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A Gamified Approach to Engage Sustainable User Behavior in Product Service System Solutions.

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Abstract
Product service system solutions encourage to share products, reducing manufacturing processes and increasing the product life. Therefore, this might contribute to offer more sustainable solutions to users, by considering the complete socio-ecological system, the context, the stakeholder relationship, among other aspects. Where the sustainability behavior of consumers and the data provided for new information and technology (ICT) devices are key factors in the development of solutions with a higher sustainability performance. Moreover, game elements and ICT have been used in different fields to engage users. The aim of this research is to investigate if a gamified approach motivates a substantiable behavior change in users of product service system solutions. Based on a literature review, a model is proposed and applied to a product service system case of a shared laundry facility in Sweden. The model was evaluated with experts semi-structured interviews and a survey with users of the shared laundry facility. Concluding that a gamified approach has a potential to motivate behavior change towards sustainability in product service system. In future research, the proposed model will be adapted to be tested in other product service system cases, with the purpose to improve it for its application in industry and education.

Keywords: strategic sustainable development, game elements, product development, smart PSS, behavior change.

1. Introduction

Society is facing a systematic increment of negative environmental impacts, e.g., global warming, water acidification, biodiversity lost, and other impacts that affect the human wellbeing and the nature. These impacts are linked to human activities, that in many cases involve the manufacture and use of products. With the introduction of Product service systems (PSS) as a business model, products are combined with services to create long-lasting products, reduce materialization, focus on the functional result instead of ownership, among others benefits (Tukker, 2004), e.g., paying per hour flight. A PSS solution might not imply compliance with sustainability (Kjaer et al., 2018). In line with this, the role of the stakeholders and their relationships with the system are crucial for the development of more sustainable PSS solutions (Haase et al., 2017), where the customer behavior might improve or deteriorate the sustainability performance of a PSS solution (Kjaer et al., 2018). Furthermore, the implementation of services into the products can bring some challenges to the consumer, such as manipulation or lack of trust (Shi et al., 2017). There are several key aspects to determine the Circular economy in PSS, like the active collaboration between stakeholders, life-cycle thinking in the complete process, value preposition, among other aspects, requiring a transformation of the model business, where gamification can be used to improve the implementation of sustainability in PSS

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(Fernandes et al., 2020). Game elements have been applied with a high success in the improvement of business models, user engagement, learning, training, simulation, among other applications (Werbach & Hunter, 2012). Gamification has been used to engage user behavior for the development of sustainable solutions (Valencia et al., 2015). The aim of this research is to determine a clear understanding of the use of gamification for sustainability behavior change and its relationship with the development of sustainable PSS solutions. This study is guided by the following research question, how can a gamified approach motivate sustainable user behavior in the development of PSS solutions?

