ phase, consisting of two steps (chapter 4.2.16, 4.2.17), was added to the DT process as a seventh bubble. The resulting workshop consists of 18 workshop steps over three days, with six steps each (Table 8).

4.2.1 Workshop setting

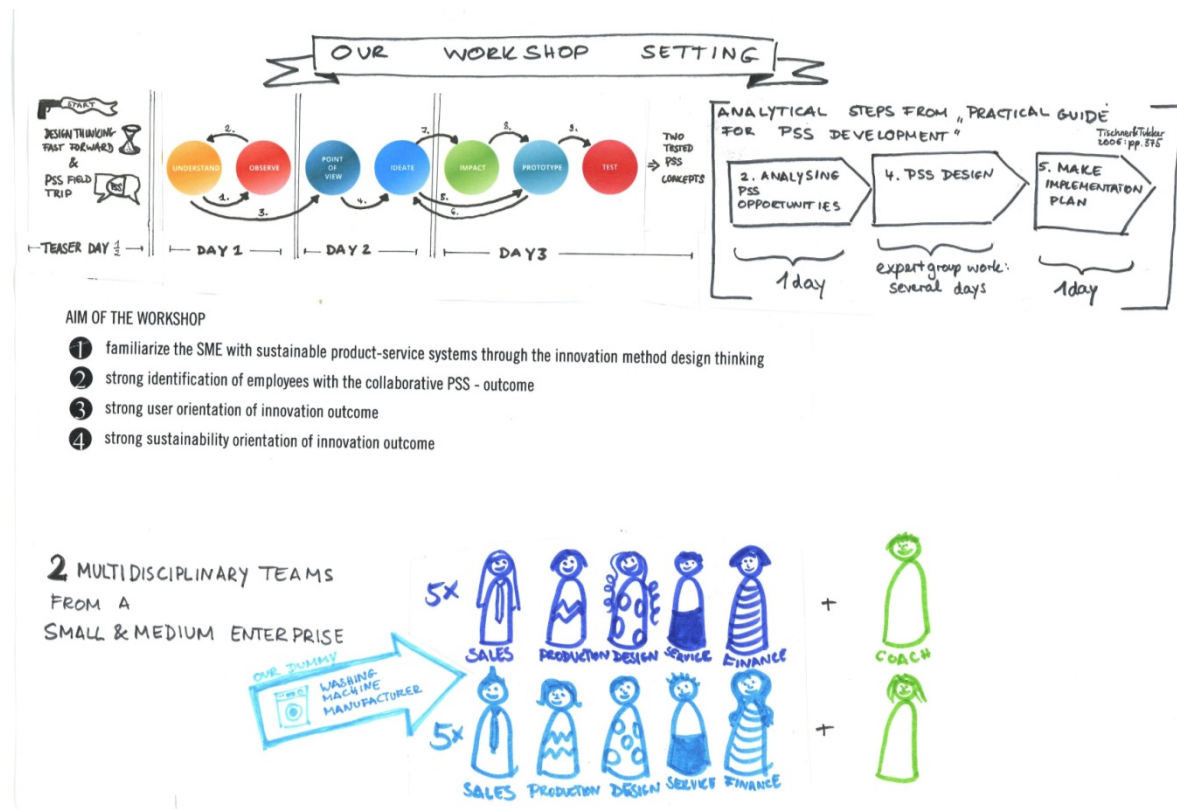

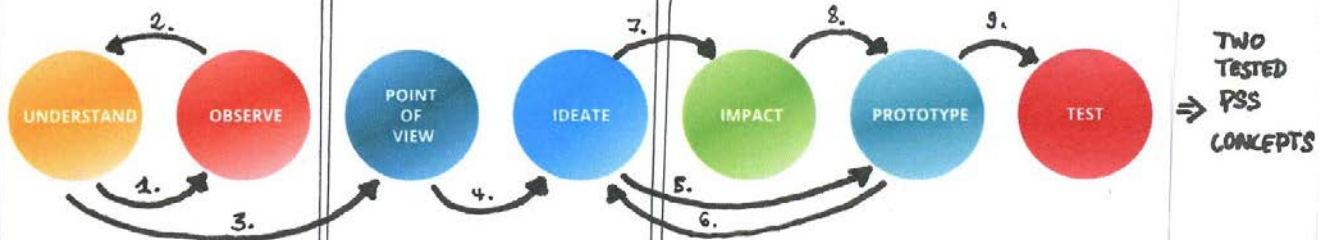


Figure 22: Workshop Setting

The presented DT workshop for sustainable Product-Service System Development consists of 18 steps, conducted within three workshop days and a preparatory teaser day with the duration of half a day (Table 8). It builds on the six DT steps, plus the self-added “impact step” for strong sustainability-oriented solutions. Results are two user tested PSS concepts, strategically oriented towards a product based manufacturing SME, establishing a PSS in B2C relations.

Table 8: Overview of the DT Workshop for sustainable Product-Service System development showing a) the scheduled division of the DT phases into a preparatory- and the three workshop days b) the iterations between the DT phases c) the group mindset required for the each phase and d) the workshop steps related to each phase.

 <p>Teaser Day</p>						
<p>½ day</p>	<p>1st Workshop Day Step 1 - 6</p>		<p>2nd Workshop Day Step 7 - 13</p>		<p>3rd Workshop Day Step 14 - 18</p>	
<p>It's fast and possible!</p>	<p>Discover the challenge!</p>	<p>Find aha-experiences!</p>	<p>User + Need + Insight = Point of View</p>	<p>Go for quantity!</p>	<p>Make it sustainable!</p>	<p>Build to learn, not to last! Show, don't tell!</p>
<p>DT Fast Forward Experience Day at S.PSS Company</p>	<p>1. Get to know the Group 2. Get to know the Team 3. Understand the Challenge 4. PSS Story-board Puzzle 7. Sustainability Strategies</p>	<p>5. Interview the User 6. Storytelling</p>	<p>8. Stanford Point of View</p>	<p>9. Service Brainstorm 10. Clustering on Polarities Diagram 11. Filtering 13. Product Brainstorm</p>	<p>14. Impact mapping 15. Impact Brainstorm</p>	<p>12. Service Storyboard 16. Tangible Prototypes 17. Test 18. Next steps</p>

Moreover the SME gets familiarized with DT and creates an outcome with strong employee identification, user orientation and sustainability potential (chapter 3.2). With further modifications the presented workshop can be likewise applied to develop PSS concepts for B2B markets or suited to a service based SME. The outcomes of two self-developed and tested ideas may serve as a basis for an analytical follow-up process, facilitating the implementation. The subsequent in-depth analysis was developed and published by Arnold Tukker and Ursula Tischner with the steps of analyzing PSS opportunities, PSS design and making an implementation plan (2006a, pp.375).

The DT workshop is conceptualized with the moderation of two coaches. For the facilitation of the DT workshop for S.PSS development in practice, the authors presuppose sustainability and PSS related knowledge presented within the literature review of this thesis (chapter 2) and additional moderation skills related to DT or innovation methodology. Each coach works with a group of five employees from the client's company. In the following, the coaches are symbolized through green illustrations and the two teams are portrayed by blue color shades. Red was chosen for user-specific content. The teams are multidisciplinary assembled by respectively integrating different departments of the SME. The CEOs explicitly do not participate in the workshop because it was designed as bottom-up innovation to foster employee approval of the related change processes. Experts commented that within SMEs there might not be enough participants from five different departments. Anyhow, diversity of the team and high motivation of participants should be considered for team selection. It can also be helpful to include creative company-extern participants with DT process knowledge in the teams. For motivation and positive group dynamics, managing expectations of the participants previous to the workshop is highly recommended by experts from all fields.

4.2.2 Teaser Day

A teaser day is held prior to the workshop with the overall aims of a) familiarizing the team with the method of DT and b) giving practice insights into both, the complexity and the economic opportunities, PSS business models are distinctively characterized by. Therefore all participants run through a DT fast forward challenge, performing the process within one hour and visit an S.PSS company during an experience day.

a) DT Fast Forward

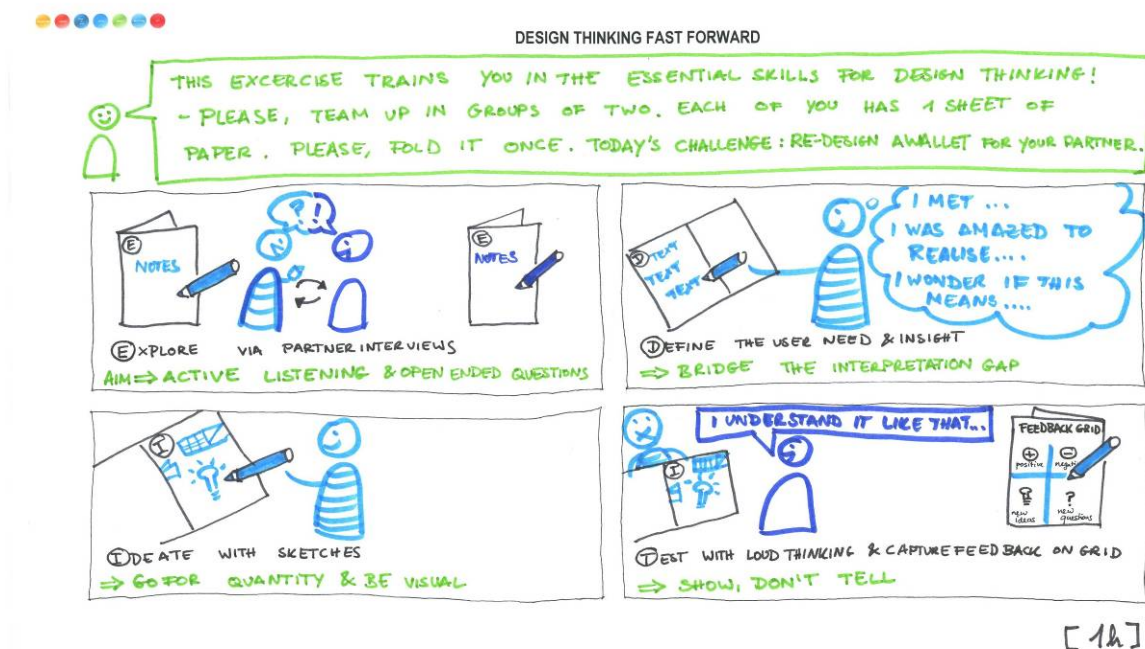


Figure 23: DT Fast Forward (inspired by the ‘Wallet Project’ by d.school Stanford 2012, EDIT by George Kembel).

The fast forward exercise trains the team members in the essential skills required for DT. The condensed DT process illustrates the main process steps by re-designing a wallet and following the EDIT-steps of Exploring, Defining, Ideating and Testing:

- E: All participants team up in couples and interview the respective opponent on the requirements of their purse. Conducting this step in two sessions each, trains posing open-ended questions and active listening during interviews. Insights are noted on the first page of a folded sheet of paper.
- D: For bridging the gap between observation and interpretation, the participants condense the “aha-moments” and reformulate them in own words on the reverse side of the interview notes.

- I: Everybody then brainstorms on possible solutions, suiting the opponents' needs. The upcoming ideas are documented by sketching on the paper. This trains the participants in generating multiple ideas and expressing these visually.
- T: Participants capture feedback on a grid constructed on the papers' backside while presenting the ideas to the opponents. They are advised to not defend their ideas but to listen to the feedback carefully.

