Development of sustainable PSS from industrial waste of the footwear sector

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ABSTRACT

The footwear sector is known for the high volumes of solid waste such as plastic and rubber derived from the cutting of the raw material used in the production of shoes and accessories. Such wastes are generally not used, which generates environmental damage. In order to provide contribution to minimize this problem, this article is based on following the research question: what sustainable solutions can be developed for the correct destination of solid waste generated in the footwear sector? Based on this practical problem, this article has an emphasis on requirement engineering and the use of innovation methods and tools, commonly found in the literature in a disaggregated form. The objective is to present the application of a method for the development of a sustainable PSS offer, based on a case study of a startup from Southern Brazil. The startup's business model is based on the use of industrial waste management for the footwear sector. Through this study, we identified and prioritized the requirements demanded by the main stakeholders. Additionally, we designed the processes necessary for the development and delivery of the PSS and the concept of the prioritized offer. This was done based on the integration of tools used in product and service innovation, requirements management, and PSS design. The concept of the PSS offer prioritized by the stakeholders resulted in a product-oriented PSS for waste management in the footwear industry.

Keywords: Product Service System; PSS; Sustainable; packaging.

1. INTRODUCTION

The Product-Service System is a strategy adopted by managers who seek to develop integrated solutions that meet the needs of consumers, which potentially reduce environmental impacts in relation to traditional offers. Mont (2002) defines sustainable PSS as the PSS that supports networks and infrastructure, designed to be competitive and meet the needs of customers with less environmental impact over traditional business models. According to Tukker (2004) PSS have three classifications to characterize the integrated offer of products and services, namely: product; use; and result-oriented PSS. The product-oriented PSS is characterized by the commercialization of products, with some aggregated services, increasing customer value. Use-oriented PSS is the commercialization of products without transferring the property of the object to the client. The object is granted to the client for use. The result-oriented PSS consists in the marketing of a result, whereby the customer and supplier consent to an end result. Thus, the supplier is paid for the solution of the problem presented.

The correct use of a PSS classification would provide meeting the needs of customers in an integrated way, establishing competitive differentials and adding value to the product; creating a relationship of loyalty with customers; reducing costs through product lifecycle expansion, and more autonomy to create sustainable product-service systems (TUKKER, 2004).

In the product development field, the sustainable innovation theme for Product-Service System (PSS) is a global trend in the search for more sustainable solutions. One of the main agents of this transformation are industries, the established companies, and also the Startups. The development of sustainable PSS is an emerging issue, as it deals with a new way of managing the integrated development of a solution, changing the paradigm of traditional product and service development models that consider independent processes. The theme is discussed in several studies, but the integrated development of the PSS is still a challenge, as its competencies are usually polarized, that is, focused only on products or services (e.g., Amaya, 2014, Maussang, 2003, and Van Halen, 2003). These studies address how to establish value for customer in products and services, while treating value separately for products (Tan et al, 2009); and for services (Thoben et al., 2001). In the same way, broadening the vision for more sustainable solutions, methods and tools have been developed to meet the demands of development phases for product and service life cycle (eg., Souza-Zomer and Miguel, 2017, Li et al., 2016).

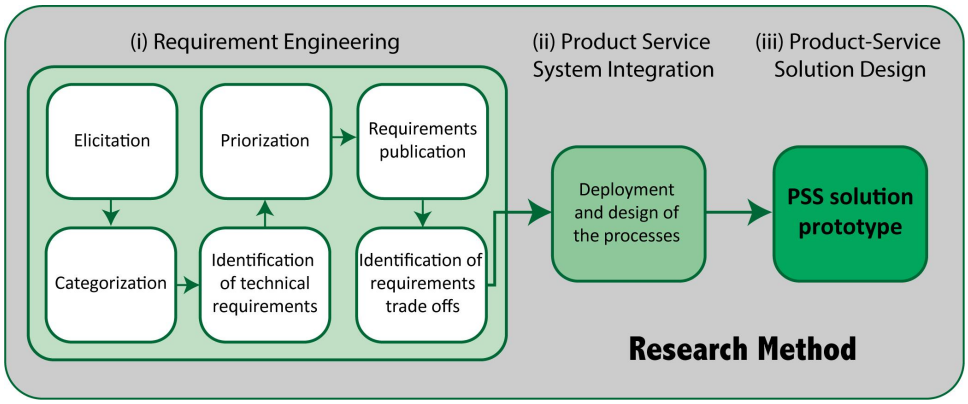
In this scenario, the present study aims to integrate knowledge from requirement engineering, innovation tools and PSS design, in a holistic way, from the application of a structured method, focused on the initial stages of development process, for the innovation of a PSS in the context of waste management in the footwear sector.

