DIGITAL TRANSFORMATION TYPES FOR PRODUCT-SERVICE SYSTEMS

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ABSTRACT

Digital transformation has become a mega trend topic for many enterprises globally. For some companies, customer interactions have been digitalized. But many companies still rely on physical interactions of customers with their products in the core value creation processes. Thus the key challenges for digital transformation efforts would be associating product-centered value propositions with digitalized services. In other words, the transformation of product-centered values into experience values co-created by customers with services supporting customers. The research goal of this paper is to identify different strategies for digital transformation in product-service systems (PSS) design so that diverse paths for digital transformation can be considered in designing PSSs. Three types for digital transformation strategies have been identified from PSS design cases conducted in a manufacturing servitization support framework project where PSSs have been designed for 15 manufacturing companies including SMEs and large companies with varying levels of digital technology. A classification for digital transformation strategies could be postulated with three primary dimensions and two supplementary dimensions.

Keywords: Product-Service Systems (PSS), Experience design, Industry 4.0, Digital Transformation, Customer Experience

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1   INTRODUCTION

A Product-Service Systems (PSS) is a system of products, services, supporting networks and infrastructure that is designed to satisfy customer needs and to generate values (Goedkoop et al. 1999; Tukker, 2004; Tan and McAloone, 2006; Tukker, 2015). Providing ecological values in addition to economic value was primary intention in early development efforts of PSS (Goedkoop et al., 1999; Tukker, 2004). Then socio-cultural aspect of services has been addressed in PSS design (Morelli, 2003). Industrial PSS developments (Meier et al., 2011) emphasized service supporting products mainly addressing economic values for manufacturing companies. Recently, efforts are being made to accommodate experiences issues as primary design goals in PSS design by reflecting characteristics of customer experiences in human-centered design approaches (Gemser et al., 2012; Kim et al., 2013; Valencia et al., 2015; Costa et al., 2018; Dewit, 2019; Kim and Hong, 2019). Also PSS customization issue are addressed recently (Zine et al., 2014; Song and Sakao, 2017; Kim and Hong, 2019). PSS design for a circular economy is drawing a lot of attention as the environmental issue has been a main focus throughout the PSS development efforts (Kjaer et al., 2018; Fernandes et al., 2020).

Many different PSSs are designed and developed reflecting companies' characteristics and intended value propositions. To compare and classify different PSSs, a PSS representation framework has been proposed (Kim, 2020). The representation is comprehensive to address the products and business contexts of manufacturing companies with information on their customers and other stakeholders as well as key values of them. The representation also describes the characteristics of resulting PSS design including service concepts, business model strategies and interaction information. It allows both rough comparison and detailed comparison of PSS cases. The service space of the representation can be used in guiding service concept design and directions for PSS design. A representation of PSS development process has been developed so that different PSS development processes can be compared and management of PSS development process can be supported (Kim and Lee, 2021).

Digital transformation has become a mega trend topic for many enterprises (Schwab, 2016). Consumer behavior is changing in response to digital revolution (Verhoef et al., 2021). Communication with other consumers and with product/service providers have been made easy and increased. More and more customers are willing to make their own participations and involvements to get better benefits (Schwab, 2016). Consumers experience more and more touchpoints in their customer journey (Verhoef et al., 2021). A conceptual framework of customer experiences composed of three realms of digital, physical and social has been proposed (Bolton et al., 2018). Enterprises are seeking strategies for business model innovation in the era of digital transformation (Kohtamaki et al., 2019). Digitalization supports servitization. Coreynen et al. (2017) discussed how digital technologies are leveraged to enhance service offering by proposing pathways for digital servitization. Specific digital capabilities relevant to current and potential servitization functions have been identified including user and product identification, condition monitoring and usage monitoring (Ardolino et al., 2018).