Overall this step shows that DT can quickly produce applicable results, which strongly correspond with the user needs. Performing the fast forward exercise on a single sheet of paper highlights that DT highly depends on engaging in the process and is feasible without much supporting infrastructure.

b) Experience Day at S.PSS company

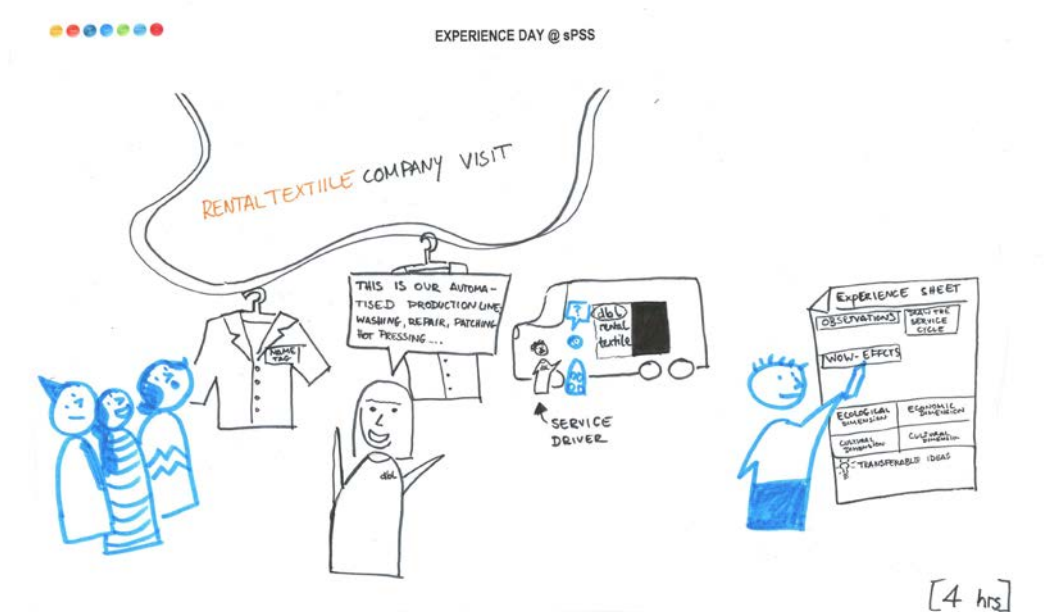


Figure 24: Experience Day at S.PSS company (own method inspired by Scholz & Tietje, pp.243)

The coaches arrange an experience day for the workshop participants, visiting a S.PSS offering company. The teams are prepared to analyze what characteristics are key to simultaneously professionalize in product and service distribution. While visiting the company sites, participants are moreover asked to document sustainability relevant characteristics together with interesting observations and transferable ideas on an experience sheet. The experience sheets are afterwards recapitulated in groups of two and then presented in the plenary. Giving feedback on this step within all evaluation iterations experts were skeptical about the practicability but also recognized the benefit of giving a practical example as a reference point. Alternatively, a presentation and discussion with an S.PSS providing CEO or sales manager was suggested to report on the business model. Business consultants recommended raising awareness by asking participants about improvement-suggestions and equipping teams with cameras for follow-up analysis.

4.2.3 Day 1 - Get to know the Group - Warmup

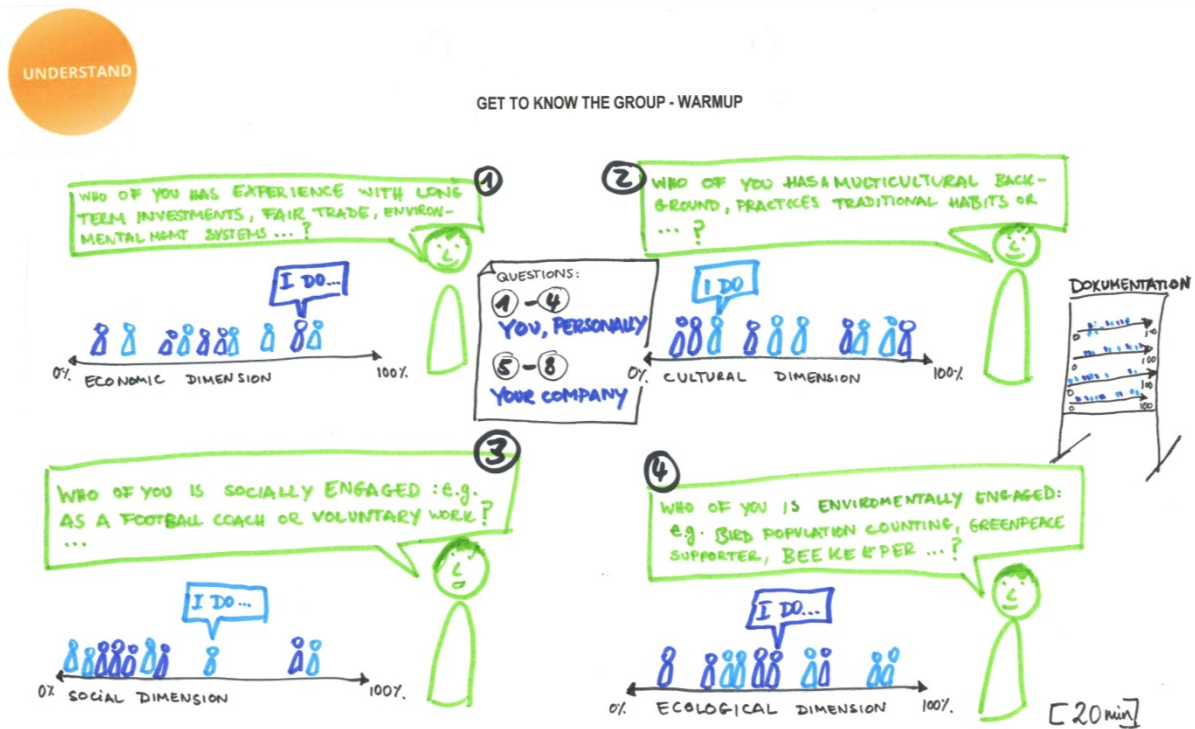


Figure 25: Get to know the Group - Warmup (own method).

As a warmup all group-members are asked to line up on a spacial diagonal with regard to each of the four sustainability dimensions. The coach gives real life examples related to the economic-, ecologic-, social- and cultural sphere. The group-members self-estimate and then indicate their knowledge or commitment towards the respective sustainability dimension between zero and one hundred by positioning themselves between the poles of the diagonal. The group members then quickly comment the own position on the continuum. This process then is repeated by estimating the company’s position on the polarities diagonal. The coach documents the positioning on a flip chart, which may serve later as a reference for sustainability achievements. The aim of this step is four folded. First, the participants become familiar with each other, secondly relate sustainability dimensions to daily life issues and thirdly reflect on sustainability within the company. Fourth, an open and agile working atmosphere is established. DT Experts recommended performing this step as a group warmup, before going into the individual teams. Repeating the evaluation on the perceived company sustainability performance was also brought to the concept by expert-feedback.

4.2.4 Day 1 - Get to know the Team



Figure 26: Get to know the Team (own method inspired by d.school HPI Potsdam).

For an introduction to the working-team of five members, each employee fills out a personal template that contains issues to reflect on. Examples include the last vacation, the role within the company or a personal superpower, symbolized by a hero. These issues may be adapted to be more formal or informal according to the setting. Each team member then presents him/herself within three minutes. Furthermore, positive and negative experiences of working in groups are shared within the flashlight, giving the coach opportunity to adapt the moderation to the group dynamics. For the success of this workshop step, the coach encourages participants to dare to show personality, to be funny and to go beyond classic status introduction. Thereby the recognition of team resources and mutual acceptance is fostered. PSS scientists and consultants were concerned that participants may not like to present themselves in a colloquial manner while DT coaches recognized the contribution to the working atmosphere. The aim here is to form a collaborative team by learning about individual preferences, responsibilities within the company and qualities of the various team members.

4.2.5 Day 1 - Understand the Challenge

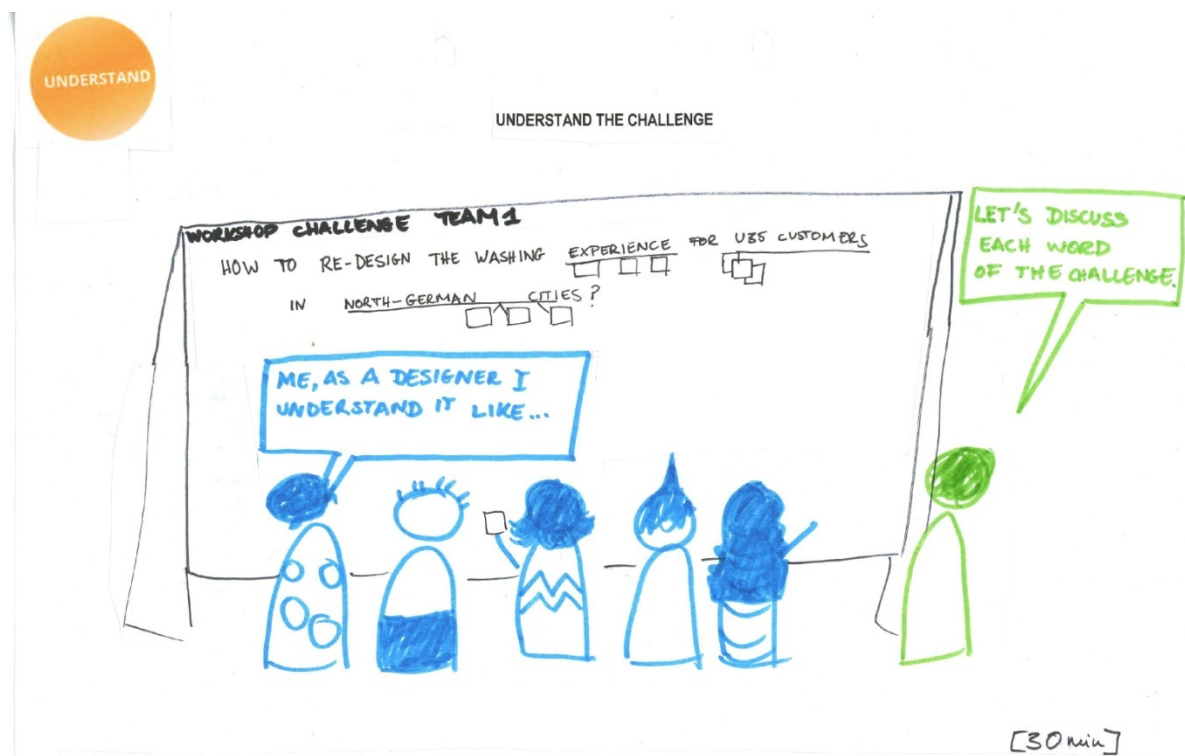


Figure 27: Understand the Challenge (inspired by DBL Marwitz, d.school HPI Potsdam; Nast 2006).

Previous to the workshop and on behalf of the CEOs, the coaches frame a part of the portfolio to be transferred into a PSS business model. As two teams are working on individual challenges, the management decides that teams work on equal tasks, on different portfolio segments or customer clusters. The chosen definitions are then formulated into ‘How to re-design...’-questions for the team challenges. When presented at the workshop, the teams discuss the precise understanding of the wording and the task by pinning individual interpretations to the aspects of the challenge. Experts stressed the importance of giving the participants the opportunity to re-define the challenge for a personal identification with the DT challenge. Opinions diverged on the level of pre-set operationalization in the task. The wording of ‘re-designing’ the user experience was chosen due to its low level of complexity in contrast to an academic PSS wording. The aim here is achieving a common understanding and a personal connection to the challenge within the team. The joint discussion of the problem already enhances creativity for its solution. A DT coach suggested that the team should be asked to envision the social environment, as work sphere or private conditions, of the client groups to open cognitive spaces.

4.2.6 Day 1 - PSS Storyboard Puzzle

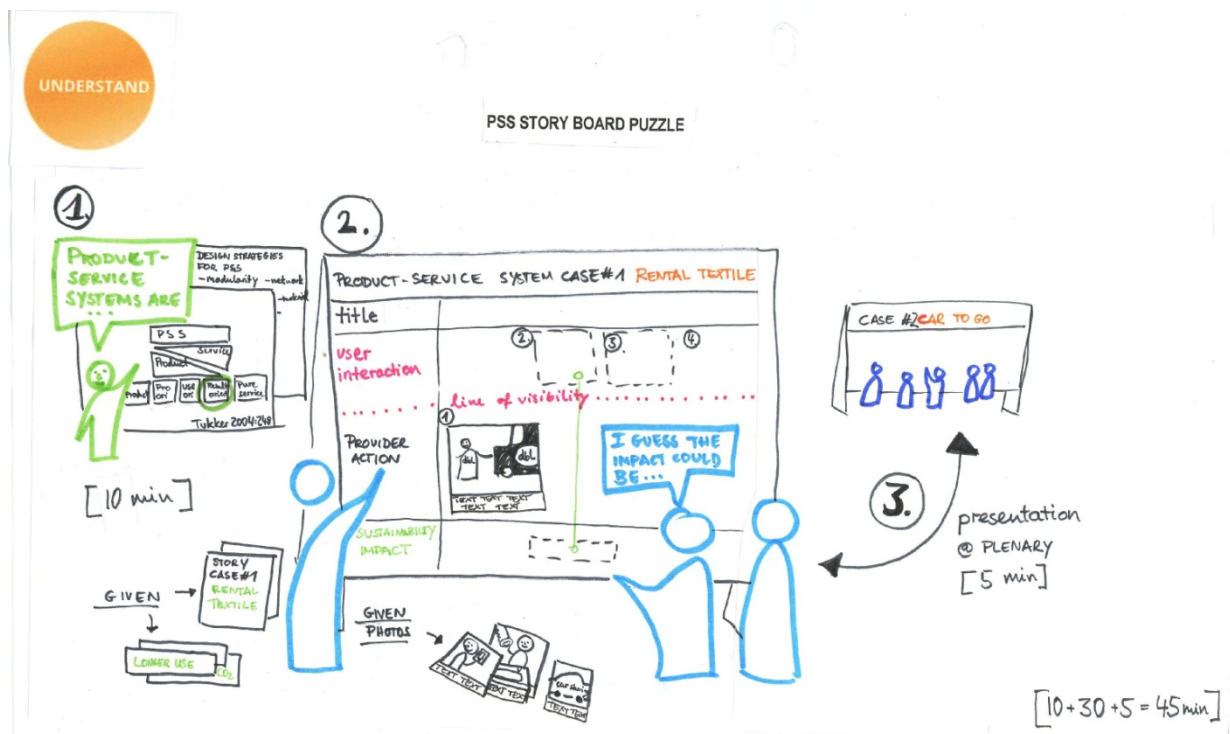


Figure 28: PSS Storyboard Puzzle (own method inspired by Vezzoli et al. 2014, pp.123, pp.147).

