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Using Heuristics in the Creative Process of Product+Service System (PSS): Example of a case study using Blueprint Matrix

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ABSTRACT

The creative process of Sustainable Product + Service Systems (PSSs) that involve a variety of social, economic and environmental elements is a very complex process that can be characterized as a wicked problem. The following study highlights that, currently, the tools used in PSS assist in the system design process but often explore the design process intuitively based on the designer's experience. When dealing with complex problems it is important to use a more structured design approach, which involves multidisciplinary teams to explore systematic design techniques. In this sense, a method recognized to assist in the process of creating complex systems is the heuristic. The use of heuristics is considered a cognitive strategy that not only accelerates the creative process, but also generates solutions, regardless of spontaneous creativity. In this article, an analysis of the creative potential of heuristics was carried out with the blueprint tool. The research method used included an unsystematic theoretical survey, followed by an exploratory case study. Therefore, it is intended to contribute to the detection of emphases and gaps in the literature and demonstrate through practical application, the interaction of designers with heuristic principles in the creation process of PSSs.

Keywords: Product-Service System, Wicked Problem, Creative Process, Heuristic Methods.

INTRODUCTION

According to Tschimmel (2010), the importance of creativity in different social contexts is increasing, as these are rapidly changing, increasingly demanding the ability to deal creatively with several complex situations and problems. Today the challenge is not only to innovate in the area of products or services, but also integrate them in a system.

In this context, a concept that has been gaining prominence is the Product + Service System (PSS). PSS can be defined as a set of products and services integrated into a system to meet the customer needs (Goedkoop et al., 1999). Thus, the PSS approach shifts the designer's attention from producing isolated physical products to offer integrated systems that meet the ever-increasing demands of consumers (Marilungo, 2016).

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The creation of PSSs has particular characteristics that demand a more empathic process that considers the existence of multiple points of contact, involving intangible and tangible aspects, which makes these systems more complex (Marilungo et al., 2015; Vasantha et al., 2012). While creating sustainability-oriented PSSs this complexity increases, approaching the reality of wicked problems, requiring the adoption of distinct creativity techniques and methods with a more systemic and holistic approach.

Manzini & Vezzoli (2010), Nguyen et al. (2014), Qu et al. (2016) and Baines et al (2017) reinforce, however, that there is a lack of methods, techniques and tools that adequately support the development of PSS, considering the complex interactions and individualities of products, services and systems. Even though the process of creating PSSs can benefit from adapting existing creativity methods and tools aimed at creating products and services in isolation, in many situations these tools are not capable of dealing with multiple and often simultaneous interactions occurring throughout the development of a Product-Service System. Thus, idealizing and designing a PSS does not correspond to a simple or direct activity, but rather to a complex process that requires multiple abilities and cooperation between functions within the company (Kim et al., 2012).

Chu et al. (2010) points out that among the existing methods of creation, one that can be recognized for meeting complex demands and assisting the generation of ideas, are those that involve more structured systems, such as heuristic methods. According to Yilmaz & Seifert (2011) heuristics serve as cognitive strategies applied to the creation of projects that lead designers to a space of diverse, unexplored solutions, generating more creative ideas with high innovative potential.

Forcelini et al. (2018), also point out that creativity techniques involving heuristics accelerate the creative process and are capable of generating solutions at the time and place where they are needed, regardless of spontaneous creativity, allowing the creative potential of each member of the team to emerge. This feature can assist in the creation process in competitive environments, as all participants receive stimuli and similar external knowledge, with internal knowledge being relevant but not limiting.

Thereby, in the following study, after searching in recognized literatures, the heuristic principles that come from consolidated tools recognized for their quality in the product scope (TRIZ, Altshuller 1940 proposal), service (ServQual, proposed by Parasuraman, Zeithalm & Berry, 1985) and sustainable systems (SDO-Mepps, Vezzoli proposal, 2010) are highlighted. Thus, an exploratory analysis of the integration of such heuristics in a PSSs

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creation tool is proposed. The objective is to stress emphases and gaps in the creation process, focusing on the initial stage of concept generation for PSSs, through heuristic principles.