Transformation of physical experiences into digital experiences with services would critically contribute to digital transformation of manufacturing industry. Smart PSS (Valencia et al, 2015; Abramovici et al., 2015; Chowdhury et al., 2018) would be characterized by context-awareness and specificity, strong human centration including personalization, interchangeable and reconfigurable product and service elements and massively co-creative value provision of many stakeholders. Active utilization of use data and knowledge combined with user experience evaluation would be critical. The service aspects tightly integrated with co-created experiences of diverse actors drive intelligent customization values in modern smart solutions. As customer experiences evolve with previous experiences and their reflections, experience evaluation and management in digital forms together with use data would make critical contribution in digital transformation. That is, customer experiences evolve as customers experience, evaluate their experiences and engage with others and themselves iteratively. Integrated customer experience design of customer-led *experience – evaluate – engage* iterations should be emphasized in designing smart PSS. Note that design thinking has been recently explained in the framework of visual thinking composed of interactive iterations of *seeing – imagining – drawing* (Kim and Park, 2021). Design thinking of *seeing – imagining – drawing* iterations and *experience – evaluate – engage* iterations for user experience process are to be associated in designing experiences.

The research goal of this paper is to identify different strategies for digital transformation in PSS design so that diverse paths for digital transformation can be considered in designing PSSs. Three strategies for digital transformation have been identified from PSS design cases conducted in the

Manufacturing Servitization Support Framework (MSSF) project (Kim, 2020). PSSs have been designed for 15 manufacturing companies including SMEs and large companies with varying levels of digital technology in the MSSF project. In the next section, three different PSS design cases are briefly reviewed using the PSS representation (Kim, 2020) including the characteristics of service concepts in the service space. Then, the interaction spaces (Kim, 2020) of the three cases are described in section 3 so that digital transformation strategies used in these cases can be characterized. The paper is concluded with discussion on the postulation of digital transformation strategy guide and remarks on future work.

2 THREE PRODUCT-SERVICE SYSTEMS (PSS) CASES

In this section, three different PSS design cases are briefly reviewed. The first case is lighting customization for LED lighting conducted with a medium sized company leading LED lighting industry. The second case is the PSS for female shoes case for a shoes company with niche female consumers. The third case is the PSS design case for a shower equipment company.

2.1 Lighting Customization PSS

As a servitization project for an LED light manufacturing company, the Lighting Customization PSS has been designed. The medium sized company is a leader in Korean LED lighting industry with a high digital technology profile. The CEO was interested in having lighting cafés where potential users can experience the advantages of LED lighting.

Experience values customers pursue at cafés have been identified. Among these values, functional value of *customization* and active emotional value of *control* could drive other critical values of *fun, pleasant* and *comfortable* as well. The customers go to a café to do their various activities and they want to control and customize the environments of the café for these activities. People conduct various activities to achieve some values under diverse contexts (Kim and Lee, 2011). For example, we read books under a certain environment with a certain kind of space structures and with a certain kind of lighting condition. We get some emotional experience values in such reading activities. Different persons may get different kinds of values in their activities. Especially emotional experiences are elucidated in different ways depending who are the actors, what activities they are doing, and under what contexts. In the same lighting, different persons may get different emotional experiences. On the other hand, one person's most preferred lighting could be different from another person's most preferred lighting. Such diverse preferences of customers are to be taken care of by services through personalized customization.

The lighting customization service has been devised. LED lighting can provide huge variations of lighting conditions combining different brightness, color temperature and RGB effect. A user may conduct a specific activity under many different lighting conditions. As a user conducts a specific activity under a specific lighting condition, the user evaluates her own experiences. The evaluation results are stored with the specific activity information and the specific lighting condition using the Context-specific Experience Sampling and Analysis (CESA) method (Kim et al., 2011). As the experience evaluation data get accumulated, if the user wants to have the best lighting condition among those she has experienced for a specific activity, the system retrieves and provides that lighting condition. To expand the search space, a user may try many alternatives and accumulate experience evaluation data. When the activity is critically important so that the best condition so far experienced is needed, this lighting condition can be provided. This service unit referred to as *My Spot Customization* is the key service concept. *My Spot Customization* is typical customization based on cultivated relations through interactions between the user and the service system involving the primary function of the LED lighting product. This service concept is classified as a service supporting mainly customers and involving the product, *SSCp* (Kim, 2020). To promote more user-initiated behavior of doing activities under most desirable lighting conditions and evaluating experiences, the *My Spot Community* service has been introduced for self-reflection and engagements. This is classified as a service supporting customers, *SSCC* (Kim, 2020). Thus the key touchpoints are the *use* and the *engage* touchpoints as shown on the right lower corner of Figure 1, which shows classification of five service units.