The coaches first give input on the concept of S.PSS and related design strategies by using the illustration from Tukker (2004). The group is asked to allocate current business activities within the presented continuum for a better understanding. Subsequently, the coaches provide templates on which each team creates a PSS storyboard. On the basis of given case stories and additional information, such as subtitled photos, illustrations and sustainability impact cards, the team members are asked to analyze the interaction between user and provider over the life cycle. This step requires substantial preparation by the coaches but it enables a deep understanding of S.PSS characteristics and leverage points for sustainability impacts within the collaborative team. Finally the results are presented to the complementary team as inspired by DT expert feedback. PSS scientists further underlined the relevance of selecting an exemplary case with relevant analogies to the particular business. As an alternative, business consultants also suggested the possible self-preparation on the basis of provided material for directly discussing the results in the workshop. Here, the collaborative solution of the task has the aim to enforce individual understanding.

4.2.7 Day 1 - Interview the User



Figure 29: Interview the User (inspired by d.school HPI Potsdam).

The teams first prepare to interview potential users, as framed within the challenge. In order to do so, they reflect on issues to address, figure possible locations for interaction and are divided into teams of two with one interviewer and one observer. The participants are encouraged to rotate positions in order to gain competence at each station. Most important is a preparation on how to interview the user, instead of providing a question catalogue. The interviews are conducted for getting a diverse picture on problems instead of evaluating first ideas on the challenge. Hence, what- and why-questions are posed to inquire customer motifs, needs, behaviors and preferences, adding to the picture of ‘the job to be done’. During interviewing the observer is responsible for documentation. For a more vivid reflection the interviewers should either take a picture of the interviewee or capture the approximate age and gender on the backside of the notes. If willing to further participate in the test phase, especially enthusiastic interviewees should be asked for their contact details. Experts highlighted the need for preparation to fruitfully gain insights from the real world, which then serve for verifying assumptions as well as a source of inspiration. To prepare, the coaches can provide a map with possible interaction points or even book the matching customers from a market survey agency. Feedback moreover suggested conducting expert interviews or the questioning of extreme users.

4.2.8 Day 1 – Storytelling

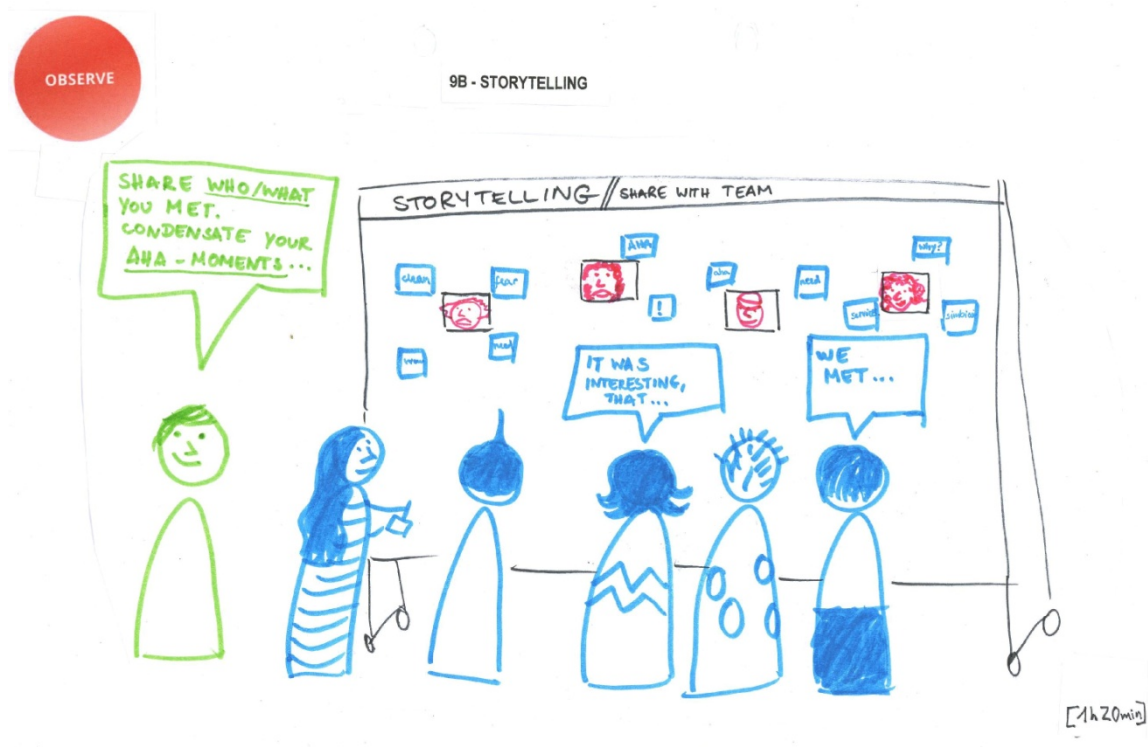


Figure 30: Storytelling (inspired by d.school HPI Potsdam).

During storytelling the team members report on their observations and insights from the field. The coaches keep up the speed by reminding to only briefly report on the setting and be precise on interesting insights. The stories must be short and contain the relevant “aha-moments“. Thereby only the important findings are shared within the team. The documented pictures and user characteristics support the stories, adding to a vivid understanding. After each of the short presentations, time is given for asking questions and clarifying certain aspects. During storytelling the coaches facilitate the documentation and clustering of given insights on the whiteboard. Expert feedback underlined storytelling as an essential step for synchronizing the team on practice needs, which later serve as the basis for user-centered solutions. DT coaches stick to the basic rule that a quarter to a third of the questioning time should be dedicated to for storytelling. Finally the teams commonly try to identify underlying trends from corresponding insights.

4.2.9 Day 2 - Sustainability Strategies

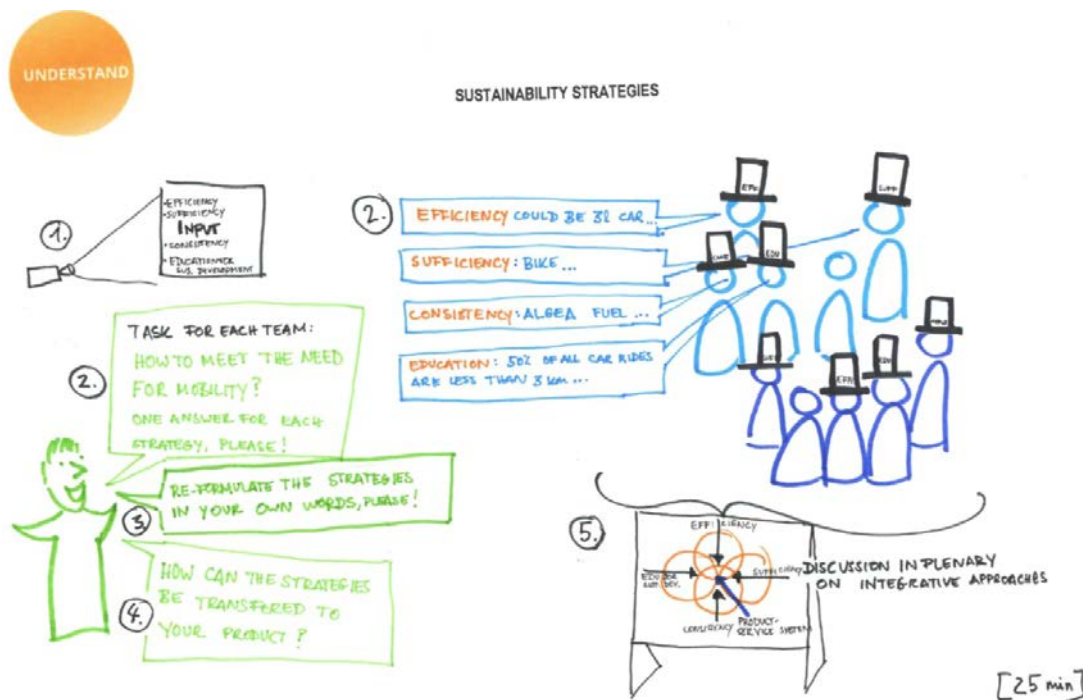
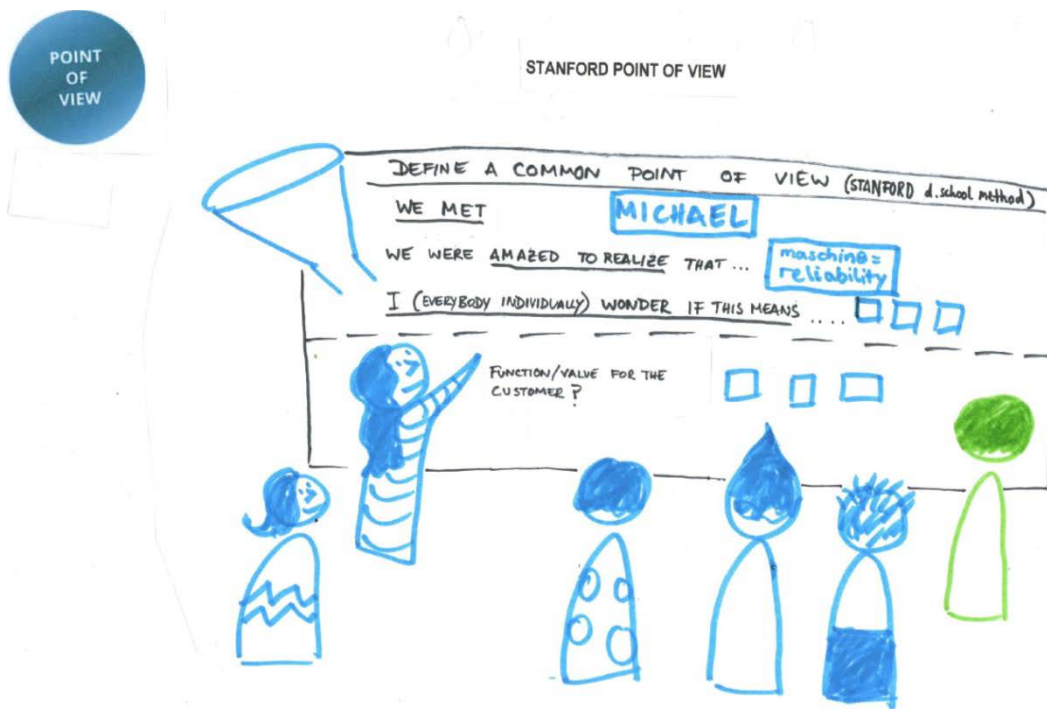


Figure 31: Sustainability Strategies (own method based on theory by Huber 1995a, pp.31).

The second workshop day starts with an input on the four sustainability strategies: efficiency, consistency, sufficiency and education for sustainable development, presented to both teams. The plenary is first asked to apply each sustainability strategy to the need of mobility as a given example. After reformulating the strategies in own words the teams are asked to relate the strategies to the company’s own product, as recommended by expert feedback. Therefore the four strategies are assigned to the participants, each representing one approach. By giving time to reflect on the nominated strategy a richer contribution from each perspective is achieved. The answers are then discussed in the plenary and formulated towards an integrative approach with assistance of the coaches. The step of integration is essential for understanding the mutual aim of the strategies and is visualized on a board. The sustainability strategies have to be understood as supportive instead of competitive and serve as a source of inspiration for the following process. Experts liked the operationalization of this step, making a very complex issue applicable for novices and showing the diversity of possible solutions. For a deeper understanding they further suggested to provide multiple examples in the first place, to apply the strategies to each of the dimensions or to first use reverse brainstorming facilitating the integration discussion.

4.2.10 Day 2 - Stanford Point of View



[1h]

Figure 32: Stanford Point of View (d.school Stanford 2014; Tukker & Tischner 2006a, p.380).