In Brazil, the footwear industry is made up of approximately 7,700 companies that directly generate more than 300,000 jobs and produces around 944 million pairs of shoes per year (ABICALÇADOS, 2017).

Therefore, the footwear production generates a large volume of solid waste (plastic/rubber) that originates from the cutting of the raw material. The management of such waste must comply with operating licenses and must also comply with relevant legislation. For this purpose, the National Solid Waste Policy (PBRS) was created (Law No. 12,305/10) to provide mechanisms for waste generation prevention and reduction, based on the proposition of sustainable consumption habits to reduce the main environmental, social and economic consequences of inadequate solid waste management (Ministry of the Environment, 2017).
In this context, this article aims to explore sustainable solutions that can be developed for the correct destination of solid waste generated in the footwear sector through a PSS offer. The conception of this new business model starts from the concept of a sustainable PSS offer for the industrial waste management of the footwear sector.

2.RESEARCH METHOD

This study was carried out based on a case study of a waste reuse startup. The startup reuses waste from factories located in the State of Rio Grande do Sul (Brazil). The work method was structured in the following phases: (i) Requirement engineering - which includes the steps of elicitation, categorization, prioritization, identification of technical requirements; requirement publication, and identification of requirement trade-offs; (ii) Product-Service System Integration - which addresses the deployment and design of the processes for the development and delivery of the sustainable PSS offer; and (iii) Product-Service solution design - which presents the concept and the design of the PSS solution prototype.
The first phase was developed based on the steps proposed by Sommerville (2005) and Kontonyae and Sommerville (1992) and on the application of the Quality Function Deployment (QFD) (Kim; Yoon, 2012; Ribeiro et al., 2001) for the prioritization of requirements. In the second stage, the design of the processes of the PSS offer was done following the Product Service Blueprint proposed by Geum and Park (2011). In the last phase, the concept design and description was carried out using System Map tool (Tischner and Vezzoli, 2017), which synthesizes the main stakeholders and their relations in the new offer. The stages and activities contemplated in each phase of the applied method are detailed in the Results section.



[Figure 1] *Research Method*

3. RESULTS AND ANALYSIS

3.1. Requirement Engineering

In this phase, step 1 was started. The elicitation process collected requirements to identify the needs of critical stakeholders. To that end, a qualitative research was carried out with the startup (case study) managers and companies of the footwear industry. The research with the main stakeholders ratified the importance of incorporating sustainable aspects into the business model. In addition, other needs identified in the qualitative research addressed: the possibility of transforming waste into packaging for footwear as a product of the new solution, pickup services, environmental consulting, reverse logistics, among other PSS offer services.

In Step 2, requirements categorization was done through a Hierarchy Tree (Akao, 1990), which presented the primary requirements for Product and Service. Requirements were deployed at secondary (categorization of needs) and tertiary levels (important requirement) from the perspective of the customer. In Product category, process requirements (maximization of the use of the waste generated) and usability (impermeability, maintenance, resistance, and assembly) were pointed out. In Service category, the deployed requirements were Management (management and negotiation), Logistics (activities of separation, transportation and correct destination of waste) and Regulatory (legislation and regulations).

Step 3 comprised the prioritization of customer requirements, identification of technical requirements and specifications. To do this, a quantitative survey was conducted with 28 respondents from the footwear industry, which are potential users of the new offer. The quantitative survey aimed to assess the degree of importance of the requirements demanded. Prioritized items correspond to the Management and Usability aspects of the offer. The most important ones were: (i) Optimal packaging size for transportation and storage; (ii) Maintenance of the physical integrity of the product through packaging; (iii) Ease of packaging assembly; (iv) The packaging must be resistant to piling; (v) Easy placement of the shoe in the package; (vi) The packaging must be impermeable or absorb the least moisture; vii) Contracting a company to collect and dispose of the waste generated; viii) Training to ensure the correct separation of the waste collected; ix) Improvement in the use of the raw material to packaging manufacture, and x) Reliability in transportation and final disposal of external waste.