2. Conceptual background

2.1. Sustainable PSS

For a more strategic sustainability perspective, the framework for strategic sustainable development (FSSD) supports a system thinking contemplating the social, environmental, and economic dimensions of sustainability (Broman & Robèrt, 2017). The FSSD is based on backcasting, where a sustainability vision is created, and strategic actions are determined to reach that vision. The FSSD is founded on the sustainability principles (SPs), which are: "in a sustainable society, nature is not subject to systematically increasing (1)concentrations of substances from the Earth's crust, (2)concentrations of substances produced by society, (3)degradations by physical means, and, in that society people are not subject to structural obstacles to (4) health, (5) influence, (6) competence, (7) impartiality, and, (8) meaning-making" (Broman & Robèrt, 2017). The circular economy (CE) proposes circular loops in the product life cycle, ensuring that everything is used inside the system, eliminating the concept of waste in the process (Matschewsky, 2019). PSS is linked to sustainability, PSS is "a system of products, services, supporting networks and infrastructure that is designed to be: competitive, satisfy customer needs and have a lower environmental impact than traditional business models" (Mont, 2002). PSS solutions are classified in three main types (Tukker, 2004): 1) Product-oriented PSS, where supplementary services are supporting the ownership of products, e.g., maintenance service; 2) Use-oriented PSS, where the provider owns the product and the consumers rent or share the product, e.g., bike sharing system; 3) Result-oriented PSS: where users pay for the final result, e.g., pay per copy. Haase et al, (2017) identified PSS characteristics such as 1) Physical products; 2) Product and service; 3) Actor network and infrastructure; 4) Satisfy customer needs and create value; 5) Reduce environmental impact; 6) Competitive; 7) New Business model; 8) Innovation strategy/ design process; 9) Customer life cycle; 10) Product life cycle; and 11) Self-learning system. In line with this, Kjaer et al. (2016) determined seven PSS characteristics that need to be consider for an environmental assessment, saying the PSS 1) enables innovation, 2) affects and relies on user behavior and perceptions, 3) is context dependent, 4) is (often) a design strategy, 5) involves the whole product life cycle, often including end-of-life options thereby extending into multiple life cycles, 6) is a system of tangible (product) and intangible (service) elements, and 7) relies on a supporting background system. In some cases, a PSS can trigger rebound effects, where a PSS can be overused due to its high sustainability performance perception, incrementing the negative environmental impacts (Kjaer et al., 2018), e.g., the overuse of a washing machine in a laundry sharing system, causing a higher energy and water consumption. PSS solutions might be supported by ICT,

known as Smart PSSs, providing benefits such real time data, track of the system performance, better stakeholders communication and eco-efficiency (Valencia et al., 2015). Smart PSSs gather relevant data for the PSS design (Wiesner et al., 2016), by simulating the system, collecting user experience data, encouraging sustainable use and report the system status, e.g., maintenance (Villamil et al., 2020). Moreover, a gamification approach applied in the use of a PSS solution might facilitate the user´s communication (Valencia et al., 2015).

2.2 Gamification and behavior change

Gamification has been defined as "the use of game elements and game-design techniques in non-game contexts" (Werbach & Hunter, 2012). The inclusion of game element needs a clear comprehension of the behavior of players. Therefore, Bartle (1996) determined a typology of players according with their skills and expectations: 1) Explorers: investigate and find new things; 2) Achievers: solve challenges and get mastery in the process; 3) Killers: compete with themselves or against others; and 4) Socializers: collaborate and share with others. Some companies use rewards to engage users, e.g., customer loyalty cards, although many rewards seldom guarantee a behavior change and a long-term commitment. For that reason, Chou, (2019) proposes the Octalysis framework with 8 drivers: 1) Epic Meaning & Calling, players actions are very relevant, e.g., low income communities donations; 2) Development & Accomplishment, users solve difficult challenges and improve their skills, e.g., top of a leader board; 3) Empowerment of Creativity & Feedback, players provide their ideas, e.g., co-design; 4) Ownership & Possession, users gain and keep something that is valuable for them, e.g., virtual goods such avatars; 5) Social Influence & Relatedness, users interact with others: e.g., support other players; 6) Scarcity & Impatience, users are pressured by constraints, e.g., time limit; 7) Unpredictability & Curiosity, users are interested to discover and reveal secrets, e.g., uncertain missions; 8) Loss & Avoidance, players prevent losing something meaningful, e.g., level downgrade. In this framework, the drivers 2, 4 and 6 are related to the extrinsic motivation (Chou, 2019), which is connected to short-term behavior change. In contrast, the drivers 3, 5 and 7 are linked to the intrinsic motivation (Chou, 2019), which is associated with the long-term behavior change. Ponce et al. (2020) proposed a gamification platform to reduce energy consumption by using the Octalysis framework and the player typology, suggesting that gamification enables user behavior change. Wells et al. (2014) developed a journey planner gamification platform to select the most sustainable transportation options, where users can compete with themselves by reducing CO2 emissions and get transportation system discounts as rewards.