The teams recapitulate the practice insights from storytelling by displaying the previous day’s results. The point of view summarizes these insights within one fictional user. The coaches therefore provide templates with the fields: ‘We met ...; We were amazed to realize that ...; I wonder if this means ...’ to capture the user, the need and the practice insight. After agreeing on the first two steps, the latter ‘I wonder if this means ...’ -field is individually brainstormed on. The results serve as a basis for a discussion on the critical function behind the product, which ultimately delivers value to the customer. The aim here is breaking down the gained insights and thereby revealing their hidden value. Expert workshop evaluation suggested further specifying and dividing the customer value into its technical and emotional function. DT experts, familiar with this method agreed on the Stanford method being more beneficial than a visualized persona, as the latter may be misleading from the actual observations. Experts further recommended constructing several points of view for additional iterations of the DT process and classifying the customer needs into must-be and attractive requirements.

4.2.11 Day 2 - Service Brainstorm

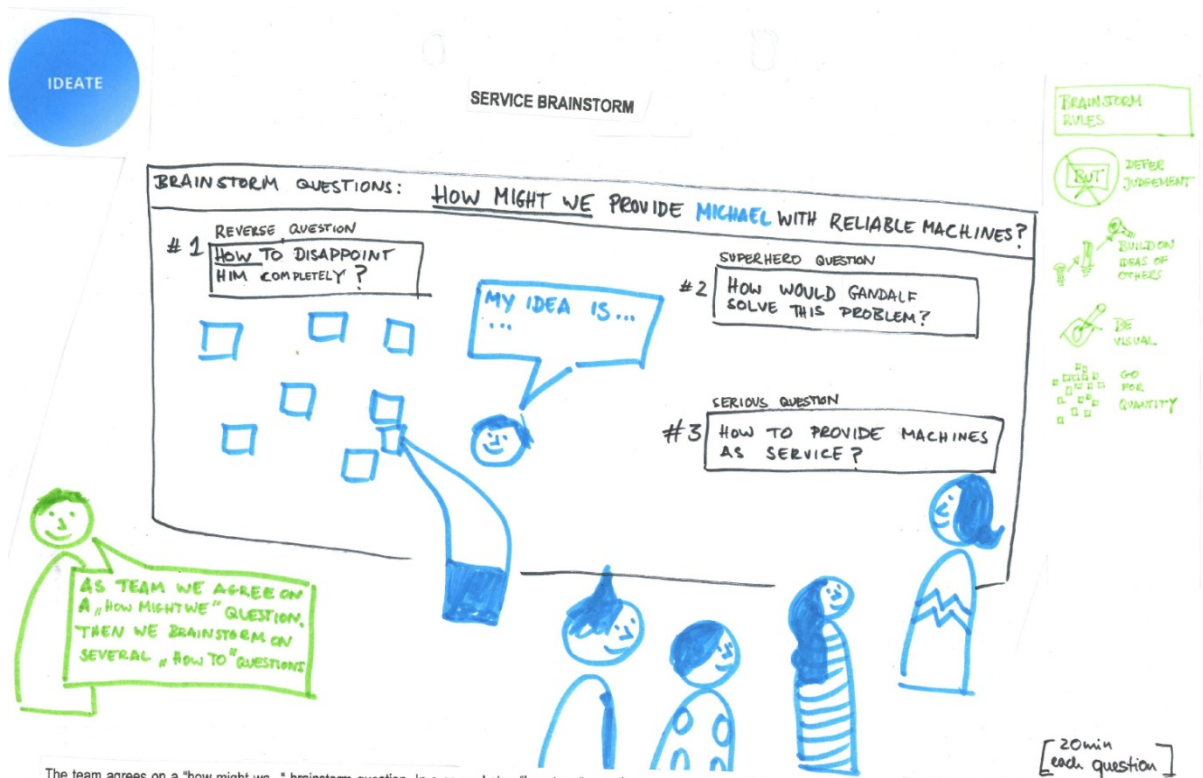


Figure 33: Service Brainstorm (own method inspired by d.school HPI Potsdam, Osborn 1963 cited as in Dow et al. 2011).

For the subsequent service brainstorm, coaches explain and then insist on following the brainstorming rules, which are: defer judgement, build on the ideas of others, be visual and go for quantity. Building on the point of view definition, the team agrees on a ‘How might we...’ brainstorm question. Then various ‘How to ...’ questions are posed on which team members generate ideas and pin them to a board with sticky notes. The coaches meanwhile stimulate the creativity process of their teams by posing reverse questions, superhero questions and serious questions. Superhero questions ask how people with special abilities, for example Gandalf or Superman, might solve the problem and thereby enable thinking outside of any limitations. The aim in service brainstorming is to generate wild ideas with a strong service orientation. Experts with DT experience suggested repeating the service brainstorming process for multiple critical functions if revealed within the point of view. It was further proposed to discuss and document ideas that have already emerged in both teams before brainstorming. Moreover DT coaches recommended to first conduct a creativity-enhancing warmup and then go into the brainstorming session. For maintaining overall productivity and concentration in the group this step should not exceed one hour.

4.2.12 Day 2 - Clustering on Polarities Diagram

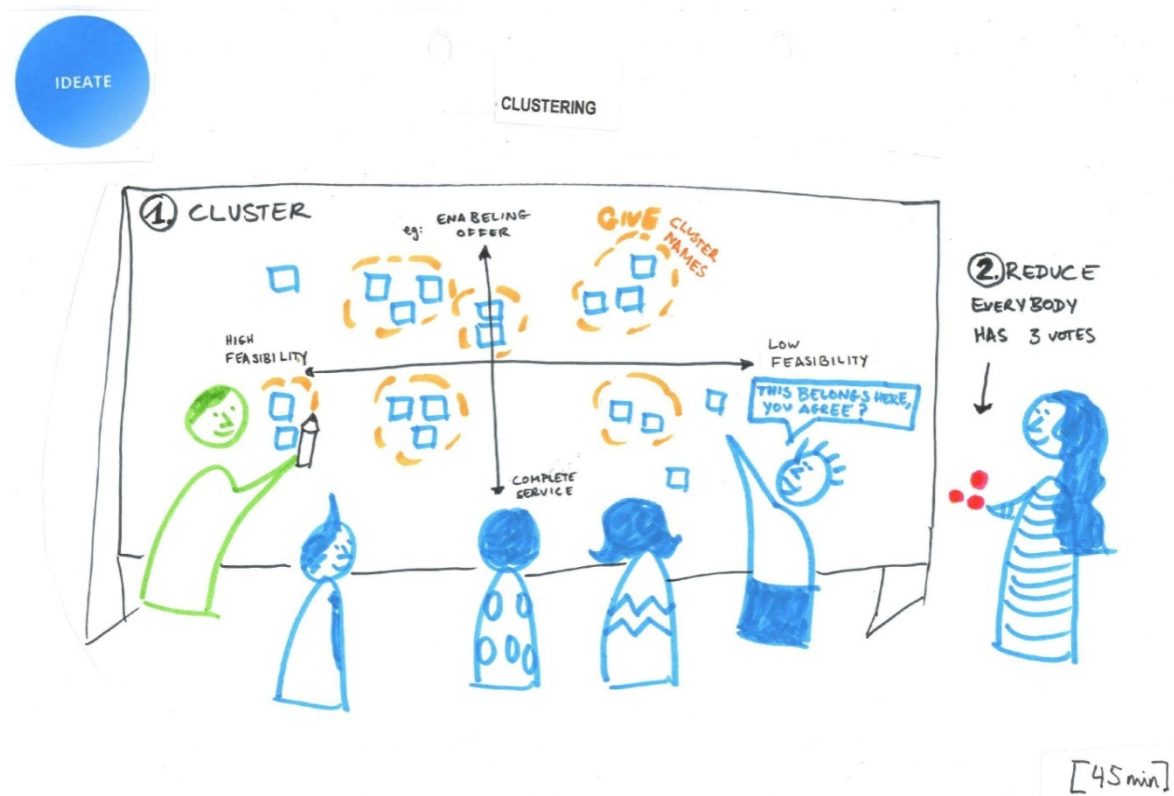


Figure 34: Clustering on Polarities Diagram (inspired by Vezzoli et al. 2014, pp.158).

For structuring the previously generated ideas and reducing the options, the clustering step is conducted. The coaches construct a polarities diagram with two axes and two complementary characteristics each. With the help of the coach, team members re-pin their ideas from service brainstorming on the diagram and define idea-clusters. Each cluster is given a title to express its deeper content. In a second step, team members vote for their favorite ideas via stickers. During prototype testing, experts accentuated the adaptive choice of criteria according to the case. A PSS researcher found the clustering process to be idea stimulating for additional iterations in the process, while another suggested performing this step with both teams' attendances. Besides the broad approval a concern regarding the complexity of service ideas was mentioned, as these may simultaneously consist of both, high and low feasibility aspects. Therefore the proposal of displaying different aspects of a single idea was made. Hence, it is crucial that the coaches pay attention to the conditions of the case and characteristics of the ideas for successfully individually adapt the clustering process.

4.2.13 Day 2 - Filtering

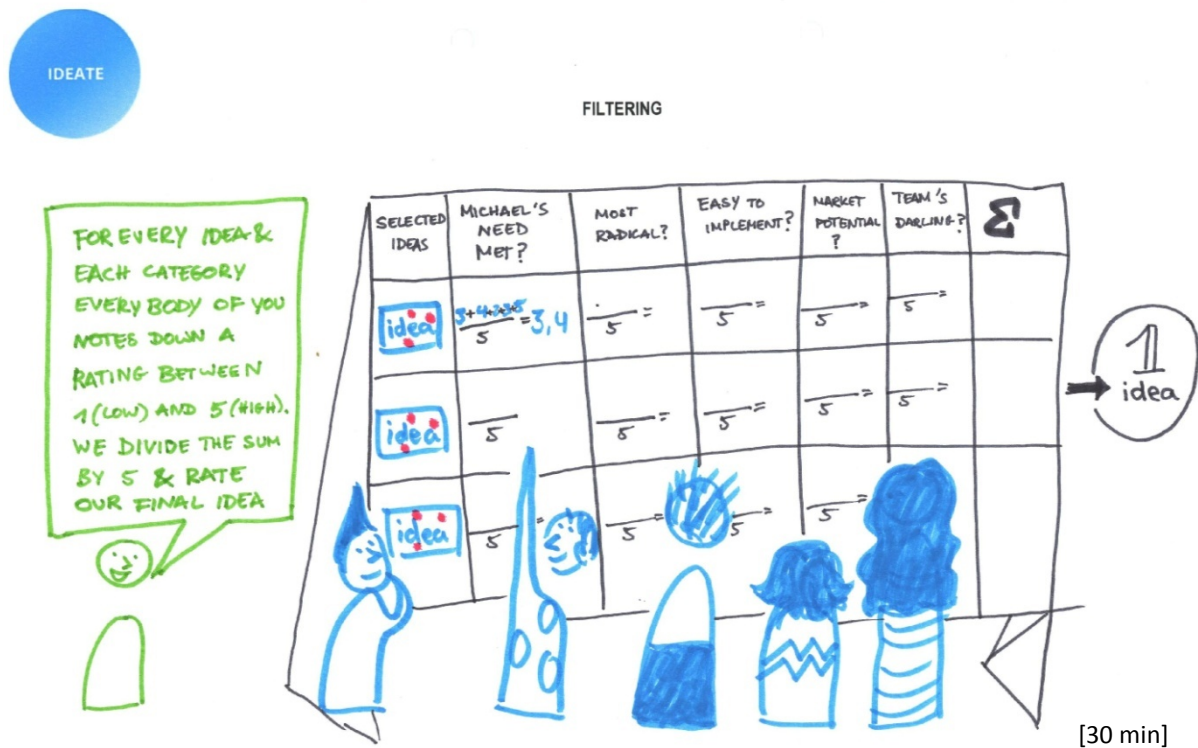


Figure 35: Filtering (own method inspired by Blue Engineering, Tukker & Tischner 2006a, pp.386).

In the process of filtering, the most-voted ideas from clustering are weighed against several criteria. First, team members are asked whether the service ideas a) meet the user needs, b) are radical, c) are easy to implement d) meet an expected market potential or e) are favored by the team. If certain guidelines apply to the company, additional individual categories can be added to the filter. The coach prepares a filter template on which the team members evaluate the ideas in each category by giving points from one to five. The mean values are calculated and summed up per idea. The highest sum decides which idea passes the filter. DT experts recommended further operating with only a single idea, as the enthusiasm for working on perceived inferior ideas rapidly decreases. Business consultants argued that the estimated rating, especially of the category market potential, should be complemented by a deeper analysis. The last category can be seen as redundant with the rating of the clustering step. This second evaluation should stimulate the discussion between participants. Although atypical for DT this step was rated positively by all groups of experts.