In step 4, we presented and asked the development team and requirement managers to approve the customer-prioritized requirements with metrics/indicators (measurable technical requirements associated with stakeholder requirements), and specifications (which assess if technical requirements are being met).

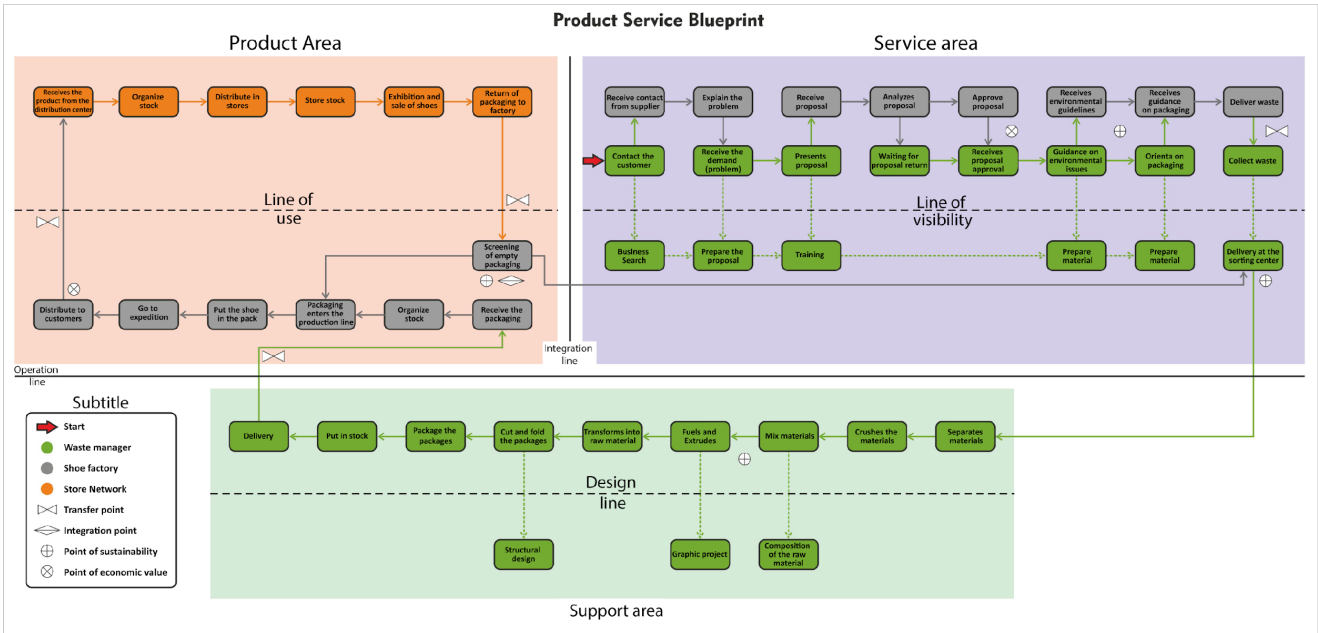
Next, in step 5, trade-off relationships between technical requirements were identified from the QFD quality matrix roof (see Akao, 1990). The 10 technical requirements that presented a greater influence on customer satisfaction were prioritized: (i) Percentage of free area in the horizontal opening of the packaging; (ii) Resistance to compression (weight/thickness); (iii) Percentage of liquid absorption; (iv) Resistance to column compression (kgf/cm); (v) Space optimization (m^3); (vi) Time necessary to build creases in the package; (vii) Easy placement of the shoe in the package; (viii) Amount of material sent to landfills/recycled material; (ix) Percentage of personnel trained for the separation and collection of waste; and (x) Percentage of models of waste use based on software simulation.

3.2. Product-Service System Integration

In this phase, the necessary processes to meet the quality characteristics were deployed using the Product-Service Blueprint tool for PSS (GEUM, PARK, 2011), presented in Figure 1.

The processes in Figure 1 are divided into product use area, service area, and support. Several stakeholders were found in the PSS offer (Startup, footwear industry, and footwear commercial establishments). The following points of sustainability were highlighted in the offer: recycling of waste to produce packaging, packaging reverse logistics, and life cycle extension due to packaging sorting. The economic value point is reached when Startup services are contracted. The startup is responsible for managing customers' waste (from the footwear industry) throughout the entire product life cycle.