Note that the *physical activity* of doing certain tasks under various lighting conditions has been transformed to *digital experience services* of *My Spot Customization* and *My Spot Community*. In this way, diverse personalized customization services can be devised combining experience evaluation

together with physical context data obtained from various internet of things. This is the case where the CESA method was used to devise the new service beyond evaluation in prototyping tests.
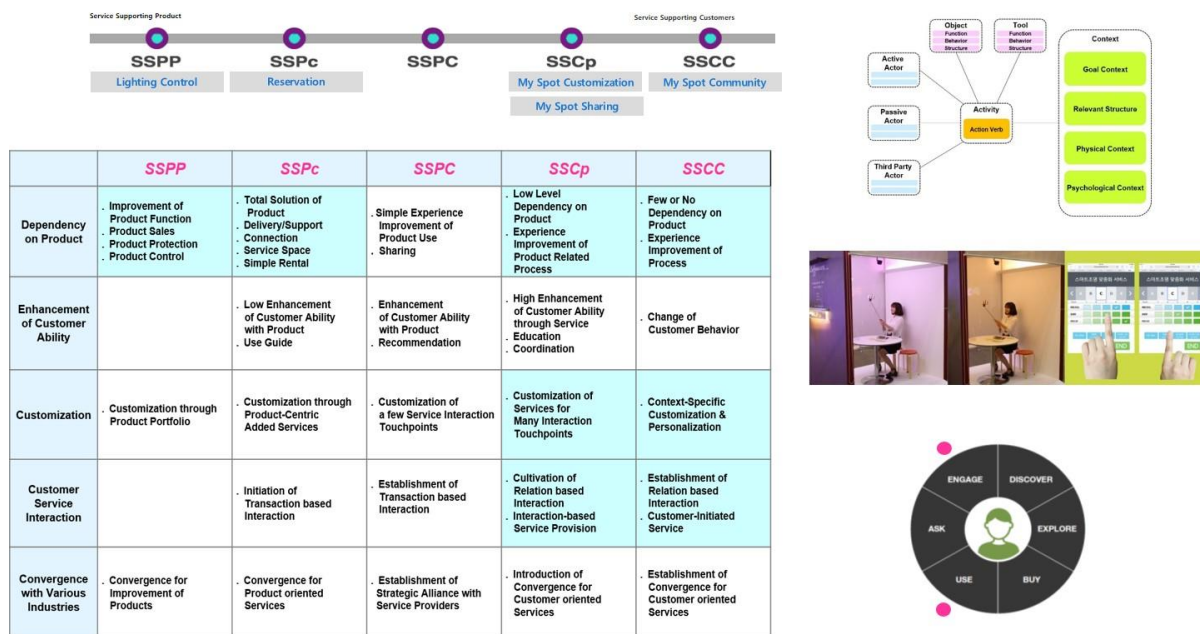

Figure 1. The service space classification of the lighting customization PSS

2.2 Female Shoes PSS

As a servitization project for a female shoes manufacturing company, the Female Shoes PSS has been designed. The company designs and develops female shoes with unique feminine characteristics with many outsourced fabrication partners. While the company is within top 10 shoes companies in the Korean domestic market, the company has a very low digital technology profile as the whole shoes industry is very low in technologies unlike some global brands like Nike. However, customers of the company are very familiar with digital technologies.