4.2.14 Day 2 - Service Storyboard

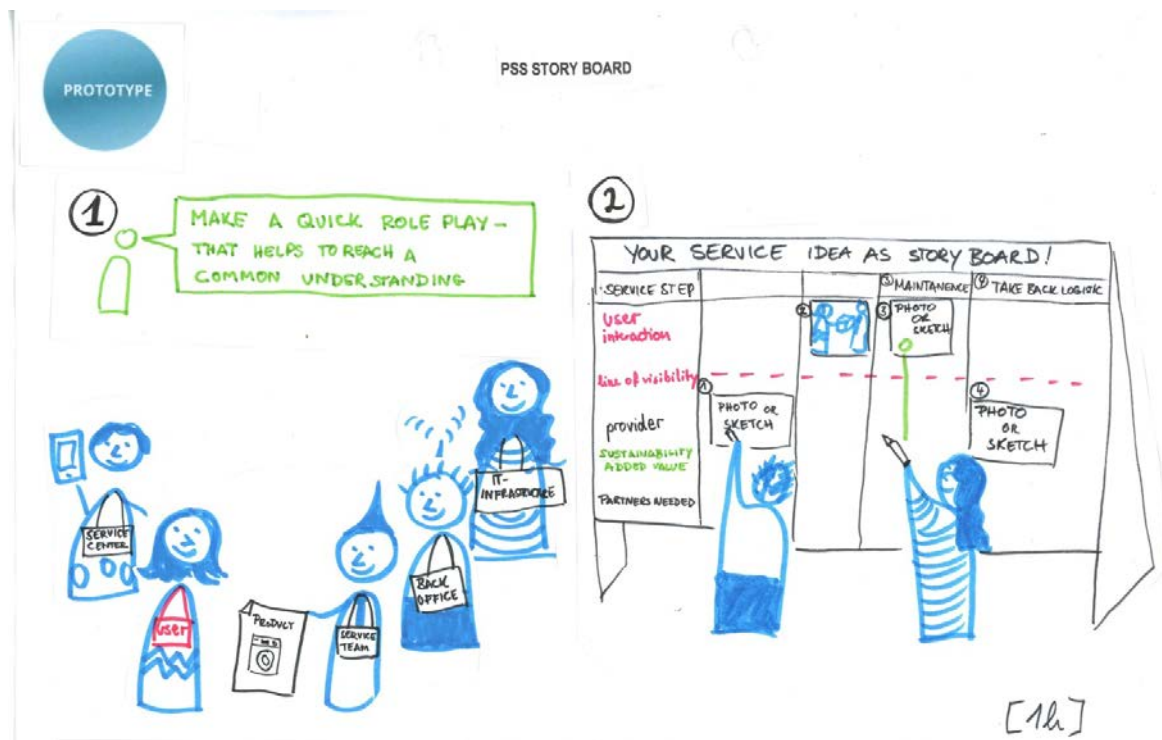


Figure 36: Service Storyboard (inspired by d.school HPI Potsdam; Tietze 2013 at CAU Kiel, Vezzoli et al. 2014, pp.123, pp.147, Shostack 1984).

For PSS storyboarding the teams first do a role-play in which the selected service idea is briefly exercised. Each team thereby independently transfers the PSS facets into a joint experience. The team members take the roles of the user, the involved employee positions and if needed external stakeholders. Thus the team synchronizes and achieves a common understanding of the service idea with all its major processes involved for service delivery. The aim of the role-play is enabling a better envisioning and understanding of the service aspects. Afterwards the teams sketch the process on a storyboard, using the same template as for the storyboard puzzle. A line of visibility differentiates between user interaction, and back-office company activity. The constructed storyline is illustrated with pictures or icons, partners for service delivery are listed and sustainability impacts are highlighted. This serves for documenting the common understanding of the steps involved in front and behind the scenes. Conducting the role-play and the storyboarding as a common thought experiment was encouraged by expert feedback, who further pointed out the importance of good facilitation by the coaches. DT experts suggested to extract and document underlying hypotheses from this step for the testing phase.

4.2.15 Day 2 - Product Brainstrom



Figure 37: Product Brainstrom (own method).

For adapting the product to complement the previously envisioned service model, the product brainstorm is conducted. The sequencing of first designing the service aspects and then adapting the product was highly approved by experts from all fields, arguing that herein most sustainability potential is exploited. Moderated by the coaches, the team brainstorms on a ‘How might we re-design...’-question, how to best suit the product to the service idea. Then more specific ‘How to ...’-questions are posed on the practical component of different service aspects. Brainwriting can be used as an alternative to the brainstorming method, if obeying to the brainstorming rules proved to be difficult within the group. DT experts recommended to roughly prototype first ideas of product modifications within the brainstorming session. Thereby the participants achieve a deeper common understanding on critical issues to resolve, which otherwise might be too complex and are likely to be misunderstood. Within this process step the coaches stimulate creativity by questioning and reminding the teams to bear the target group in mind, as formulated within the challenge or point of view. Within a discussion the group settles on up to three sticky notes.

4.2.16 Day 3 - Impact Mapping

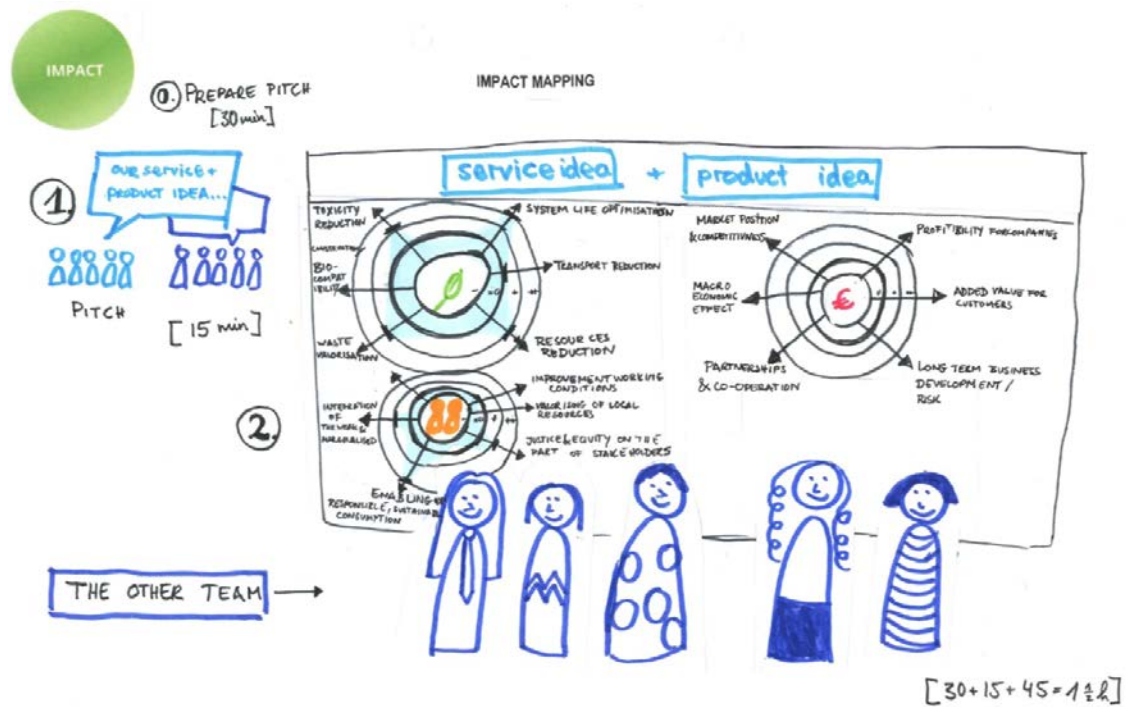


Figure 38: Impact Mapping on: 1. ecologic dimension: a) toxicity reduction, b) bio-compatibility, c) waste valorization, d) resource reduction, e) transport reduction and f) system life optimization; 2. social dimension: a) improved working conditions, b) enabling of sustainable consumption, c) equity and stakeholder justice, d) valorizing local resources and e) integration of weak and marginalized; 3. economic dimension: a) competitiveness, b) profitability, c) added customer value, d) long-term opportunity, e) cooperations and f) macro economic effect (own method inspired by Tischner et al. 2000, Vezzoli et al. 2014, p.113, van Halen et al. 2005, p.165).

The third workshop day starts with both teams mutually presenting their results from the previous day within a pitch. After a preparation, short presentations give first insight to the product-service system ideas. For a better understanding, simultaneously displaying the storyboard and presenting the ideas within a short commercial was recommended by experts. The teams then respectively evaluate the other presentation on an impact map, depicting sustainability criteria in ecologic, social and economic dimension. Thus the sustainability impacts of the other teams’ PSS solution are assessed, indicating strengths and potentials for improvement. The coaches provide spider-web diagrams to rank strong-, weak-, non- and counterproductive characteristics in each dimension. Experts rated this step positively without exception and found the best guess evaluation sufficient, as impact mapping mainly serves as an inspiration for further improvements. Ursula Tischner, this method’s originator, suggested to first explain the criteria and remind participants on the sustainability dimensions experienced within the group warmup step. Knowing the questioned criteria in the first place is important for the participants to later judge the presentations. By widening the audience to the

CEOs, the short presentations also provide the possibility to give management first insights into the PSS ideas.

4.2.17 Day 3 - Impact Brainstorm



Figure 39: Impact Brainstorm (own method based on Ketchie et al. 2013, p.44).

The results from previous impact mapping are displayed and serve as a basis for impact brainstorming. The teams reflect on the impact map evaluation and refine their ideas through brainstorming on how to improve sustainability criteria. Therefore the coach poses reverse questions on the four sustainability dimensions for instance: 1. ecologic dimension: ‘How to produce most of unhealthy and non-recyclable waste?’, 2. social dimension: ‘How to make it socially unfair?’, 3. economic dimension: ‘How to make it least profitable?’ and 4. cultural dimension: ‘How to make it suitable only for western lifestyle?’. The input on sustainability strategies is also expected to help modifying the PSS ideas towards a strong sustainability orientation. Expert feedback confirmed the potential contribution of the impact step for creating S.PSSs and underlined reverse questioning as an especially beneficial method for stimulating additional improvements. A PSS scientist argued that this step provides the opportunity to rearrange teams for further working on favored ideas.

4.2.18 Day 3 - Tangible Prototypes

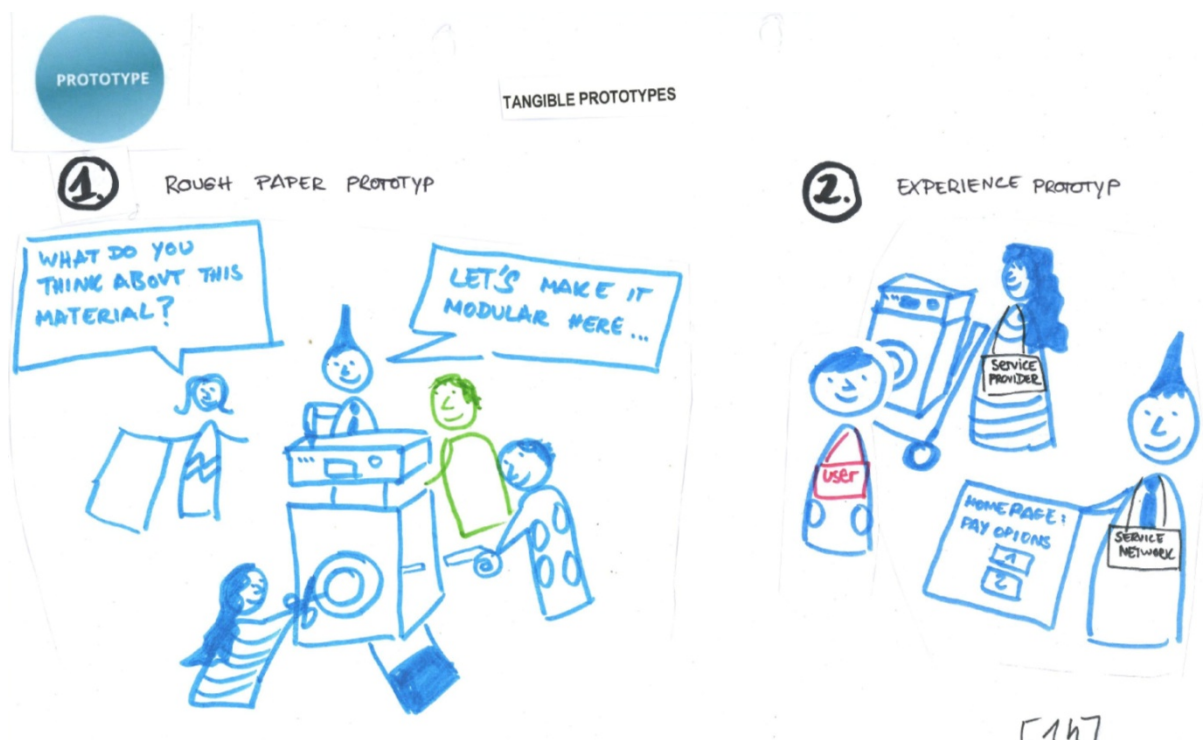


Figure 40: Tangible Prototypes (inspired by d.school HPI Potsdam).