The method used in this article is qualitative in nature and relies on an unsystematic bibliographic research, followed by an exploratory case study and analysis by applying a questionnaire. The exploratory case study research was attended by eight students, involving designers and engineers. The context of analysis occurred within a workshop held as part of a discipline offered by the Postgraduate Program in Design of the Federal University of Paraná.

1. THEORETICAL FOUNDATION

This research is based on three themes: PSS and Sustainability; PSS and Wicked Problems; Creativity and Heuristic method.

1.1. PSS and Sustainability

PSS's strategic and systemic approach to business innovation is primarily aimed at decoupling value creation from increased resource consumption. The term PSS arises from the need for a new approach, which values systemic discontinuity in production and use patterns (Vezzoli et al., 2018).

Currently, several authors have pointed out that one of the barriers to the implementation of more sustainable principles is related to the rigid models of product commercialization (Vezzoli et al., 2018). For these authors, a more effective sustainability-oriented solution is the possibility of innovating in systems that involve aspects that go beyond "physical artifacts" (Vezzoli et al., 2018). Thus, the main emphasis is on meeting the needs of the end user, respecting the social demands and environmental limits of the surroundings. In this context, the combination of Products + Service Systems (PSS) enables the proposition of a new user satisfaction unit.

According to Tukker (2004) the PSS can be classified into three main categories: product oriented; use oriented; and result oriented.

In the product-oriented model, the customer has the product ownership, and extra services are added. The services offered are directed to the product in order to enhance its life cycle and make it more efficient (UNEP, 2009).

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In the use-oriented model, the product continues to play a central role, but ownership remains with the PSS provider, which offers availability and a customer-friendly platform. In this category the customer may opt for: leasing (pay usage fee for individual and unlimited access); rent or share (pay usage fee, but product may be used by other customers); pooling (multiple customers have access to the product simultaneously).

In the third model, result oriented, the focus is on the outcome and there is not necessarily a previously involved product. The customer does not buy the product but pays for the result they want without having to worry about the processes and systems involved. Thus, the delivery of a result is combined, and the provider have the freedom to define how to deliver it.

Tukker & Tischner (2006) point out that these three models that guide the PSS to fulfill functions, without necessarily increasing the production of new physical artifacts, aroused the interest of environmental and business researchers. Involving professionals from the industry and the academia due to the relevance of the PSS for competitiveness and sustainability (Marques, 2018).

In this context, the approach of the PSS to the sustainability tripod is described, highlighting its relationship with environmental, economic and social aspects.

Regarding environmental aspects, according to Baines et al. (2007), the expectation of researchers in this area is that a PSS, when properly designed, can result in lower environmental impacts when compared to the traditional pure product model, where the transfer of ownership and responsibility for the physical artifact it's from the client. Mont (2002) points out that when industry has greater responsibility for maintaining ownership of the physical artifact, it tends to abandon the strategy of programmed obsolescence. Thus, adopting practices to make improvements to the products and recondition to put them in circulation in the market. However, Tukker (2015) states that a PSS will not always be more resource efficient than product systems. Being the result-oriented PSS the most likely to bring gains in resource efficiency. Thus, Vasantha, Roy & Corney (2016) state that PSS solutions will only be more environmentally sustainable if they are developed for this purpose or may suffer from rebound effects.

Regarding the economic aspect of PSS, according to Marques (2018), the possibility of being able to generate sustainable value propositions also from the economic point of view makes the concept of PSS even more attractive. For Manzini & Vezzoli (2010), with the

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implementation of a PSS, organizations can generate economic benefits mainly related to operational efficiency and its strategic positioning. The improvement in strategic positioning, in turn, comes from the customer's perception of the value offered by the organization, which offers not only products, but services, based on utility delivery, which may present a customization differential (Marques, 2018). According to Tukker & Tischner (2006), PSS proposals with more customized solutions deliver greater value to the consumer, both material and immaterial.

Finally, regarding the social dimension of the PSS, the authors Beuren, Ferreira & Miguel (2013) highlight the aspects related to well-being and social inclusion that it can provide. PSSs that consider social issues may enable increased access by people, even those with low purchasing power, to certain products (e.g. business models in which rental and lease agreements are made, among others). The focus shifts to access instead of possession. Aurich, Fuchs & Wagenknecht (2006) further add that socially oriented PSSs can boost the creation of knowledge-enhancing jobs and can also lead to a more equitable geographical distribution of work, bringing improvements to the social dimension of sustainability.

