A Product/Service System

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Product/service system (PSS) is widely considered as a promising design object with the potential to enhance environmental sustainability of industrial solutions. The state of the art of PSS design research includes several prescriptive PSS design support tools, methods and procedures. This body of literature has been extensively reviewed in the past. However, there is a lack of consolidation of the available prescriptive knowledge in a condensed and practically useful format that can be used by practitioners to guide their conceptual PSS design activities and by researchers to build their work on. Thus, to address this gap in our knowledge, we use an intra-disciplinary literature analysis and meta-synthesis approach to consolidate the extant prescriptive PSS design knowledge in the form of a schema for conceptual PSS design.

Keywords: PSS design schema ; conceptual PSS design ; Product/Service System Design ; environmental sustainability ; resource-efficiency

1. Introduction

A product/service system (PSS) can be defined as a mixture of tangible products and intangible services that are designed and combined so that they jointly are capable of fulfilling customer needs [1]. The conceptual design phase is considered to be crucial for PSS development [2], as its outcomes tend to determine the characteristics of the PSS being developed. Although the state of the art prescribes several support methods and tools that address the different dimensions of PSS development, there is a lack of consolidation of this disparate knowledge in a condensed and practically useful format that can be used to guide the conceptual design activities of practitioners. To address this lack of consolidation, in our research article [3], we carried out an intra-disciplinary meta-analysis of existing reviews of PSS design literature and a subsequent synthesis of the recurring facets of PSS design to distill its essence. The distilled essence was then poured into an existing and conventionally used framework for conceptual design known as Pahl and Beitz' systematic approach (PBSA) [4]. This consolidation is described below.

2. Consolidation of a PSS design schema

The result of the meta-analysis was consolidated in the form of a prescriptive PSS design schema [3]. This schema was constructed by pouring the distilled essence of PSS design from the meta-analysis into the framework of PBSA. The PSS design schema represents a practical guide in terms of aspects to consider in a structured manner during conceptual PSS designing. It is an iterative series of 10 steps, which is recommended to be used as a procedural guide during conceptual PSS designing, in a methodical yet flexible manner. Some of the 10 steps are peculiar to conceptual PSS designing in contrast to conceptual designing by PBSA. This consolidation of the schema and relationships to PBSA conceptual design are represented in Table 1.

Table 1. Representation of the consolidation of product/service system (PSS) design schema (adopted from [3]).

PBSA Framework for Conceptual Design	Distilled Essence of PSS Design	Consolidated Schema for Conceptual PSS Design
1. Abstract to identify the essential problems	**1. Functionality-oriented designing** **2. Identification of relevant actors along the PSS lifecycle**	**1. Functional unit definition** **2. Stakeholder identification** **3. Requirement consolidation**
2. Establish function structures: overall function—subfunctions		
3. Search for working principles that fulfil the sub-functions	**3. Value proposition** **4. Development and integration of system elements**	**4. Value proposition** **5. Criterion identification** **6. Element integration**
4. Combine working principles into working structures		

PBSA Framework for Conceptual Design	Distilled Essence of PSS Design	Consolidated Schema for Conceptual PSS Design
5. Select suitable combinations	**5. Examination of the balance of the integration**	**7. Balance examination** **8. Selecting combinations**
6. Firm up into principle solution variants		
7. Evaluate variants against technical and economic criteria	**No essence applicable**	**9. Evaluating combinations** **10. Solution selection**

The ten steps of the PSS design schema are explained as follows (adopted and modified from [3]).

Step 1: Functional unit definition— a peculiar facet of PSS design is the emphasis on delivering functionality oriented solutions [5]. In the PBSA to conceptual design, designers are initially prescribed to abstract the problem they are addressing on a higher level and to identify functions and sub-functions that can address this problem. In the consolidated PSS design schema, designers are prescribed to assign a functional unit to guide their conceptual design process. A functional unit in this context represents the measure of the teleological aspects of the PSS being designed in terms of the expected performance or results, rather than the specific contents of the PSS [3]. By including such a functional unit as a frame of reference for PSS design, it potentially allows the designers to consider a wider range of solutions and to compare potential environmental impacts of the solutions per unit of functionality to be delivered. Thus, it can potentially contribute to the enhancement of the conceptual design process and environmental sustainability of the PSS being designed.

Step 2: Stakeholder or actor identification— in the second step, designers are prescribed to identify all the relevant stakeholders or actors from a lifecycle and systems perspective. This expansion of the systems boundary during stakeholder identification is deemed necessary, as PSSs are essentially socio-technical systems which requires the involvement of a wide range of actors along the value-chain [6].