3. Research approach

This research follows the Design Research Methodology (DRM) framework (Blessing & Chakrabarti, 2009). See Figure 1. In the research clarification (RC), a semi-systematic literature review was conducted, analyzing a certain amount of references in a systematic way (Snyder, 2019). The web of science and Scopus databases were used with the following research query: product* service* system*", servitiz*, product* service*, service* based, sharing* system, shared, environmental, sustainab*, eco*design, efficiency,

circular economy, circular*, green, gamif*, seriou* gam*, game approach*. After reading the tittle, keywords, abstract and conclusions of each article, the reviewed material was selected with the following criteria: 1) study relevance, 2) relationship with the research core concepts: PSS, sustainability and game approach, 3) potential contribution to the study as a conceptual background, 4) focus mainly on the PSS use phase and user behavior, excluding those that are related to the design and manufacturing phases, 5) only journal papers, book chapters and conference proceedings, excluding company reports, 6) published between 2010 to 2022, and 7) written in English. Additionally, an exclusion process was based on the relevance and meaning of the concepts: 1) sustainability in terms of economic, social, and environmental dimensions, 2) PSS related to product-oriented PSS, use-oriented PSS, result-oriented PSS, service design, and sharing economy, and 3) gamification linked to game approach, game-based learning, serious game, and game elements application. Furthermore, a snowballing process helped to add key references (Wohlin, 2014), by selecting references that have been highly used in the research area. In total 32 references where selected. The data analysis allowed to determine initial codes, main categories, patterns and differences, crucial aspects in the research and finally, to interpret the data (Braun & Clarke, 2006). The result of the RC provided the bases for the descriptive study (DS-I), which is an advanced analysis of the literature review with a specific focus on the key aspects of the field and the inclusion of a PSS case. The findings of the RC and DS-I supported the development of the prescriptive study (PS), which presents a model and its further application in a PSS case. For the descriptive study II (DS-II), an on-line survey with 23 PSS users and semi-structured interviews with seven experts provided a better understanding of the proposed model. The experts are listed in Table 1, they are mainly working in Sweden, and they were selected for their expertise in the field in academy and industry. The semi-structured interview guideline focused on evaluating the proposed model by identifying limitations, opportunities and improvements. Therefore, the obtained qualitative data was analyzed with a coding process (Braun & Clarke, 2006), by identifying similarities, differences and key concepts.

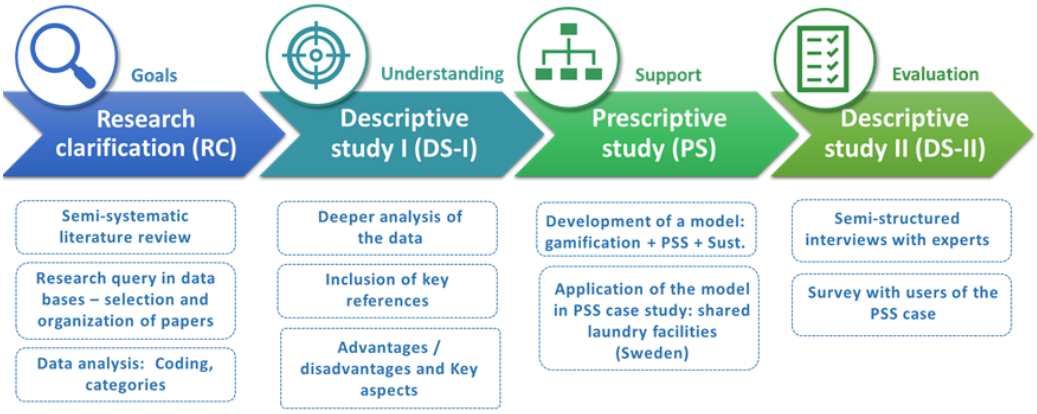

Figure 1. Research approach used in this study (based on Blessing & Chakrabarti, 2009).

Table 1. List of the experts that participated in the semi-structured interviews of DS-II.

Expert	Field	Expertise
A	Game development	Academy
B	Sustainable product development	Academy and industry
C	Strategic sustainability development and education	Academy
D	Mechanical engineering, product design and behavior change	Academy and industry
E	Software development	Academy and industry
F	Sustainable product development and behavior change	Academy and industry
G	Software development – data science	Academy and industry

4. Results

Gamification might encourage a "pro-environmental behaviour change" (Ouariachi et al., 2020). This section describes the advantages, disadvantages, and recommendations of this approach in PSS.