Therefore, it can be concluded that properly designed Product - Service Systems (PSS) have the potential to meet customer needs and provide competitive economic advantages to companies while at the same time providing social advantages and reducing resource consumption and the environmental impact. However, the creation of a PSS that considers such aspects is a complex task, since it requires the elaboration of systematic strategies and a more empathic process, with creation methods and tools that allow a faster project.

1.2. Wicked Problems and PSSs

Rittel & Webber (1973) and Roberts (2000) classify problems according to their degree of harmfulness and categorize them according to their complexity and impact. In this way, they consider less harmful the simple problems and more harmful the so-called wicked problems (Rittel & Webber, 1973). Wicked problems are incomplete, contradictory and with changing requirements (Rittel, 1973). These commonly refer to areas related to public policy and today's economic, social and cultural challenges (Cipriani & Rossi, 2018).

Suoheimo (2016) points out that complexity and diversity are the defining aspects when a problem is simpler or more complex (wicked). A simple problem would be when all actors involved share a single opinion or objective, and the problem are known, on the other hand a super wicked problem occurs when actors share conflicting interests and values and both the problem and solutions are previously unknown (Suoheimo, 2016). Another thing to

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consider is that wicked problems in their nature do not have a correct and unique solution but have an ideal solution within a given context and time period (Ritchey, 2013; Rittel & Webber, 1973). Thus, wicked problems demand the use of more structured and empathic design strategies, with creative methods and tools that allow a systemic view of the problem, not seeking only a single correct and absolute solution.

It should be noted again that the Product + Services Systems (PSSs) focused on Sustainability, have characteristics that resemble to wicked problems. Because even though PSSs have differences in the degree of complexity of problems, they mostly involve multiple touch points and stakeholders who share interests and have opposing values.

Roberts (2000) highlights three possible strategies for dealing with different types of problems: authoritarian, competitive or collaborative strategies. The author points out that authoritarian strategies should be used for simple problems, as these usually do not need negotiations. Collaborative strategies are more evident in wicked problems, due to the need to involve all actors to share responsibility for the resolution. That way, in the present article is highlighted, through a case study, the collaborative strategies, which help in understanding a problem in various points of view, by involving people from different areas.

It should also be noted that choosing appropriate techniques and tools to deal with wicked problems is not an easy task. Suoheimo (2016) highlights some tools developed for wicked problems and others that were even developed for simpler problems have already been applied for wicked problems solving, such as: mess map, resolution map, concept maps, blueprints, prototyping, among others. One thing in common among these tools is the easy and wide visualization of the entire system it should provide.

The above considerations, aimed at understanding and solving complex problems, were fundamental for the definitions concerning the application of the exploratory case study of the present article. Thus, it was used a collaborative strategy, with the involvement of designers from different areas, selecting the blueprint tool for the integration of heuristics, as it is indicated for both the PSS project and the structuring of complex systems.

Silva (2012) also highlights that the blueprint matrix makes possible to map the entire life cycle of the service including the different touch points, the customer's actions and all interactions of the company for the service to occur, whether visible or invisible (frontstage or backstage). Thus, reinforcing the selection of this tool for the case study in conjunction

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with the application of heuristics, in order to stimulate the creative process and the visualization of complex systems in a schematic way.

1.3. Creativity and Heuristic Methods

Design methods, with their systematic approach, aim to contribute to creation by extracting and stimulating thinking beyond the ordinary. Pazmino (2015) reinforces that "methods are not the enemies of creativity, imagination or intuition, on the contrary, they lead to innovative solutions".

According to Pazmino (2015) when working with complex problems, the methods are also very relevant. Because of their ability to foster collaborative externalization, sharing and discussion, everyone can brainstorm ideas and join efforts to find solutions to the complex problem.

There are several specific design methods to assist and stimulate creative thinking. According to Mann (2002) most of them were developed on the belief that a very small proportion of brain capacity is used in creation. Thus, in general, they try to increase the flow of ideas by removing the mental blocks that inhibit creativity or expanding the area in which a search for solutions is made (Cross, 2008).