While the primary sales channel is offline, the company is weak in managing customer experiences in the purchase touchpoint. Through empathetic understanding of shoes purchase experiences, purchase support services have been designed to support the experiences in physical activities of browsing and searching for shoes, trying on, comparing and making purchase decisions. To enhance customer experiences in shoes purchasing, the *My Shoes Looks* service concept was devised. She would want to look at her with those shoes on from the front, from the rear and from a close-up look in a natural manner while she can see her entire body look. This experience is enhanced with taking photographs of her trying on with three different cameras and showing the three different looks on a screen near the mirror as shown on the upper right part of Figure 2, which shows classification of six service units. She can even store her shoes looks and compare multiple trials side by side by retrieving previous looks. This service unit is referred to the *My Shoes Looks* service. With *My Shoes Looks*, physical experiences at several touchpoints of a typical shoes purchase journey have been combined with digital experiences.
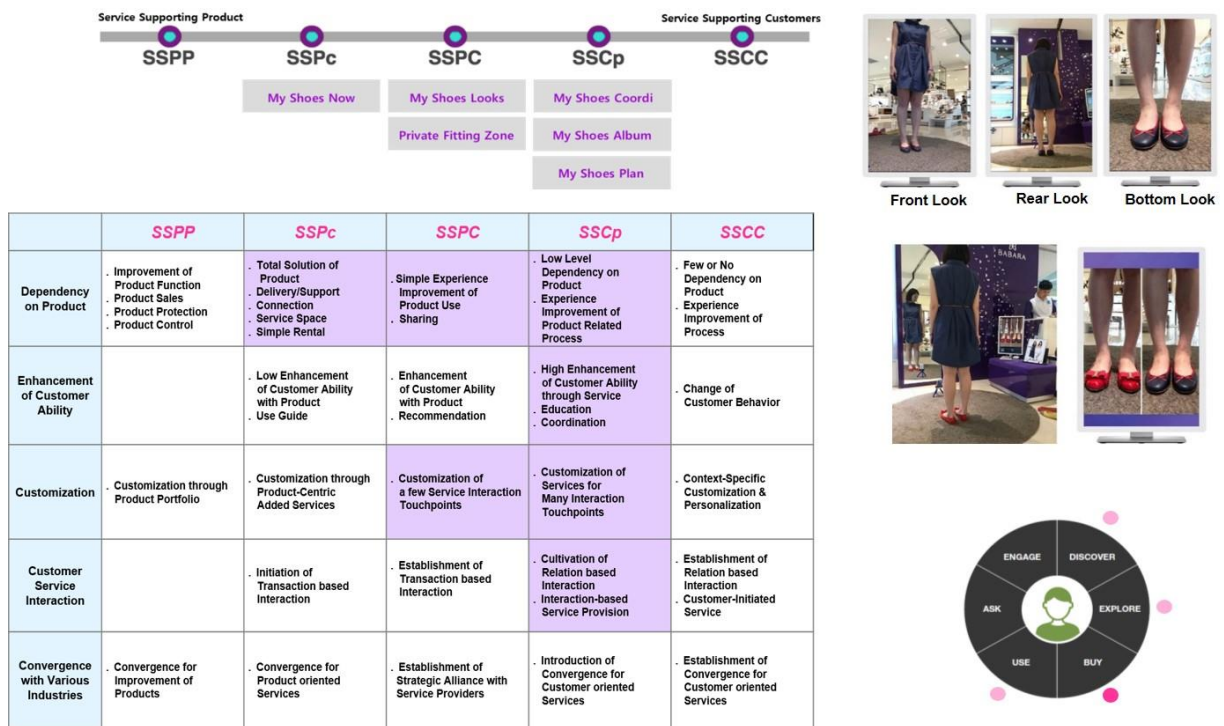
Figure 2. The service space classification of the female shoes PSS

	SSPP	SSPc	SSPC	SSCp	SSCC
Dependency on Product	. Improvement of Product Function . Product Sales . Product Protection . Product Control	. Total Solution of Product . Delivery/Support . Connection . Service Space . Simple Rental	. Simple Experience Improvement of Product Use . Sharing	. Low Level Dependency on Product . Experience Improvement of Product Related Process	. Few or No Dependency on Product . Experience Improvement of Process
Enhancement of Customer Ability		. Low Enhancement of Customer Ability with Product . Use Guide	. Enhancement of Customer Ability with Product . Recommendation	. High Enhancement of Customer Ability through Service . Education . Coordination	. Change of Customer Behavior
Customization	. Customization through Product Portfolio	. Customization through Product-Centric Added Services	. Customization of a few Service Interaction Touchpoints	. Customization of Services for Many Interaction Touchpoints	. Context-Specific Customization & Personalization
Customer Service Interaction		. Initiation of Transaction based Interaction	. Establishment of Transaction based Interaction	. Cultivation of Relation based Interaction . Interaction-based Service Provision	. Establishment of Relation based Interaction . Customer-Initiated Service
Convergence with Various Industries	. Convergence for Improvement of Products	. Convergence for Product oriented Services	. Establishment of Strategic Alliance with Service Providers	. Introduction of Convergence for Customer oriented Services	. Establishment of Convergence for Customer oriented Services