The tangible prototyping session consists of two steps. First, rough paper prototypes are built for demonstrating the product part of the PSS. During prototyping, the teams synchronize on the idea by solving upcoming problems practically. In addition to paper, any other helpful material can be incorporated to simulate the critical function. DT coaches suggested to only provide recyclable materials at prototyping for supporting sustainable outcomes. The critical function has to be translated into something comprehensible and experienceable, which can then be tested. Secondly, the prototypes also have to be able to demonstrate the service part of the PSS. One team member takes the role of the user and is put into the precise position of experiencing the PSS. The teams can rearrange the furniture, use additional supportive materials, display a certain surrounding with a beamer or conduct a role-play. To bring the teams into a prototyping mood, two useful suggestions were made during evaluation. First a building exercise as a warmup before this step was recommended and secondly it was suggested that the moderators join the groups at prototyping for the first few minutes. Scientists and business consultants were skeptical about setting a time limit of one hour, while DT trainers were used to operate within short timeframes.

4.2.19 Day 3 - Test



Figure 41: Test (inspired by d.school HPI Potsdam).

As a final step of the DT process, the product-service offer is tested with a potential user in the intended situation. Testing participants can already be recruited in the observation phase. During testing, the team only gives few explanations, reserves judgment and carefully listens to the feedback. Notes are taken on a feedback grid to document the insights. Before testing, the team previously reflects on hypotheses from prototyping and precisely documents positive and negative feedback, next to new ideas and new questions. After testing, the team determines whether the solution meets the user’s need and how to further modify the solution. Decisions on further iterations within the process can be taken. A business consultant stressed the need to prepare test-customers for tests on rough prototypes in order to avoid a ridiculous appearance of the teams. It was further suggested to first test the ideas with other employees of the enterprise or the opposite team instead of an immediate public presentation. The aim here is a reality check by getting feedback on the current prototypes and thereby realizing the need for further improvement. For a good group dynamic at the end of the workshop, both teams should celebrate their achievements by loudly applauding.

4.2.20 Day 3 - Next Steps

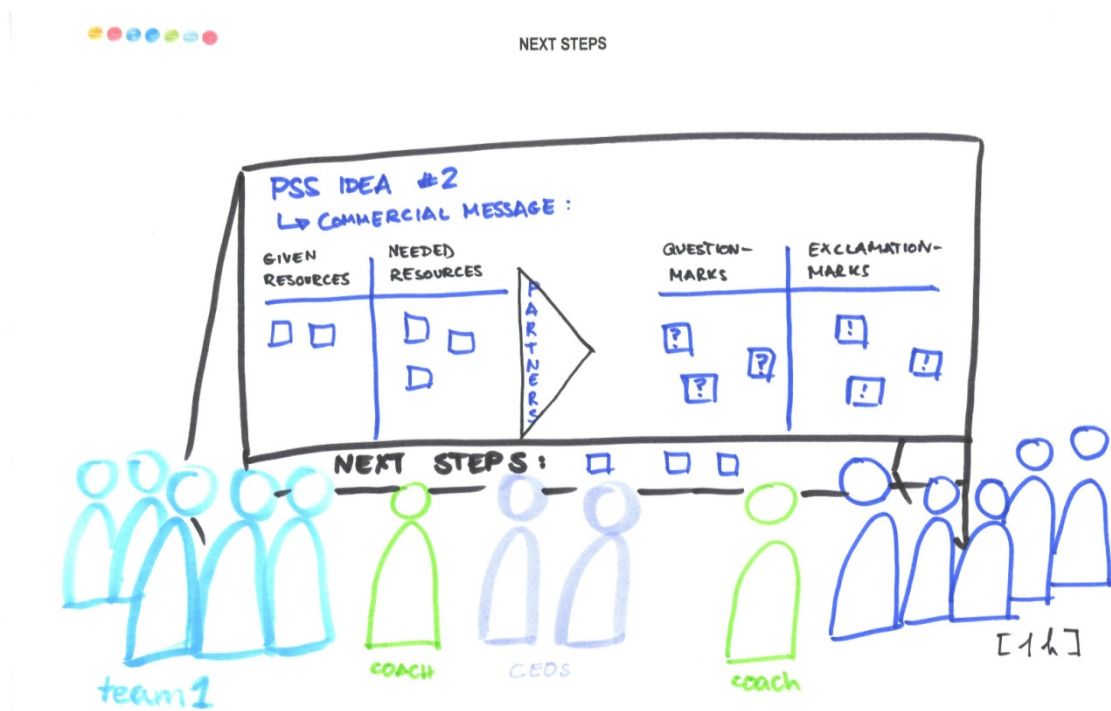


Figure 42: Next Steps (inspired by testing feedback from Veronika Schubring and Pascal Gemmer).

As suggested by DT expert feedback the workshop is finalized with a reflection step on the PSS ideas. The developed S.PSS concepts need to be transferred from an idea into corporate reality. Together with the SME management, the coaches and the respective other team, PSS solutions are discussed and ideas concerning the implementation are captured on a board. This gives each team the chance to quickly adapt and display the short commercial message together with the storyboard from step 12. The ideas' feasibility is then commonly discussed regarding given and needed resources. For the latter, possible partnerships and learning possibilities are derived to intercept actual shortcomings. Another field defined by question marks and exclamation marks serves to capture unclear issues and highlight the most important PSS characteristics. Finally the group reflects on next steps to take clarifying unclear points and bringing the concept into practice. It was suggested to conduct this concluding step in-house and present it to the company, for appreciation of the three-day effort.

4.2.21 Questionnaire results

Most significant textual expert feedback has been stated within the descriptions of the single workshop steps. In the following, the corresponding ratings of the *questionnaire results* are presented. The qualitative feedback on each workshop step was additionally complemented by a quantitative ranking on a line between zero (negative) and ten (positive), indicating how good or bad the experts perceived the applied methods, for achieving the overall workshop objectives (chapter 3.3.2). The corresponding quantitative evaluation proved to be helpful for the interpretation of the feedback, by indicating how serious the expressed concerns were meant. Joint feedback guided the authors for modifications, as feedback was multifaceted and perspectives on the results diverged with partially contradictory advice. The results of the expert evaluations served as a basis for modifications of the workshop within the second and third iterations. After both cohorts of expert feedback the authors therefore:

1. Calculated the overall average within each cohort and the individual average for each workshop steps. Steps rated below the overall average were considered for revision.
2. Screened the individual ratings for outliers as a second indicator. Workshop steps receiving negative feedback below five were also considered for revision.

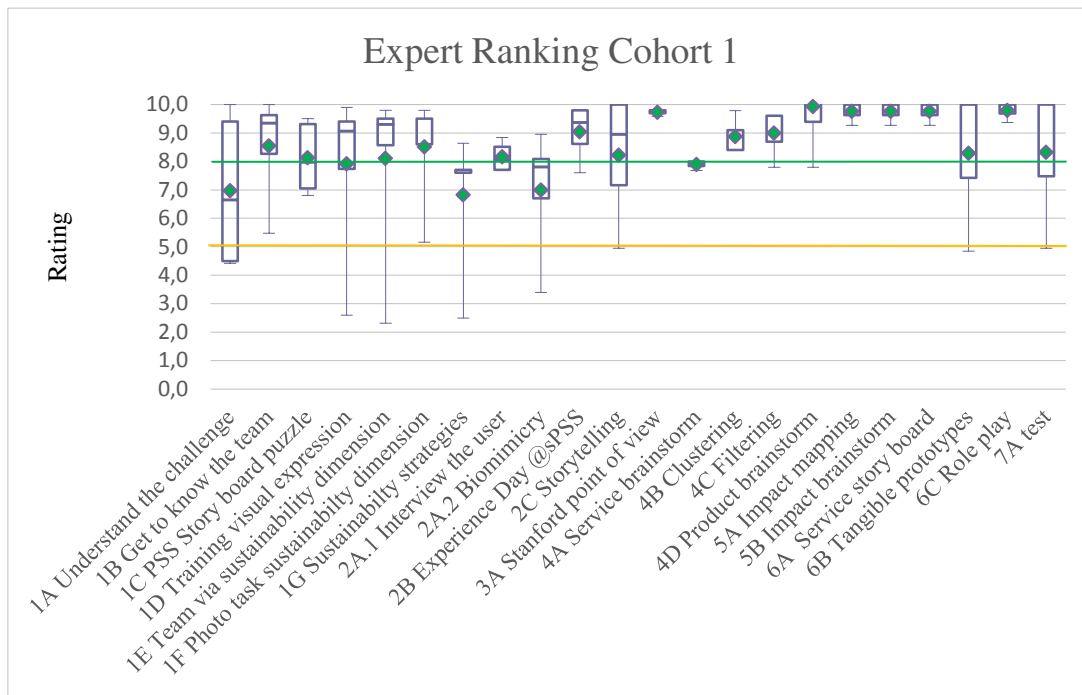


Figure 43: Expert evaluation of the DT Workshop for S.PSS development after the first Cohort

Modifications were either included by a) changing the the sequence of steps to a different assembly, b) adapting single workshop steps based on expert feedback or c) throwing steps out of the workshop.

The *first cohort* of two interviews and six expert prototype tests delivered the following feedback (Figure 43), which served as a basis for improvements in the second iteration. The overall average was rated with 8.6, indicating to rework five steps rated below eight. These were namely: Understand the Challenge, Sustainability Strategies, Biomimcry, Service Brainstorm and Training Visual Expressions. Outlier screening secondly indicated which process steps were perceived below the average quality. Understand the challenge (4.2), Training Visual Expression (2.6), Sustainability Dimensions (4.9) and Sustainability Strategies (2.5). Consequently the step ‘Training Visual Expression’ was excluded due to its inferior importance for the overall aims. Moreover the ‘Next Steps’ workshop finalization was added.

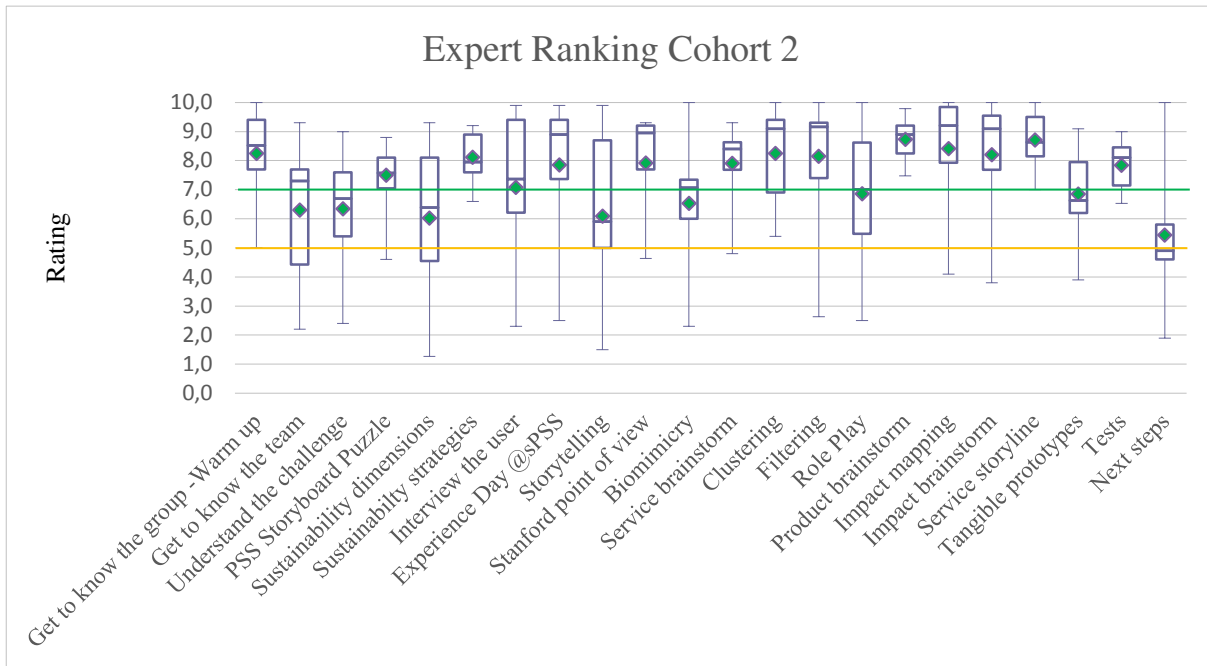


Figure 44: Expert evaluation of the DT Workshop for S.PSS development after the second Cohort

The *second cohort* with nine expert prototype tests and three interviews delivered the following feedback (Figure 44), for improvements in the third iteration. The overall average was rated with 7.4, indicating to rework seven steps rated below an individual average of seven. These steps were: Get to Know the Team, Understand the Challenge, Storytelling, Biomimicry, Roleplay, Impact Mapping and Tangible Prototypes. Individually rated outliers below five further indicated which steps had to be further modified: Get to Know the Team (2.2), Understand the Challenge (2.4), PSS Storyboard Puzzle (4.6), Sustainability Dimensions (1.2), Interview the User (2.8), Experience Day (2.5), Storytelling (1.5), Biomimicry (2.3), Filtering (2.5), Roleplay (2.5), Impact Brainstorm (3.8), Tangible Prototypes (3.7) and Next Steps (1.8). Being again poorly ranked despite modifications in the second cohort the steps ‘Biomimicry’ and ‘Sustainability Dimensions’ were excluded. Further the ‘Role Play’ was integrated into the ‘Storyboard’ step as presented in 4.2.14. Moreover the ‘Experience Day’ was shifted from the workshop setting to an external ‘Teaser Day’, which was included to the concept within the third iteration.