De Carvalho (2008) proposes the classification of project creation methods into three categories: Intuitive, Systematic and Heuristic Methods. Importantly, within the proposed classifications, overlaps may occur, since: there are systematic methods that include intuitive and heuristic methods; heuristic methods that include intuitive techniques; and intuitive methods that include heuristics. Therefore, the proposed classification is not sought to be definitive, but rather a proposition that may increase the likelihood of finding creative solutions.

Regarding intuitive methods, techniques such as brainstorming, 635, questioning and checklist are based on psychological stimuli, ie, seek to promote changes in attitudes and thinking models within the group in an attempt to generate ideas that were not observed. According to Siqueira (2015) such techniques have some limitations, as they work with pre-existing knowledge and experience, that is, no new knowledge is introduced. Unlike systematic and heuristic techniques that seek to highlight internal knowledge and add new knowledge to the creative experience.

The present article highlights the heuristic method, which is based on rules and standards of the creative process (De Carvalho, 2008). According to Siqueira (2015) the heuristic method

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proposes the "Systematized Inventive Thinking" which corresponds to techniques that use the knowledge base derived from innovative experiences in several fields of human activity, following the inventive principles of TRIZ.

In this study, three methods are classified as heuristic: the TRIZ, ServQUAL and SDO-Mepps. Each of these methods encompasses heuristics directed to product design (TRIZ), service (SERVQUAL), and sustainable systems (SDO-MEPPS). After the literature review, such heuristics were considered relevant, as they are a reference of quality in the scope of product, service and sustainable systems. Thus, these were selected for application in an exploratory case study conducted in this research.

TRIZ "Teoriya Resheniya Izobretatelskikh Zadatch" (Inventive Problem Solving Theory) is a Russian theory, created by Altshuller and his team in 1940. They sought to define the processes involved in obtaining the creative solutions contained in patents. They studied around 400,000 technology patents, of which they observed certain basic regularities and standards involving problem-solving processes. The aim of this study was to seek more effective alternatives to existing methods for creative problem solving, especially to purely psychological methods (Ilevbare, Probert & Phaal, 2013).

TRIZ is based on the premise that the evolution of technology and the generation of innovative ideas is not a random process, but predictable and governed by certain laws, based on patterns and lines of evolution (Eversheim, 2009; Zlotin, Zumann & Hallfell, 2011).

According to Siqueira (2015) TRIZ was originally created to support the solution of technical problems considered of greater complexity, especially in the development of new products and technologies. In recent years it has expanded its application and can be found in the search for new services (Weigert, 2016), and management and social problems. For Ilevbare, Probert & Phaal (2013), the inventive principles tool is one of the most used within TRIZ. It consists of 40 Inventive Principles (IPs)/ heuristics, proposed after the survey and analysis of patents by TRIZ researchers (Figure 01).

The ServQual tool was developed specifically for the service dimension. Its purpose is to uncover different gaps in service offerings, and to explain service quality as the deviation between expected results and perceived service results (Becker, Beverungen & Knackstedt, 2010).

The ServQual scale was proposed by Parasuraman, Zeithalm, & Berry in 1985, from a marketing perspective, as an instrument for measuring the quality of service perceived by

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the customer. In the research conducted by the authors, they found response patterns, which revealed ten evaluative heuristics in which the user can appropriate regardless of the service investigated, namely: Tangibility (physical appearance of facilities, equipment, workforce and normative materials); Reliability (ability to perform the promised service reliably and accurately); Responsiveness (ability to assist users promptly); Competence (appropriation of required skills and knowledge to perform services); Cordiality (politeness, respect, consideration and friendliness of workers); Credibility (trust, truth and honesty); Safety (no danger, risk or doubt); Accessibility (proximity and empathic contact); Communication (keeping users informed in a proper language) and Understanding (striving to understand the user and their needs) (Pena et al. 2013). These heuristic principles of the Servqual tool (Cavalieri & Pezzotta, 2012) can be used in both the generation and evaluation of concepts, assessing the quality of services.

The Sustainability Design Orienting-Product Service System Methodology (SDO-MEPSS) <http://www.sdo-lens.polimi.it/> proposed by Vezzoli (2010) directs heuristics to the three dimensions of sustainability in the development of PSSs (Figure 01). With this the platform aims to guide the design process towards sustainable PSS solutions. The specific objectives of the platform involve: setting sustainability priorities; guide and verify sustainable design; and use guidelines to visualize improvements over an existing reference system and its sustainability priorities (Vezzoli, 2010).