Fashion coordination information on specific shoes that she is interested in can be provided to support her purchase decision. This is the *My Shoes Coordi* service. This would result in enhancement of the customer ability in using the shoes as well as shoes fashion coordination in general beyond the specific shoes. With digital data obtained from *My Shoes Looks*, other digital services like *My Shoes Plan* and *My Shoes Album* have been designed as well. *My Shoes Plan* informs the customer of the marketing plan of new shoes similar to the shoes that the customer purchased or showed interests. This service addresses multiple touchpoints in the customer journey even involving life-cycles of more than one pair of shoes with multiple purchases and trials. The *My Shoes Album* service maintains the record of the customers purchases and trials including the photos the customer selected from the digital data of the *My Shoes Looks* service. This service provides some customization aspects at multiple touchpoints including at purchasing, trial and even flexible browsing at her convenient time. Note that the primary experience touchpoint for this service is the purchase touchpoint as shown with the hot pink dot in the right low part of Figure 2. Other touchpoints of discover, explore and use are also supported over multiple life cycles of shoes as loyal customers would buy not just once, but many times repeatedly.

Note that this digital transformation has been realized with cameras and associated interactive services. The product element of camera introduced in this service is not among the product elements the company manufactures or sells. Camera is not at all related with shoes products in their functionality.

2.3 Shower Equipment PSS

As a servitization project for a shower equipment manufacturing company, the Shower Equipment PSS has been designed. While leading shower equipment companies manufacture other products used in bath rooms as well, this company manufactures shower equipment only. Thus new service concepts need to be designed while its competing bigger companies offer bath room remodelling services. Regarding technological capabilities, the company has solid technical strengths on basic functions of shower equipment but its digital technology profile is pretty low yet. In Korea, only the top-most leading company in the industry has the digital shower technology.

Experience values such as *healing*, *beauty* and *health* have been identified from the user research. Very recently fragrance and therapeutic shower capsules have been introduced. It is anticipated that many different shower capsules would be produced in the near future and users would use many different capsules from diverse companies to suit for their personalized life style preferences and context varieties. Premium customers, who would be willing to make their own participations and involvements to get better benefits, would like to do book-keeping of their showering experiences with

different shower capsules to improve their showering experiences. Experiences of capsule showering should be evaluated in real time together with context data. This service unit is named *In-Shower Experience Evaluation* service where the user evaluates her experiences of specific capsule shower so that experience evaluation data are stored with the context elements (Kim and Lee, 2011) such as the shower theme as the goal context, the perfume capsule information of the scent and the maker as a part of the relevant structure context, and the physical context including date, time, location and weather information.

The *Information Provision* service unit with personalized customization has been designed to enhance customer's healing, health and beauty as well as her ability to choose a right perfume capsule for various context. Service interaction should be relational and led by the user with her initiation. The experiences are dynamic and evolutionary so that their future experiences are going to be better since experience evaluation data with context information are accumulated. If a consumer would like to choose a capsule based on accumulated experience evaluations, the capsule information would be *controllable* while the showering theme, time and weather serve as *constraining* contexts (Kim & Hong, 2019).