5 DISCUSSION

5.1 The Case Study on DBL Marwitz GmbH

Taken together, the results of the case study research allow the formation of propositions on the long-term success factors of PSS that could be considered in S.PSS development research and practitioners' daily routines. In existing case studies on S.PSS most research focuses on development or descriptions of new PSS cases (Tukker & Tischer 2006; Grosse-Dunker & Hansen 2011; Lindahl & Sakkao 2013; Hernández-Pardo et al. 2012; Tietze et al. 2013). Regarding the public accessibility of case examples it is notable that case study databases on PSS, built by EU funded projects, do not remain online after the funding period⁸. This study contributes in line with Tukker (2015) to PSS theory by deducting insights on long-term success factors from a detailed case study with 40 years of history.

“The most important contribution of the post-2006 literature is probably the strong attention to what PSS development means for a company’s structure, culture, capabilities and management. (...) This, probably much more than having a sound design method, is currently the key success factor, particularly for product oriented companies that want to put PSS on the market” (Tukker 2015, p.82).

In the following chapter the key findings of our case study on Marwitz are discussed.

A national association of 17 family owned small and medium enterprises is able to operate as a network successfully.

DBL proved its success by becoming the third largest provider of workwear leasing in the German market through a mixture of uniform service on the national level and individual flexibility on the regional level. In other words, the success of

⁸ a) Database of PSS case studies constructed between 2000-2004 with primarily cases from the UK. www.sustainablepss.org (Recommended here: Tukker & Tischer 2006a, p.402)

b) First network on sustainable Product-Service-Systems Development promoted by the EU. www.suspronet.org (Recommended here: <http://p2pfoundation.net/SusProNet> 21.07.2015 14:05)

c) ServiceInnovation – Website for S.PSS. www.serviceinnovation.at (Recommended here: <http://www.fabrikderzukunft.at/> 21.07.2015 14:12)

the DBL association was supported by a common professionalization and individual adaptability to regional particularities. Driven by the requirements of corporate clients, the delivery of a uniform service is obligatory to all DBL partners since January 2015. On the regional level the ‘Kon-Tiki’-like maneuverability allows solo efforts that are evaluated by the network’s internal benchmarking. We regard the configuration of the DBL network as unique in the context of PSS. It seems probable that this form of cooperation might be specific to the German ‘Mittelstand’. In PSS literature the demand for transparency within PSS networks is seen as the biggest hurdle to diffuse knowledge (Oliva & Kallenberg 2003, p.169). Tietze and others conclude that this network capability is critical to control the PSS innovation (2013, p.12). We suggest the DBL association as a role model in knowledge diffusion among associates, possessing the required network capability.

The initial implementation of PSS requires commitment of the top management. For continuous innovation in the long-term a supportive integration of the employees is important. Organizational structures should be flexible and adjusted to the service offer and the person who fills the position.

Consistent with the hypothesis by Mont (2008), we found the presence of a ‘catalyst’ very important for successful S.PSS introduction. In our findings the former owner manager was identified by several interview partners as the main catalyst. This special role can be similarly found in innovation management literature as a ‘promoter’ (Witte 1973; Gemünden 1985). We suggest this position needs further internal support by additional key figures after the initial S.PSS implementation. Corporate sustainability management theory for example coined the role of the ‘gatekeeper’, a person from middle management or accounting, translating between department silos (Zvezdov 2011; Kraakman 1986; Coffee 2006). In our case study we observed that the additional hired sales force and later head of sales fulfilled exactly this role. Internally he helped the executive board to restructure the company aligning with the service-centered mindset. Prevailing in this process, positions were tailored to the personalities, who filled the position. Externally, the same former head of sales participated actively in the supra-regional sales committee of the DBL association. This committee offers a platform to diffuse knowledge between associates and the DBL. Additionally he engaged in non-hierarchical small task forces of sales managers to innovate on a voluntary basis

on specific issues, such as a new nursing collection. We find that these short communication routes, which have been highlighted as a success factor, imply that long-term PSS works best when a committed top management gives free space for bottom-up ideas and suggestions.

Pilot phases and stepwise organic growth are keys to PSS development

It took around ten years to completely replace the old business model of laundry service. Key to the successful implementation of workwear leasing in the early 70ies was the courage of the former manager to test the application of a leasing model. This was first done as part of the network, then in collaboration with a regional lead user. Building on the experience with the lead user, a car garage, the automotive sector became the first target group. Stepwise other possible markets were explored by trial and error. Trial and error served also internally as a main source of learning. Some process were adapted from the network partners, others were solved individually. For instance, the owner manager used handwritten patches in the first leased coats to individually assign them to the wearer before professional imprinting equipment was acquired. It seems reasonable to suggest that low-resolution pilots and collaboration with lead users are a valid success factor even in times of elaborated technological possibilities (Exner et al. 2014). The case study reveals this successive learning process being mirrored in the structural development. This stepwise growth in employment, additional facilities and warehouse capacities is ultimately key to PSS success.

A human-centered firm culture supports a deeply embedded user-centeredness. This mindset can be taught to new field personnel, accomplishing the demanding task of distributing PSS, by special trainings.

It seems possible that the open door policy of the executives and middle management at Marwitz enables a culture where sales forces actively suggest new products to the portfolio satisfying customer needs. From a managerial perspective, it is worthwhile noting, that months are dedicated to intensive training of new field personnel. Tukker summarizes “the need for staff to possess both product knowledge and relation management skills“ (2015, p. 82) as a new insight in post-2006 S.PSS literature. Regarding ‘product knowledge’, new sales personnel of Marwitz are educated on product range and corresponding norms. For acquiring ‘relation management skills’ novices shadowed an established service driver for

three weeks and are trained to actively listen to identify user needs. In this regard the former head of sales applied ‘emotional sales’ theory, originating from ‘neuro-linguistic programming’ (Schäfer 2012), to PSS practice. Management might find the three recognized archetypal customer types interesting. First, the security-oriented type can be convinced by compliance. In other words the offered service solution fulfills work security or hygiene regulations. Second, the status-oriented type fancies visible corporate identity with customized emblems and clean appearance of the employees. Thirdly, the technology-oriented type is persuaded by functional material of the workwear, e.g. ‘GORE-TEX’, or by the CRM feature which keeps track on the clients’ sizes.

DBL Marwitz proves that revenue streams from offering leased C-items are reliable.

Another proposition is that offering C-items in a PSS is a ‘safe bet’ on the long-term. This runs counter to the presumption that markets of high volume and low-value products are caught in the throwaway mindset (Mont 2008, pp.58). In this context, our findings have direct managerial implications. Many manufacturers face the challenge of volatile sales from month to month. In contrast Marwitz benefits from periodical revenue streams defined in three year contracts. From the customer’s perspective, workwear is one of the last expenditures to be cut when reducing spending. Even though the amortization of workwear purchases takes longer, the resulting advantage lies in the better accountability, especially for SME clients. This statement is in line with accounting research on leasing from academia and research of the European Investment Fund (Graupe 2013; Kraemer-Eis & Lang 2012).

Long-term PSS contracts and CRM tools turn SMEs into premium customers of high interest while the utilization rate has to be balanced.

The experience of Marwitz in the B2B market with small margins and high volumes of corporate customers on the one hand and SME clients that require higher acquisition efforts on the other, resulted in the strategic decision to focus on the latter. Nevertheless a diverse customer structure, including large corporations, allows a high utilization rate of the sorting plant. Based on CRM data, several SME customers are classified internally as premium customers. This classification indicates a higher degree of goodwill to the assigned contact person in customer

service, who is for instance in charge of deciding textile replacements. An interesting implication for practice in this context is the insight that Marwitz rethinks the incentives for sales staff to acquire profitable customers selectively, spreading fixed costs and risk on many shoulders. It seems to be advantageous, especially in rural areas, to intensify S.PSS acquisition efforts because major competitors pay less attention, due to limited accessibility.

In conclusion, management decisions of Marwitz represent an excellent example of inhouse social sustainability. The best example is the choice of technical equipment for the automatized sorting plant due to noise-reducing criteria that bears in mind the health of the employees. MEWA, a direct competitor of Marwitz, has been analyzed in literature as a representative for s.PSS. Their full service on reusable cotton wipers is declared to oppose throw-away consumption patterns (Tischner & Vezzoli 2009, pp.61; Vezzoli et al. 2014, p.61). Marwitz has a similar business model which is, from our perspective, even more economically sustainable by associating in the SME network, DBL. Nevertheless we come to a different conclusion on the rental workwear by Marwitz. To our understanding Marwitz does not yet meet the criteria for S.PSS because their products are not re-designed to meet sustainability criteria. Neither materials for circularity, end-of-life solutions nor fair trade standards in the supply chain are taken into account. Meanwhile workwear providers with such approaches do exist in the market, which are worth investigating for the textile sector (Hugo Josten At Work 2013; Manomama 2015; Bierbaum-Proenen 2014; Laufenmühle 2015; Dieckhoff 2015; Van Puijenbroek Textiel 2014; RAS Materials 2015). Considering logistics as Marwitz' core business activity, sustainable mobility solutions are necessary to truly achieve a sustainable PSS. Steps in these directions were discussed within the DBL but were not feasible.

5.2 Design Thinking as an Enabler for S.PSS Development

The developed workshop represents specific propositions on how design thinking can contribute to S.PSS development. The essential difference highlighted in the findings of this study is a set of highly applicable methods that invoke the methodological advantages of Design Thinking to overcome the main challenges in the

field. For S.PSS development these namely are user-centeredness, employee integration and fast testing.

Design Thinking is a highly adopted innovation process without a pre-defined outcome, whereas S.PSS development is perceived as a complex academic field (Vezzoli et al. 2015). Design Thinking might represent an easier access method to practice while in turn S.PSS adds a normative framework in which to direct the process.

“Sustainable Design may be the key ‘Trojan Horse’ which allows design graduates and design thinkers to find space to change, for the better, the services and products which society depends on socially, environmentally and economically” (De Eyto et al. 2008, p.341).

Going to the field and capturing user needs fosters empathy with the customer’s processes for user-centered workshop outcomes

Despite the fact that current debates revolve around the user needs in PSS development (Pawar et al. 2009; Manzini & Vezzoli 2002; Grosse-Dunker & Hansen 2011) no applicable methods are suggested. Direct interaction with the user is a crucial element of Design Thinking. User-centeredness in this context is not to be confused with co-creation processes, but rather explorative approximations to the problem space, which require its own interpretations. “The ultimate goal would be to anticipate future needs” (Schmitt and Hatfield 2008 cited as in Isaksson et al. 2009, p.345). Our findings show that especially in the context of an employee workshop the direct interaction with users in the field is perceived risky by academia, business consultants and PSS experts as the outcome of the observation phase cannot be controlled. In contrast, the DT coaches are confident about the purposefulness of this step from their work practice. They underline the enthusiasm arising from ‘self-explored’ user insights. On this subject they provided us with helpful insights on risk preventing preparation and precise instructions to the teams. These contradictory findings could be due to the opposing prevailing success rationales of the professions. From a sustainability perspective the necessary cultural orientation (Grosse-Dunker & Hansen 2011) may be achieved by the strong user orientation of the Design Thinking process. In other words, we hope to

proactively forecast behavioral trends, regional habits, traditional knowledge, user acceptance and connected lifestyles.