Figure 01 summarizes the main heuristics of each of the previously analyzed methods. Being considered the 10 heuristic principles of quality of service, originally proposed by Parasuraman, Zeithalm, & Berry in 1990 (ServQUAL), 40 TRIZ inventive principles (Altshuller, 1998) and 18 sustainability principles for the PSS - SDO Mepps (Vezzoli 2010), totaling 68 main heuristic principles.

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Figure 01. Heuristics Principles: Altshuller, 1940 (TRIZ); Parasuraman, Zeithalm, & Berry em 1990 (SERVQUAL); Vezzoli 2010 (SDO MEPSS).

2. METHOD

The present study follows a qualitative approach of interpretative nature. According to Polaine et al. (2013), quantitative data do not reflect the subjective reasons why people stop using certain services.

Firstly, an unsystematic bibliographic survey was conducted, aiming at contents related to PSS and Sustainability; Wicked Problems and PSS; Creativity and Heuristic Method. Subsequently, an exploratory case study was carried out through a practical workshop application in order to analyze the use of heuristics applied in the creativity tool for PSSs. According to Yin (2015), the exploratory case study is a strategy that aims to analyze real life situations.

Data collection consisted of participatory observations (Blessing & Chakrabarti, 2009), including photographic and video recording, as well as collection of documents produced by designers during the creativity session. In the analysis phase, after using the creation tool, the designers were instructed to answer a previously structured questionnaire, recording their perceptions about the tool. The results were compared with the propositions obtained from the literature review, allowing the development of key guidelines regarding the integration of heuristics in PSS creation tools.

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3. CASE STUDY

The creative workshop took place within the Design and Service discipline offered by the Postgraduate Program in Design of the Federal University of Paraná. The study involved eight students, six from design and two from engineering courses. In the briefing of the dynamics of the workshop, the proposal was for the students to develop a Sustainable and Innovative PSS for a local company that produces automated solutions for watering plants in the urban environment. The application of the exploratory case study followed a four-phase protocol:

a. Informational and icebreaker: Briefing contextualization and "icebreaker" among participants to avoid creative blockages by internal or environmental factors;

b. Tool presentation: Students were divided into two teams which received the blueprint matrix and the heuristic principles that were translated into heuristic cards;

c. Idea generation: Both teams analyzed all heuristic cards, seeking to generate ideas for each PSS step in the blueprint matrix. The generated ideas were written on post-its, and fixed in the blueprint matrix, indicating the heuristic card responsible for the proposed solution;

d. Questionnaire application: In order to obtain a more direct feedback related to the understanding, use and effectiveness of the heuristic cards, it was proposed a questionnaire at the end of the workshop.

For the application of the exploratory case study, 29 heuristic principles were selected for the development of the heuristic cards. Being 10 principles from TRIZ, 10 principles from ServQual and 9 principles from SDO-Mepps.

The blueprint matrix had only a few basic indications with gaps to be filled with removable heuristic cards. In order to facilitate the identification dynamics of the heuristic cards in the blueprint matrix, they had an alphanumeric code, such as the TRIZ heuristic principles: T1, T2, (...) T9 and T10. Heuristic cards also had different visual and textual configurations, in order to further analyze possible preferences regarding the usability of the tool (Figure 02).