Step 3: Requirement consolidation— during this step, designers are recommended to simulate potential use scenarios and consolidate potential requirements of the identified stakeholders or actors per unit of functionality for the PSS concepts being designed.

Step 4: Value proposition—after identifying the requirements, designers are expected to identify potential value propositions, which is a crucial facet of PSS development [7]. Value in this context is considered as the trade-off between various perceived benefits and sacrifices or costs [8].

Step 5: Criterion identification— during this step, relevant criteria for assessing potential PSS concepts are formulated based on the identified requirements and value. Environmental impacts or customer requirements can be examples of evaluation criteria.

Step 6: Element integration— during this step, designers are recommended to conceptualize the contents of the PSS. Subsequently, these contents are recommended to be integrated from a systems and lifecycle perspective, which in combination can effectively address the requirements and facilitate values to the recipient actors. Integration of product and service elements, and the channels that facilitate them are considered to be peculiar for PSS design [9].

Step 7: Balance examination— during this step, designers are recommended to examine the balance of the inter-dependencies of the system elements, from a systems and lifecycle perspective.

Step 8: Selecting combinations— during this step, designers are recommended to select specific combinations of integrated concepts of system concepts, based on the balance examination.

Step 9: Evaluating combinations— during this step, designers are recommended to assess the selected combinations of system contents based on the criterion established in Step 5.

Step 10: Solution or concept selection—in the final step, designers are recommended to select multiple combinations of the system contents that together address the requirements and value propositions, while fulfilling the identified functional unit.

These ten steps are recommended to be applied by practitioners during conceptual PSS designing in a semi-methodical and flexible manner.

2. Conclusion

In this entry, authors present the results of an intra-disciplinary literature analysis and meta-synthesis of existing systematic reviews of PSS design literature, which is a part of our article [3]. The result is essentially a consolidated schema for PSS conceptual design, which is a series of 10 design steps. This schema represents the essence of PSS design literature in a condensed and practically useful format. It can be used by i) practitioners to comprehend the advances of the state of the art in PSS design research, ii) practitioners to guide their conceptual PSS designing, iii) researchers to present the overview of the contributions of PSS design literature in a condensed format and iv) researchers to use it as a framework to build further research on. The schema is also expected to contribute to improved resource-efficiency and environmental sustainability of the PSS being designed. In our article [3], we show a concrete case of how the schema can be utilized as a framework to build further research on and in [10], we show how such a schema can be used to support the conceptual PSS designing by expert practitioners in a protocol case study.

References

1. Tischner, U.; Verkuijl, M.; Tukker, A. First Draft PSS Review; Econcept: Cologne, Germany, 2002.
2. Youngjung Geum; Yongtae Park; Designing the sustainable product-service integration: a product-service blueprint approach. *Journal of Cleaner Production* **2011**, *19*, 1601-1614, 10.1016/j.jclepro.2011.05.017.
3. Tomohiko Sakao; Abhijna Neramballi; A Product/Service System Design Schema: Application to Big Data Analytics. *Sustainability* **2020**, *12*, 3484, 10.3390/su12083484.
4. Pahl, G.; Beitz, W. Engineering Design: A Systematic Approach; Springer-Verlag: London, UK, 2007.
5. M.T. Alonso Rasgado; Graham Thompson; Bengt-Olof Elfström; The design of functional (total care) products. *Journal of Engineering Design* **2004**, *15*, 515-540, 10.1080/09544820412331271176.
6. N Morelli; Product-service systems, a perspective shift for designers: A case study: the design of a telecentre. *Design Studies* **2003**, *24*, 73-99, 10.1016/s0142-694x(02)00029-7.
7. Nicolas Maussang; Peggy Zwolinski; Daniel Brissaud; Product-service system design methodology: from the PSS architecture design to the products specifications. *Journal of Engineering Design* **2009**, *20*, 349-366, 10.1080/09544820903149313.
8. Wolfgang Ulaga; Samir Chacour; Measuring Customer-Perceived Value in Business Markets. *Industrial Marketing Management* **2001**, *30*, 525-540, 10.1016/s0019-8501(99)00122-4.
9. Horst Meier; Rajkumar Roy; G. Seliger; Industrial Product-Service Systems—IPS 2. *CIRP Annals* **2010**, *59*, 607-627, 10.1016/j.cirp.2010.05.004.
10. Neramballi, A.; Sakao, T.; Gero, J.S. Effects of a design support on practitioners designing a Product/ServiceSystem—A case study. In Human Behaviour in Design; Eriksson, Y., Paetzold, K., Eds.; Universität derBundeswehr München: Tutzing, Germany, 2019; pp. 11–22.