The workshop setting promotes employee integration to the PSS development. Bottom-up innovation creates a shared vision and understanding of sustainability and S.PSS

Our findings from the expert panel show that top management commitment is key to legitimate the innovation teams. At the same time there is no better way to enable bottom-up innovation than entrusting a company's own employees with finding solutions. The implications for practitioners are two-folded. First, by applying the shown methodology, action learning is achieved regardless of the workshop output (Lawson 2006/1980; Lawson & Samson 2001). Prior S.PSS studies endorse capability development to pave the way for organizational change.

*“Probably the most interesting contribution of the post-2006 literature is that it focused not only on PSS development per se, but also on the **capability development challenge** and transformation processes that firms have to deal with to achieve market success with PSS” (own emphasis, Tukker 2015, p.84).*

Second, allowing the employees to explore solution spaces prevents the dismissive ‘not-invented-here syndrome’ that occurs when extensive strategic decisions such as PSS implementation are developed in a top-down manner without the participation of the company's employees (Hussinger & Wastyn 2015). Our findings suggest communicating the workshop participation as an award to the team members.

Design Thinking workshops enable manufacturing SMEs to explore the potential of PSS as they are fast and inexpensive compared to normal R&D activities.

The S.PSS development workshop offers an affordable, compact course to firm-based teams. Often high initial investments are given as reason why PSS are not widely distributed (Oliva-Kallenberg 2003, p.167). Rather than compressing and applying all academically suggested evaluation tools we decided to put emphasis on processing only the essences of PSS development in a self-explorable manner. Bearing the SME constraints in mind, the workshop and the teaser are scheduled

for 3 ½ days. The daily work of the DT agencies shows the willingness of companies to allocate up to twenty people for such workshops. Recommendations of the experts implied a dissection into smaller workshop unities with distinct functions. This was adopted with the ‘teaser unit’. Despite the fact that business consultants rated the overall duration as too long, the feedback highlighted the surprisingly holistic outcome of the conceptual workshop. Until now there has been little investigation of how Design Thinking is put to SME use. Based on the findings, we propose that low-fidelity prototyping and user testing take a stepwise PSS implementation into account.

Sequencing of first designing service aspects and then the product is considered promising to ensure a sustainability reframing of the S.PSS

Critics may find the workshop goals too broad to be achieved. In consequence the experts welcomed the minimalist methodological twist to place a service brainstorm session on need fulfillment first, and subsequently brainstorm on the product re-design. We specifically added an ‘impact step’ to the Design Thinking process for strong sustainability-oriented outcomes. Our approach adopts insights from prior studies that sustainability benefits are not exhausted by current PSS development methodologies (Lindahl & Sakao 2013; Ceschin 2014). It is argued that these were too occupied with elaboration of new business models instead of conducting the sustainability-relevant product re-design (Ceschin 2014). We argue this shortcoming can be overcome by focusing on economic potential of revalorisation of disassembled materials in the circular economy (EMF & McKinsey 2013, EMF & McKinsey 2012; WRAP 2011).

5.3 Limitations and Future Research

The aim of this study was to a) gain insight on long-term PSS success factors and b) propose applicable methods based on the methodology Design Thinking for S.PSS development. As with any research, there have been inherent restraints to our research design.

5.3.1 Limitation

As Design Thinking was applied as both, the research design and the theoretical background, the study could be accused of partiality. To counter these allegations

adequate academic established research methods were orchestrated in a manner similar to Design Thinking (chapter 3.2; 3.3). For answering the first research question of this thesis, the case study was content analyzed by paraphrasing the transcript comprehensibly using the coding software MAXQDA. In this regard a shortcoming is that we cannot provide the translation of the transcripts, as the interviews were conducted in German. Further, the characteristics of Marwitz as a B2B PSS provider that clothes client's employees with individual preferences, bears the contradiction of meeting B2C constraints simultaneously. Our case study findings might therefore not be assigned selectively to neither B2B cases as discussed in the IPS² research field nor the B2B targeting S.PSS literature.

Regarding the second research question, the conceptual 'Design Thinking workshop for S.PSS development', readers might expect a deeper academic debate on the definitions of S.PSS and its assimilation in the workshop. Recalling the prior set constructivist didactical frame, we refrained from further theoretical complications. Finally, the workshop was developed as a conceptual groundwork for further action research with firmbased teams. Academic evaluation schemes to validate the purposefulness of the developed methods as an interdependent set would have exceeded the limits of a collaborative master thesis.

5.3.2 Future Research

There is great potential for research on S.PSS development to benefit from adopting a Design Thinking approach. Our unique research setting of testing the workshop draft with experts from both fields allows for first consideration of the implications on the adoption by firmbased teams. In order to validate the developed workshop, a sector specific longitudinal study on the implementation at SMEs could be conducted. Here, team members' job satisfaction might be an interesting indicator to capture among others. Seidel and Fixson (2013, p.31) point out that new management methods undergo periods of diffusion and abandonment described as a 'management fashion cycle'. If this theory applies to Design Thinking, the current window of opportunity should be utilized as long as it is in the focus of attention. From the user perspective the psychological mechanisms behind ownership in PSS context would offer ground for investigations. Additional work could focus on meta-frameworks to PSS such as transdisciplinarity (Scholz

& Tietje 2002; Bergmann 2012; Stauffacher et al. 2008), practice based innovation and embedding S.PSS research in the circular economy debate. In S.PSS literature Tukker and Tischner (2006a, pp.368, pp.45) and Ceschin (2014) have argued that transitional studies and multi-level perspectives deliver insights for a strategic design methodology. From this perspective, concepts from sustainability science such as change agents, windows of opportunities and living labs (Liedtke et al. 2015) are key factors for PSS-development and its transition paths (Ceschin 2014). This can be taken further by underlining the parallels between Design Thinking and Education for Sustainable Development (ESD) (de Haan 2008; Vare & Scott 2007) to enable capability building to educated change agents (see chapter 2.1. & 2.3). Design thinkers name the desired skill ‘creative confidence’ while ESD researchers define ‘key competencies’ (De Haan 2006, Wiek et al. 2011). Design Thinking teaches inter- or multidisciplinary student teams by working on real world challenge while ESD calls for transdisciplinary projects in higher education with interdisciplinary student teams collaborating with practitioners. All these parallels could be investigated in the context of capability building in S.PSS research.

As the ecological potential of PSS is highly emphasized within current debates, the social dimension could be further investigated. Our case study findings indicate that low qualification jobs are PSS specific and that mechanization is possibly counterproductive for inclusion, both of which are worth investigating in this regard.

6 CONCLUSION

Within the presented thesis we investigated conditions for a successful introduction and further prevalence of S.PSS in SMEs. We firstly examined promoting factors for long-term success and upscaling of S.PSS in SME practice. We derived practice insights from a PSS case with over 40 years of experience by conducting a case study on DBL Marwitz GmbH, offering mainly workwear-leasing. The Lüneburg based enterprise is part of a SME network named DBL, which delivers the same service standard on the German market. The objective was to gain insights on sector specific success factors for the implementation process in the 1970ies, the following continuous business development, and the corresponding sustainability performance. On the basis of this approach, the presented work provides insights on internal and external factors, seen by top management as fundamental for company success. Our analysis suggests a successive implementation of PSS in the adapting SME, stepwise growing and cannibalizing the old business model. We further found the rural area for PSS delivery as an economic advantage, due to less competitive market conditions. Results indicate that low value products in the field of textile leasing, not directly connected to the core business activity of clients, deliver added customer value by externalizing minor but complex issues to a professionalized PSS provider. Our findings suggest a user-centered firm culture paired with high top management commitment as key for long-term PSS success. The explicitly arranged diverse customer structure, consisting of SME clients for profitability and big customers for utilization rates, can further be seen as a key success finding from DBL Marwitz GmbH. Finally, engaging in the DBL network proved to be very helpful by allowing each other to mutually learning from each other at PSS introduction and further development. The case of Marwitz suggests that affiliated PSS delivery is not only possible but a key factor to success for SMEs. Taken together the case study findings provide rich and convincing arguments for gainfully implementing PSS in SMEs.

In a second phase we proposed a set of workshop steps for the contribution of Design Thinking to S.PSS development. The resulting DT workshop was first conceptualized and fifteen fold evaluated by experts. For the development of the three-day workshop, the six-step DT process as taught at d.school Potsdam, existing PSS methodology derived from literature and own ideas and experiences from

giving workshops and seminars served as a basis. Main characteristics of our conceptual workshop model are: a) bottom-up innovation by conducting the process with employees, b) user-centered outcomes through embedded field experience and c) practice approved results by testing rough prototypes with potential users. We suggest the presented workshop as especially applicable for PSS innovation in SMEs because of its low resource intensity. Expert evaluation highlighted the sequence to first design the service aspect and then matching the corresponding product part of the PSS as especially beneficial for sustainable outcomes due to the high dematerialization potential.

We herewith present applicable results for PSS research. The contribution to the case base is enlarged by a long-term PSS success story, operating in SME network structures. Sustainability science can ultimately benefit from both, practice insights on sustainability in PSS and from applicable methods for change agents, willing to transform businesses. For practicing business consultants and DT coaches the presented methodology may likewise serve as a toolbox and as a basis for adaption, further bringing the concept of S.PSS into practice. On a personal level, we extended our collaborative capabilities and developed a deeper attachment to PSS literature bearing in mind the insights and personalities behind the conducted case study.

Our implications may be limited by three factors: a) The transferability of the case study findings may be restricted due to the unique case sample. b) The workshop has been conceptualized theoretically only and not yet been applied in SME context. c) The research design and workshop outcome could be accused of being biased by the positive perception of DT methodology based on the authors' experience.

As possible future research we suggest an in-depth quantitative analysis of the associated DBL companies, examining different manifestations of PSS success factors and linking the results to specific corporate capabilities. Furthermore we recommend mutual learning of the research fields transdisciplinarity and S.PSS design, both involving multidisciplinary stakeholders and practice insights and addressing wicked and ill-defined problems from a sustainability perspective (Rittel & Weber 1973; Buchanan 1992; Scholz & Tietje 2002; Conklin 2006). Further connections can be drawn to circular economy and ESD. Action research in SME

context on the theoretically developed workshop can lead to further specifications and modifications for either the servitization or productization of businesses in different sectors, from different cultural spheres and of different sizes, as recommended by Tukker and Tischner (Tukker & Tischner 2006, p.373). It would be especially interesting to investigate the transformation process initialized by the workshop application in longitudinal studies.

In conclusion we find that academia overcomplicates the issue of value propositions in product-service combinations by following different disciplinary approaches and terminologies and focusing on sub-aspects rather than on the essence of PSS. The case of Marwitz has vividly illustrated that PSS can be a logical reaction to market pressure and successfully introduced by simply focusing on customer demand. The continuous reaction to perceived user needs and learning from trial and error are simultaneously the key characteristics of the DT process, suggesting this approach as an appropriate methodology for PSS introduction. Regarding the wider recognition of PSS we recommend to integrate and discuss the concept as a common denominator of the sustainability strategies and in the current prominent debates on circular economy and DT. As shown, the latter have raised attention of businesses, bearing the potential for further PSS application. By translating complex scientific concepts into easily applicable methods, we hope to also contribute to an exchange between the involved disciplines and business reality.

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Appendix

Appendix 1: Case study

1_1 Interview questions (in German)

1_2 Category System

1_3 Audio Data

1_4 Internal Documents (Organigram)

1_5 Secondary Data

1_5_01 Article RW Textilservice

1_5_02 Study Böttger 2007 Textilleasing in Germany

1_5_03 Image brochure DBL

1_5_04 Image brochure Marwitz

1_5_05 Press kit DBL

1_5_06 Image brochure Cupboard system DBL

1_5_07 Article DeutscheHandwerksZeitung

1_5_08 Article Iuenepost

1_5_09 Article Gemeindeblatt Ilmenau

1_5_10 Article Landeszeitung LZonline

1_5_11 Article Landeszeitung LZonline

1_5_12 Article Landeszeitung LZonline

1_6 Translation of Quotes

1_7 Transcripts of Interviews

1_8 MAXQDA File

1_9 List of Codings

Appendix 2: Workshop Conception

2_1 Workshop Paper-Prototype Version 1

2_2 Workshop Paper-Prototype Version 2

2_3 Evaluation Sheet



Druckfarben auf der Basis nachwachsender Rohstoffe



100% Recyclingpapier



produziert mit Ökostrom



klimaneutraler Druck und Versand



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