4.1 Advantages and disadvantages of using a gamification approach in PSS

With the literature review, it was possible to identify advantages and disadvantages by using a gamified approach in PSS. Most of the literature highlighted the behavior change as a crucial advantage, where it is possible to motivate users to have a more sustainable behavior (Blohm & Leimeister, 2013; Bucher & Kreisler, 2020) and co-design (Hauge et al., 2016; Loizou et al., 2019). A gamification approach is able to satisfy needs, enforce autonomy and competence (Xi & Hamari, 2019), improve the service quality and loyalty (Pasca et al., 2020), increase the sustainability performance in terms of energy and water consumption (AlSkaif et al., 2018), reduce CO2 emissions, encourage social collaboration (Albertarelli et al., 2018), among other aspects. In contrast, there are several disadvantages to use gamification (Lister et al., 2014; Petridis et al., 2014), e.g., the overuse of physical rewards might cause that players focus on the rewards instead of having a sustainable behavior (Wells et al., 2014), causing the unbalanced situation of having high effort and low results in the process (Gangolells et al., 2020).

4.2 Recommendations for the implementation of gamification in PSS

Several authors agree that gamification has a potential to encourage user behavior. In this study, some recommendations for the implementation of a gamification approach in PSS are identified. See Table 2. For the design and better communication with the customer, it is possible to consider facts related to product life cycle, market circumstances, PSS provider or PSS alliance (Nemoto et al., 2014). Where customization and partnership can be crucial to include gamification elements in the PSS design, such as rewards, loyalty programs, cross-promotion, etc. (Kwon et al., 2019). In line with this, hedonic features increment a positive user experience, e.g., sharing information with friends and networking (Hsu & Chen, 2018). Moreover, to avoid complexity, it is recommended a balance between the number of game-based elements and their purpose (Beck et al., 2019). Furthermore, gamification requires voluntary participation, avoid monetization and balance the difficulty (Reis et al., 2020).

Table 2. Recommendations for the implementation of a gamification approach in PSS.

Recommendations for the implementation of a gamification in PSS	References
Constantly update the game / provide variety	Petridis et al. 2014
Make it meaningful to users	Petridis et al. 2014, Reis et al. 2020
Encourage to use it for a long-term	AlSkaif et al. 2018, Wells et al., 2014
Target behaviour change	Beck et al. 2019, Albertarelli et al. 2018
Improve the design / visual engage	Beck et al. 2019
Allow voluntary participation - avoid obligated fun	Reis et al. 2020
Provide useful information about sustainability	Albertarelli et al. 2018, Ponce et al., 2020
Provide social support and active interaction	Albertarelli et al. 2018, Ponce et al., 2020, Ro et al. 2017
Design a flexible system that is possible to adjust to customer	Wells et al., 2014, Valencia et al. 2015
Consider different types of players	Ponce et al., 2020
Enforce intrinsic motivation	Xi & Hamari, 2019, Ro et al. 2017
Balance the difficulty (not so easy or hard)	Reis et al. 2020
Balance between extrinsic and intrinsic motivation	Xi & Hamari, 2019

4.3 Model of a gamified approach to engage sustainable behavior in PSS.

With the literature review results, it was possible to propose an initial model to implement a gamified approach to engage sustainable behavior in customers of PSS solutions. Similar to other authors (Ouariachi et al., 2020; Ponce et al., 2020), this model uses the Octalysis framework (Chou, 2019) and the players typology (Bartle, 1996), to determine the gamification characteristics. Furthermore, the model includes key aspects related to the FSSD (Broman & Robèrt, 2017) and the CE aspects (Matschewsky, 2019) to guide the implementation of a sustainability perspective, such as backcasting by SPs, system thinking approach, design of long-term solutions, circularity, among others. Additionally, the model include the PSS characteristics identified by Haase et al. (2017) and Kjaer et al., (2016) such as: stakeholders' collaboration, customer value, among others. Finally, it considers the Recommendations for the implementation of a gamification approach in Sustainable PSS (SPSS) identified in this study. See Figure 2.