A *Capsule Shower Device* has been newly devised to connect capsules of different sizes from various companies to the shower equipment. This device will also detect the identities of shower capsules. This service unit connects the shower equipment with other shower products, perfume capsules, to enable future shower experiences addressing experience values such as *healing*, *beauty* and *health*. As the user conducts capsule showering with a specific capsule, she can evaluate in real time her capsule shower experiences using the touch screen of a tablet installed near the capsule device. Evaluation keywords are selectively used according to showering themes. This new product element of the PSS transforms physical experiences of capsule showering into digital experience evaluation. The *In-Shower Experience Evaluation* service entails experiences mainly from service interactions but some contribution from the product elements, particularly the shower equipment and connecting device as well as perfume capsules, is also involved. The experiences of the use and engagement touchpoints are supported by *In-Shower Experience Evaluation* as marked by hot pink in the diagram in the lower-right part of Figure 3.
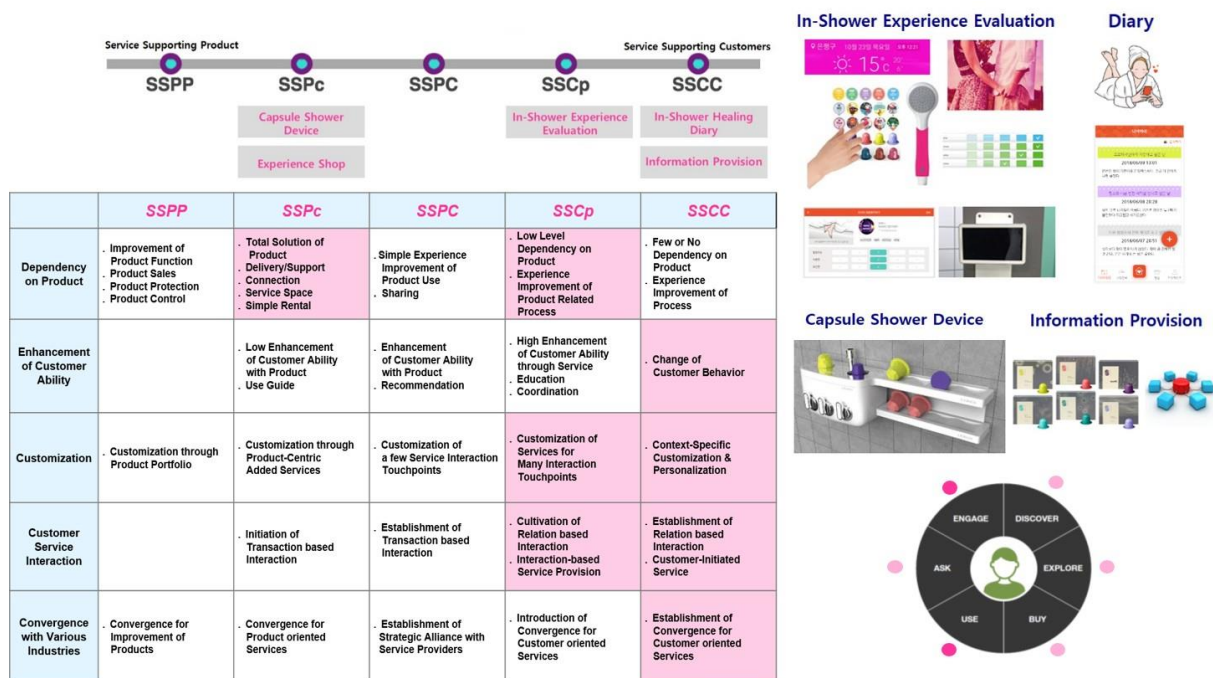

Figure 3. The service space classification of the shower equipment PSS

The *In-Shower Healing Diary* service has been devised where users can make diary comments to reflect and share their experiences in the engage touchpoint of the life-cycle. This service helps those customers develop reflection and sharing behaviors by providing their accumulated evaluation data with all the relevant context information. Users can retrieve in-shower experience data and make her

diary remarks using her smartphone. The *Diary* service changes the behavior of the customers with customer initiation.

The *In-Shower Healing Information Provision* service provides personalized customization to improve showering experiences and purchase plans of shower capsules. For example, capsules are recommended with user specified shower themes and physical contexts of time and weather. This service unit supports the touchpoints of discovery, explore, purchase as well as ask in use as marked in light pink color in the lower-right part of Figure 3. Furthermore, showering experience information of diverse users together with capsule information can be collected and provided to shower-related product manufacturing companies as a so-called platform for data business. This would achieve a new trend called reverse supply chain (Parry et al., 2016) and may involve many companies in shower-related industry.