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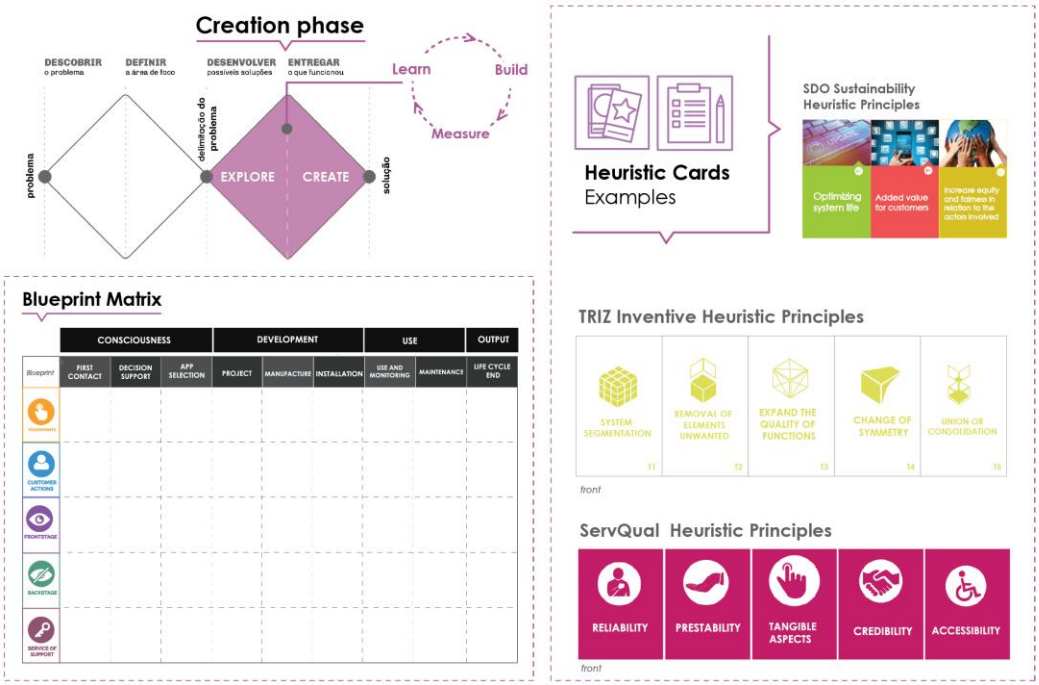

Figure 02. Schematic image of heuristic cards and blueprint tool.

The selected heuristic principles were adapted and designed to generate ideas from a more systemic dimension of the PSS. Thus, TRIZ's heuristic principles, once directed solely at generating product solutions, have been restructured to generate ideas that first consider interactions and needs within the system. If there is a need to create a new product or service this can be further proposed.

The systemic restructuring of heuristics can be exemplified by the principle of TRIZ, previously described as - “Segmentation Or Fragmentation: Dividing an Object into Independent Parts” (Altshuller, 1998) - now covering the whole system: "T1 - Configure the system in independent units but connected in networks, creating distributed systems that adapt to different contexts". In each heuristic, some examples have been added to stimulate analogies and creative process. The T1 card showed the examples: “Structuring the company in a modular way allowing certain sectors to be independent; Integrate specialized partners/third parties for certain functions in the system; Differentiated logistics system to meet the demands of different customers/users”.

The adaptation of the heuristic to the dimension of the system took into account concepts and definitions of systems presented in the literature. Ison (2002), for example,

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characterizes a system as an integrated whole from which the essential properties emerge from the relationships between the parts that compose it.

This process of restructuring and standardization of heuristics for a systemic dimension occurred in the 29 selected heuristic principles.

Parasuraman, Zeithalm, & Berry's 1990 Service Principle Cards (SERVQUAL) have on the back of the card a more detailed example of how such a heuristic principle can be applied, in addition to the icons and explanation of the principle in one of the faces. Cards elaborated with the Sustainability Principles for the PSS (Vezzoli, 2010 - SDO MEPSS) purposely did not have detailed examples of heuristics application but included questions and guidelines. This occurred in order to compare the interaction with different types of card configuration.

With the elaborated cards, in the application of the exploratory case study it was proposed to the participants that, besides generating ideas with the heuristic cards, to give their opinion regarding the similarity of each one of them. The following images show photos of the participants' interaction with the tool (Figure 03).