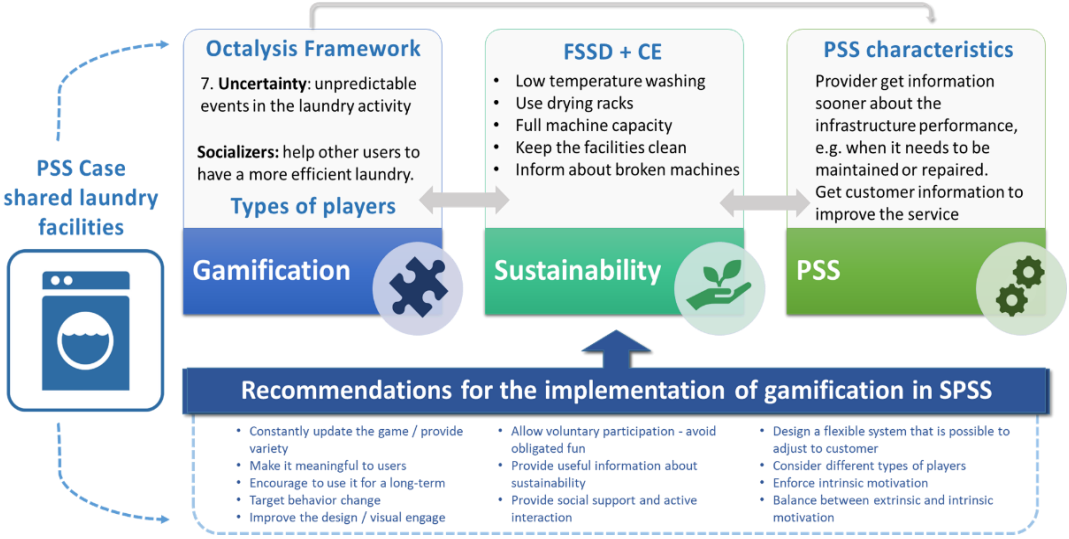

Figure 2. Initial Proposed Model of a gamified approach in a PSS case: Shared laundry facilities.

5. Discussion

The proposed model allowed to determine that gamification enables sustainable behavior change in PSS solutions. In this section, the model is applied to a PSS study case and some insights are discussed.

5.1. PSS Case study application

The PSS case used in this study is the shared laundry facilities of apartment buildings located in Sweden. Where users share the infrastructure for washing and drying clothes. In some cases, users are careless of the infrastructure integrity and have unsustainable practices in laundry room facilities, where the high temperature, machines underload, use of excessive detergent might cause environmental issues (Lutfi, 2020). The average temperature for washing is 42 OC (Schmitz & Stamminger, 2014), with a consumer behavior change it is possible to wash clothes in 30 OC (Mylan, 2015). Moreover, the energy consumption average related to washing in Sweden was 126,4 kWh/hh/year in 2011, which is higher compared with Spain 74,1 kWh/hh/year (Schmitz & Stamminger, 2014). Moreover, people with less education have more unsustainable behavior in the use of laundry facilities (Alborzi et al., 2017). With the use of ICT devices in washing and drying machines, it is possible to have an efficient service and a higher sustainability performance, requiring user engagement and support (Villamil et al., 2020). Lam et al., (2016) developed a Playful Laundry, motivating users to make the booking more effective, by using game elements such as points, leader boards and upgrading levels. Chaikittiwanich & Leakpech (2019) designed the washing machine personality for a better communication with the user. Zhao (2018) developed a gamified platform in a pay-per-use PSS, to encourage resource efficiency and low CO2 emissions. With the savings users can choose between 1) planting a virtual tree and create a virtual forest or 2) accumulate virtual money. In this study, a model is proposed considering recommendations to use a gamification approach, PSS characteristics and a strategic sustainability perspective. This model allows to identify actions to encourage the sustainability user behavior change. See Figure 2. A survey was used to test the model with the PSS case users. The survey results showed some issues with the laundry facilities, where most of the users mentioned the lack of instructions for a sustainable performance, the difficulty to book a time in non-working hours, dirty and unorganized facilities, see Table 3. In line with this, 36,4% of the users mentioned the desire to own the machines. In line with this, to improve the service some users suggested: periodic maintenance and cleaning, effective booking system, increment the number of machines with different characteristics, among others. The survey results validated the analysis of the different kinds of players in the process, where there is a variety of players with different competences and expectations. Most of the participants are interested to get information related to the laundry status, get tips, and point to improve their sustainability performance, change their points for donations. In contrast, few are interested to support other users, lose points for low sustainability performance, or get random awards. In the use of app for behavior change, they mention positive aspects such as the performance tracking and the comparison with previous use to motivate them to improve. One user mentioned "it might help me to understand my state and improve upon based on experience from many experts and users". As negative, they mentioned the high