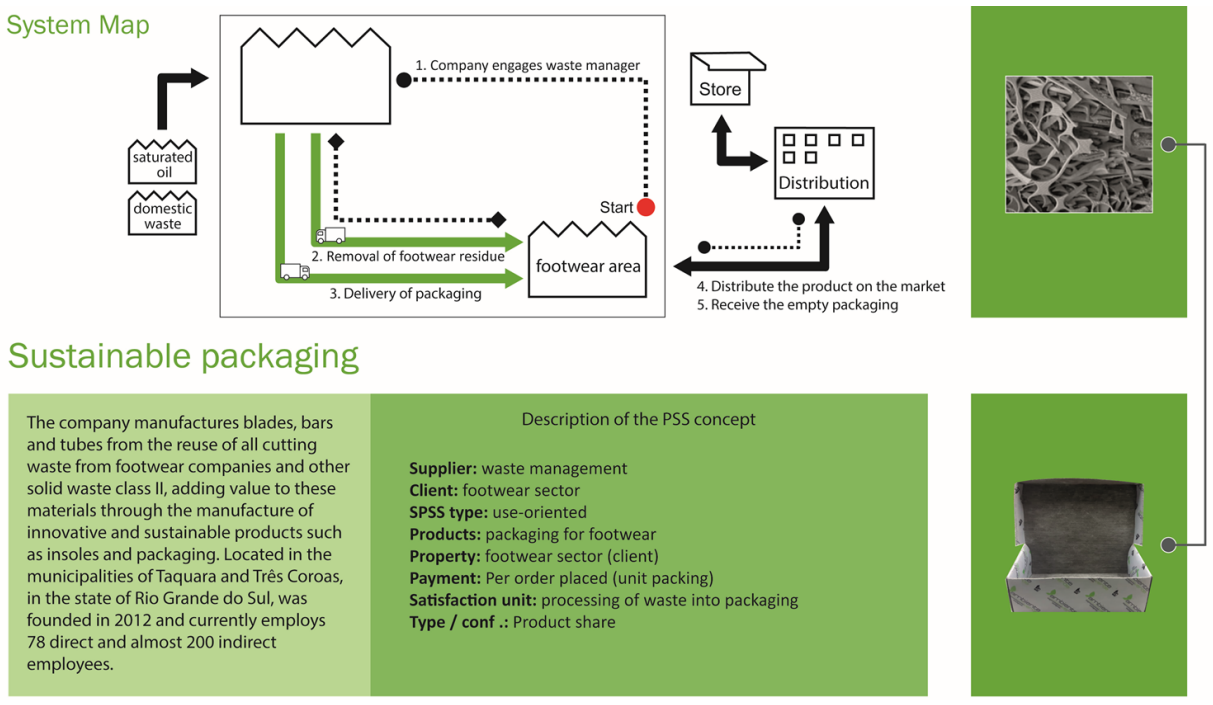
Next, in step 2, 10 critical process steps were selected that meet critical requirements following the QFD process matrix logic (Akao, 1990; Ribeiro et al., 2001). This step was done based on processes' relevance, difficulty and time to implement improvements. Prioritized processes were packaging manufacturing; packaging consultancy; commercial proposal; return of packaging to the factory; extrusion; product distribution to stores; shoe placement in the package; environmental consultancy; material sorting, and waste collection.



[Figure 2] *PSS process deployment*

3.3. Description of the Product-Service Solution

This phase includes the creation of a prototype of the integrated solution and the final design stage of the PSS offer, using the System Map tool (Tischner and Vezzoli; 2009), as shown in Figure 2.



[Figure 3] *PSS Concept*

The process begins when the footwear company contracts the company providing services to remove the waste. Thus, the company collects the waste directly in the footwear industry. Next, the company manufactures the sustainable packages, and delivers them to the footwear company to store the shoes. The footwear sector, through its distributors, delivers the products in the stores that will market the footwear without delivering the packages to the final consumer. After selling the shoes, the stores deliver the empty sustainable packages to the distributors. Then the footwear sector receives the empty packages so that the cycle can begin again.

4. IMPACTS ON SUSTAINABILITY

The PSS developed in this study addresses a solution for waste management in the footwear industry through a sustainable packaging used to store, protect and transport a material good (shoes), in addition to waste collection services, packaging management, logistics services, among others.
The impacts on sustainability for developing a package using solid waste from the footwear industry are related to the correct and sustainable destination of waste, avoiding negative impacts to the environment, in addition to contributing to the improvement of processes in products and services.

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