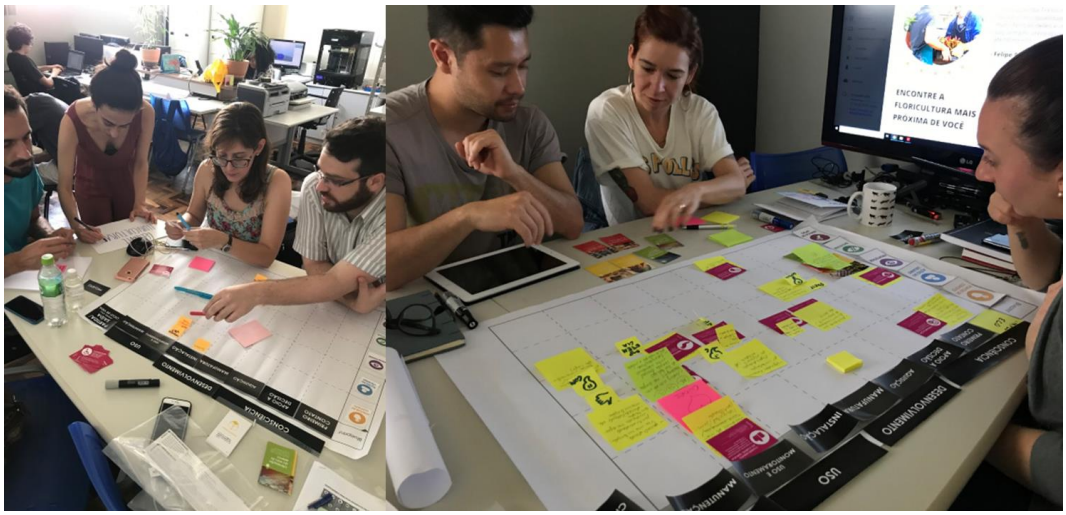

Figure 03. Team Interactions with Cards and Blueprint Matrix.

3.1. Results of the exploratory case study

In the dynamics of the workshop, one team focused on the creation of a result-oriented PSS and the other focused on the use-oriented PSS. The following images show how each team positioned the heuristic principles cards in the blueprint matrix (Figure 04).

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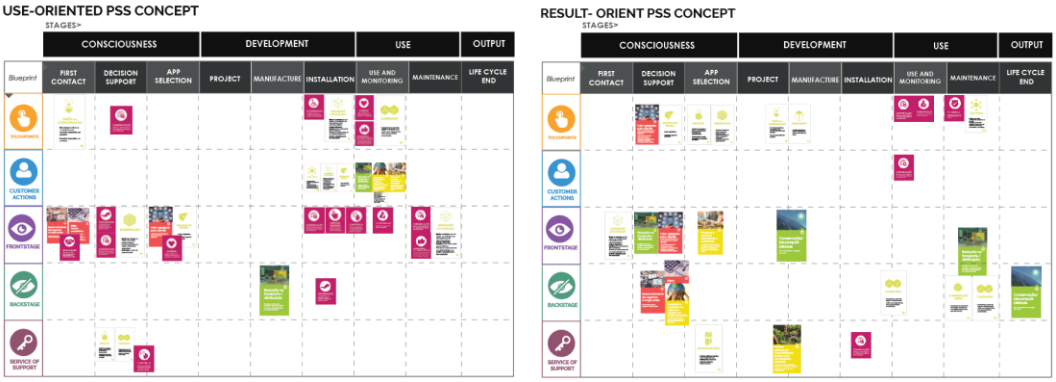

Figure 04. Blueprint with integrated heuristic cards according to ideas generated by participants of the two groups.

Many of the heuristic principles generated ideas for the same life cycle stage indicated in the blueprint matrix. Team 01, for example, students directed to the "PSS use and monitoring" stage, four distinct heuristic principles from TRIZ (1940) and SDO (2010): "Reduce system transport/distribution"; "'Increase equity and fairness in relation to the actors involved in the system"; "Promote responsible and sustainable consumption"; and "Increase Localized Quality - Assign different functions to each part of a system". With these principles were developed ideas such as: Strategic points of collection of vegetables; Social cohesion between users through the exchange of seedlings/experiences; Involvement of local producers; Transparency and personalization in the use and monitoring of vegetable gardens; among others.

In team 02, the heuristic principles, "Improve value-added system perceived by customer" and "Change symmetry: Customize system parts", were positioned in the "first contact" phase to support the user's decision, generating ideas such as: development of differentiated and thematic/customized kits or the development of plant guides through partnerships. Other heuristic principles, such as "Reduce system transport/distribution" and "Previously compensate an action in the system", were positioned in the backstage, generating ideas such as: logistics improvement using GPS and different systems, inclusion of sensors to avoid failures, among others.

As a finalization of the dynamics, participants were asked to answer a questionnaire related to their perception regarding the understanding, use and effectiveness of heuristic cards in the creative process. From the results obtained with the application of the questionnaire in the exploratory case study, it is worth highlighting some perceptions of the designers, such as:

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- The cases used as examples within the cards were considered adequate, as they give concreteness to the understanding of the concept proposed by the principle, besides being important for the generation of ideas by analogy "[...] the examples often brought new paradigms to support new ideas". However, in cards with very detailed examples, these end up inducing or limiting the thinking process.