intrusiveness, repetitiveness, and lack of instructions. Some of them mentioned that they have lost interest over-time. One user mentioned "Notifications would annoy me, unless they were to tell me the washing was ready, or the laundry room was available early".

Table 3. Sample of the results of the survey performed with 23 users of shared laundry facilities located in Sweden.

Issues in the shared laundry room	Never	Seldom	Sometimes	Very often	Always
The laundry room is always busy, it is difficult to get a time	5%	30%	35%	20%	10%
Some of the machines are broken	20%	60%	10%	10%	
Lack of instructions about the good sustainability performance of the machines	10%	10%	25%	30%	25%
Other user is using the room in my booking time	40%	45%	15%		
The Laundry room is dirty and unorganized	35%	35%	15%	15%	
There are clothes from other people in the machines	45%	40%	5%	10%	

Owning or sharing?	Buy my own washing and drying machine, to have my independency and use it at any time	47.6%
	Share the laundry room, it is more convenient, I do not have to worry about moving, maintenance, etc.	38.1%

Octalysis driver (Chou, 2019)	Willing to participate in the activities to improve the shared laundry room experience	Yes	Maybe	No
Development & Accomplishment	Get notifications about the washing and drying status	95%	5%	
Development & Accomplishment	Get tips to improve your sustainability performance	63%	37%	
Development & Accomplishment	Get information about the energy and water that you have saved	85%	10%	5%
Epic Meaning & Calling	Obtain points for being more sustainable, turn them into donations for forest plantation	90%	5%	5%
Ownership & Possession	Get awards for a high sustainability performance, example: discount in the energy bill	85%	10%	5%
Empowerment of Creativity	Give new ideas of how to improve the service	70%	25%	5%
Development & Accomplishment	Compete with yourself or with other users to get a high sustainability performance	50%	30%	20%
Social Influence & Relatedness	Support other users to be more sustainable	30%	50%	20%
Development & Accomplishment	Set specific sustainability missions, for example reduce the Temperature to 30oC	30%	45%	25%
Loss & Avoidance - Scarcity	Lose points or awards if you have a low sustainability performance	30%	35%	35%
Unpredictability & Curiosity	Get random awards for your sustainability performance, you do not know what you won	30%	40%	30%

Semi-structured interviews with experts were useful to get feedback about the proposed model. They mentioned some aspects to consider: 1) partnership with other systems such as electricity or detergent companies to engage users to reduce energy or use sustainable chemicals (Experts B and G); 2) understand customer needs to proposed a system that provides a value for the customer (Experts A, B, D, E and F); 3) consider future trends and use in smart buildings (Experts B); 4) make a clear business model and determine who and how get benefits (Experts B and D), 5) design for different kind of user/players (Expert A); 5) link the intrinsic motivation with intrinsic values and expectations (Experts C and F); 6) build sustainability awareness and knowledge in the process (Experts C and F); 7) ensure that the final function is fulfilled, the overuse of elements can turn into malfunction of the system (Expert G); 8) provide information about the user progress and sustainability contribution (Experts E and G); 9) promote team support by competing with other buildings (Expert D and F); 10) it is fun but, non-forced, non-intrusive, non-annoying and non-overwhelm the user (Experts D, E and G); 11) co-design and propose ideas to improve the system (Expert D); 12) get social support and recognition for the sustainability performance (Experts E and G); 13) allow that the activity itself is rewarding (Expert F).

5.2 Insights related to the proposed model

Strategic sustainability perspective: PSS can provide sustainability benefits, e.g., sharing solutions reduce the amount of manufacturing products (Piscicelli et al., 2015). Although, most of the literature focus on the reduction of CO2 emissions, energy, and water consumption (Ponce et al., 2020), leaving behind other negative sustainability impacts related to the social, environmental, and economic dimensions of sustainability (Villamil et al., 2020). In some cases, the sustainable behavior only remains when the system has a

gamification approach (Bui & Veit, 2015). In line with this, it is suggested to include a strategic sustainability perspective guided by the FSSD, proposing long-term behavior change, system thinking and stakeholder participation (Villamil et al., 2020). For example, long progression games keep players linked for a long period of time (Expert A). Furthermore, gamification can be connected to the intrinsic individual values to keep it for a long period of time, where collaboration is one of those values (Expert D).

Behavior change and PSS logistics: With gamification it is possible to encourage behavior change to adopt more sustainable habits (Kazhamiakin et al., 2015). Moreover, it encourages users to take extra actions, e.g., walk to a less busy station of a bike sharing system (Chiariotti et al., 2020). For the design of PSS solutions with a gamification approach, there are some aspects to consider such as visualization of the user behavior, comparison with cultural values, provide sustainability tips and encourage social interaction (Beck et al., 2019). In addition, it is crucial to make a link with the management of the system, i.e., to consider the different system elements, their interactions, and limitations (Villamil et al., 2020). The survey results verified that there are different kinds of players, and the gamification approach needs to consider this, "there is not a single game that is suitable for everybody" (Expert A), where PSS customization is a way to deal with users' diversity (Expert D). Moreover, it is possible to trigger intrinsic motivation by the activity itself, instead of using extrinsic rewards that might harm the intrinsic motivation (Experts D and F).

Stakeholder collaboration: The implementation of gamification in PSS allows to share information with customers, motivates an active collaboration between stakeholders, improves the communication between different stakeholders (Nemoto et al., 2014), e.g., the user can contact the PSS provider to inform when the infrastructure needs maintenance. In some cases, gamification can be used for training, as a social pressure, exploiting the gamification's emotional mechanics, such as competition and sharing, where social recognition and team building - competition trigger their behavior change (Ro et al., 2017). Moreover, gamification encourages co-design specifically in the PSS design process to increment the participation of the stakeholders involved (Shi et al., 2017). Subsequently, it is possible to create a competition between teams, where team members can support each other to be more sustainable (Expert D). In contrast, some survey participants mentioned their lack of interest in supporting others and participating in competitions.

Smart PSS: With the use of ICT in PSS is possible to track the product, get feedback, customize the PSS, among other benefits (Villamil et al., 2020). A gamification approach supports the user experience in Smart PSS (Wiesner et al., 2016), e.g., "adding QR codes in the detergents helps to determine which one is more suitable"(Expert G). According to the survey participants, a gamified app would encourage users to book the laundry room effectively, get sustainability tips and information about their sustainability performance, it was mentioned "I like to monitor my performance over time" (survey participant).

PSS and System perspective : To ensure a sustainability performance of a PSS solution it is necessary to manage the complete system (Kjaer et al., 2018). Therefore, the responsibility of being sustainable concerns to all the stakeholders that are involved in the whole product life cycle (Villamil et al., 2020), e.g., the manufacturer might develop long-lasting products that are designed to be shared and planned for circularity, where the PSS solutions might be maintained, repaired, remanufactured, or recycled (Fernandes et al.,

2020). In the survey, users suggested a periodic cleaning and maintenance of the facilities and highlighted the lack of information about the sustainability performance in the laundry room. As a PSS user mentioned "I'm afraid of filling the machine over the capacity, so I instead almost always use it under-capacity" (survey participant). Therefore, the service provider has the responsibility to make this information available to encourage a sustainable behavior (Expert B). It is required to reconfigure the system to be used in a sustainable way (Shahbazi et al., 2020). In line with this, an expert mentioned that it is necessary to balance the system properties and the sustainability performance, because low temperature might cause dirty clothes, and the PSS purpose is to ensure the system functionality, by "providing clean clothes" (Expert G).