- Despite the complexity of TRIZ cards, the examples helped a lot in understanding the principle during the creation process. The most generic examples directed at these cards were very important in guiding and explaining the meaning of the principles.

- One participant who had previous experience with TRIZ heuristic principles found it somewhat difficult to decouple these principles from product design even if the examples were linked to the system. Thus, the participant suggested the insertion of more examples and perhaps a greater adaptation of the terms used.

In the comparative analysis between the cards, of the eight participants, four had greater affinity with the application of the TRIZ principles, even though they were considered more complex and abstract. The other four participants were divided, two preferred the use of Parasuraman principles (1990) and the other two the principles of sustainability (Vezzoli, 2010).

Regarding the use of the blueprint matrix as a basis for the integration of heuristics, the participants considered it of high importance to assist in the systematization of the generated ideas, considering the whole PSS journey: "[...] Very good to think about the system as a whole"; "[...] essential for positioning the points"; "[...] It's a way of organizing insights according to the phases." Some of the participants had previously applied the blueprint matrix tool without the use of heuristics and considered that the integration of heuristic cards helped a lot in the process of generating ideas and filling in the matrix. Some designers also pointed out that they were able to generate ideas that would hardly be generated without the stimulation of heuristics.

All participants agreed that the tool along with heuristic principles fosters interaction with the group, noting that at times the insights brought by one card, when discussed with the team, complemented the ideas generated by other cards.

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4. FINAL CONSIDERATIONS

In the present article it is emphasized that although there are innumerable techniques and methods of creativity, few are directed to supply the complex demands of the creative process of a Sustainable PSS. Some product-oriented creation tools are mistakenly tailored for service or system design, showing a lack of knowledge and proper methods.

The asymmetric bibliographic survey allowed the identification of important concepts and methods related to the creative process of the PSS, and the compilation of heuristic principles considered as a reference in the different areas of the PSS. The selected heuristic principles involved three main groups: TRIZ heuristic principles, proposed by Altshuller (1998), aimed at product creation; Quality of service principles proposed by Parasuraman, Zeithalm, & Berry (1985); and heuristic principles focused on the development of sustainable systems, proposed by Vezzoli (2010). After the foundation it was possible to structure the exploratory case study in a more informed and consistent way.

The exploratory case study confirmed the data collected in the literature and stressed the importance of heuristic principles in the process of creating complex systems. These, in addition to guiding thought towards more relevant solutions, accelerated the creative process by not only relying on the spontaneous creativity of the participants.

The use of the blueprint matrix, according to the participants, greatly helped in the process of directing ideas. The matrix-shaped structure encouraged designers to create considering the several steps and elements of PSS. The matrix directed designers to think about user actions, and the various points of contact of the system, stimulating the generation of ideas for actions that will be visible (frontstage) and invisible (backstage) to users. In addition, the horizontal axis presented in the blueprint, which guides the representation of ideas chronologically, encouraged designers to generate systemic ideas considering all phases of the life cycle, from pre to post-PSS use.

It is considered that integrating heuristics into structured creation tools that consider the PSS lifecycle can further enhance the innovation potential of insights. Since, the understanding of the interactivity and relationship between the phases of the PSS life cycle are relevant for the designer to create considering the variables and multiple interactions existing in complex systems.

However, within the exploratory case study it was also possible to observe several gaps that need to be improved. The restructuring of heuristic principles to a more systematic dimension, although considered relevant, still needs to go through a process of improving

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the textual, graphic language and examples used. Studies have also been developed to improve the grouping of heuristics, eliminating repetitions and concept similarities.

In future studies, in order to validate the results, it is important to conduct new case studies, in addition to expanding the application of heuristics to other tools. There are many PSS-driven creation tools that make no use of strategies that guide the creative process in a systemic manner, such as: User Journey, System Map, Tomorrow headlines, Lego Serious Play, bodystorming, among others.

Finally, it should be noted that such research is part of a larger study, which is still in progress. Being showned in the present article only part of the research trajectory that has been deepened.

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