Limitations of a gamification approach: in the application of a gamification approach some gaps need to be considered such as disengagement, irritation and sabotage (Lister et al., 2014). As a user mentioned "I do not like the competitive ladder… and the daily streak just turns it into an everyday chore" (survey participant). Additionally, there is little evidence of long-term effectiveness and behavior change between different user groups (Johnson et al., 2017), and lack of knowledge about the product sustainability performance. There are other limitations such as lack of narrative, lack of deep study on behavior change and use of short-term activities that disappear in the long-term (Petridis et al., 2014). In line with this, negative elements in the game such as losing points, might discourage users, turning it into an undesirable perception and misuse of the PSS solution (Experts E and G). Instead, some game developers have explored how to trigger certain kind of behavior with new strategies of rewards, experience, or level up (Expert A).

6. Conclusions

The current research aims to support PSS designers in the application of a gamification approach as enabler of behavior change towards sustainability. PSS solutions require constant participation of stakeholders, service quality improvement and system maintenance (Villamil et al., 2020). This is possible by using gamified platforms to discover, compete, achieve, and collaborate. A gamification approach includes game elements to explore fun strategies to motivate users, improve the system usability, share with others and increment its effectiveness (Werbach & Hunter, 2012). The results from the literature review, PSS users' survey and experts' interviews showed that gamification has the potential to encourage sustainability behavior in PSS users. A contribution of this study is the identification of recommendations and feedback from users and experts for the implementation of a gamification approach, providing a better understanding of how gamification can be applied in PSS solutions. The model presented in this study used the gamification drivers (Chou, 2019) and the players´ typology (Bartle, 1996) to guide the development of strategies in the design of PSS solutions to increment intrinsic motivation for a long-term sustainability behavior change. Those strategies are team building, co-creation, stakeholder communication, challenge achievement, active interaction and self-improvement (Experts B, D, E and F). In line with this, the FSSD (Broman & Robèrt, 2017) and CE aspects (Matschewsky, 2019) were included in the model, by connecting a strategic sustainability perspective with a gamification approach allowing to implement system thinking, manage the complete product life cycle, propose long-term solutions,

guarantee circularity, engage stakeholders communication, inform about the system status, provide ideas to improve the system, ensure long-term sustainable behavior change, provide diversity and customization (Villamil et al., 2020). Furthermore, promoting education and making users feel that their contributions are relevant (Experts C and F). As Kjaer et al. (2018) stated, it is essential to include in the system design the PSS function, added value, target group characteristics, sustainability benefits and adjust the required infrastructure and logistics. Moreover, Petridis et al. (2014) and some interviewed experts suggested to consider the barriers of implementing gamification, such as the overuse of extrinsic rewards, repetitiveness and intrusion to ensure its effectiveness.

Limitations of the study: Few references were used for the RC and DS-I, leaving behind other references that might be a potential contribution to the field. For the development of the model only the Octalysis framework was used to implement gamification, there are other frameworks and guidelines that might be explored. Few experts were contacted to validate the model. Moreover, only one case study was used to test the model in a specific location, it is possible that the results might differ in other PSS cases.

Future work: The inclusion of a gamification approach in the design of sustainable PSS solutions is still an immature field, that requires additional research in terms of behavior change, e.g., providing evidence of sustainability long-term change. Furthermore, there are several trade-offs that need to be explored to ensure sustainable Smart PSS solutions, e.g., e-waste. The presented model is in the initial phase, requiring further development, and assessment in different cases and contexts to be applied in industry and education.

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