3 DIGITAL TRANSFORAMTION STRATEGIES

3.1 Interaction Space Representation of PSS Cases

The interaction space of the PSS representation framework represents interactions in PSS including stakeholder-to-stakeholder interactions and stakeholder-to-touchpoint interactions (Kim, 2020). A circle node is used for a service receiver; a triangle node, for a service provider and a square node, for a touchpoint. Furthermore, the touchpoints are distinguished into two kinds. A physical touchpoint like a typical product is represented by a big square and a service system touchpoint is represented by a small square.

A portion of the interaction space graph of the lighting customization PSS is shown in Figure 4 (a) where a subset of the interactions which are relevant to the key digital transformation of the PSS is shown. In Figure 4 (a), the key product of LED lighting of the company is directly connected with the touchpoint of the *My Spot Customization* service. This service transforms physical experience of a user with LED lighting in a café to digital experience. Note that the node of service provider is used in addition to the node of the lighting company as this service can be outsourced by the company.

(a) Lighting Customization PSS   *(b) Female Shoes PSS*
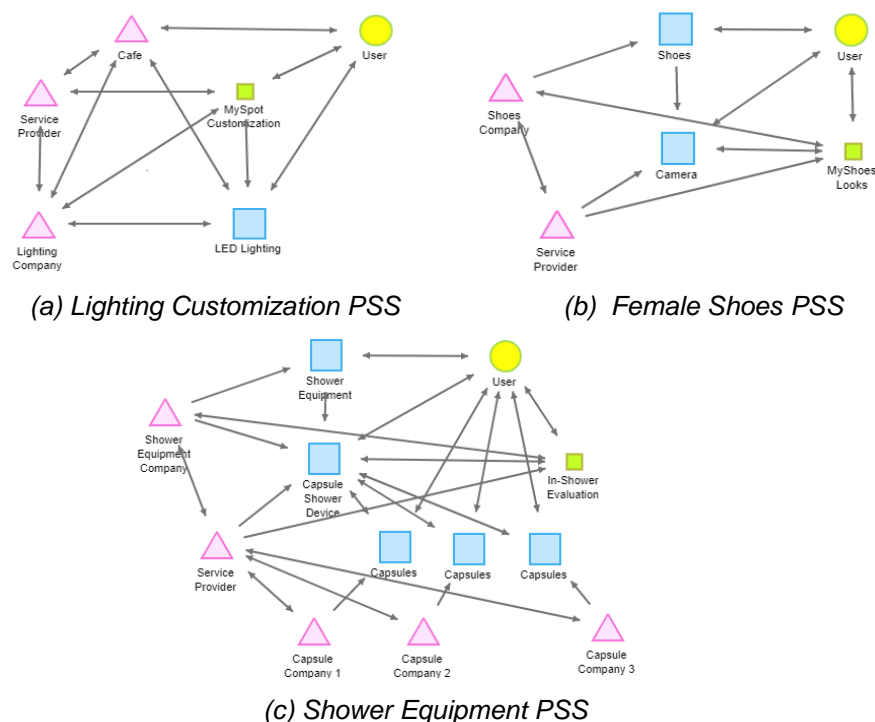
(c) Shower Equipment PSS

Figure 4. Interaction space of three PSS case

Figure 4 (b) shows the key interactions of the *My Shoes Looks* service which transforms physical purchase experience of a user with shoes to digital experience data through the product element of a camera. Introduction of a camera is critical in this digital transformation. But this product element is not relevant to the primary functions of shoes, which are the key product of the PSS. This product element is a generic product. The shoes company is connected to a camera. The *My Shoes Looks*

service enables other digital service units like *My Shoes Plan* and *My Shoes Album*. But they are not included in Figure (b) to show the key characteristics of digital transformation enablers clearly.

The interactions involved in the *In-Shower Evaluation* service of the shower equipment PSS are shown in Figure 4 (c). Shower equipment is indirectly connected with the *In-Shower Evaluation* service through the newly devised product element of the *Capsule Shower Device*. The new product element of the PSS is connected with multiple shower capsules from various capsule companies. Note that both newly introduced product elements of the *Capsule Shower Device* and perfume capsules in the PSS are involved in the primary functions of shower equipment. The *Capsule Shower Device* has been newly devised for the PSS and is directly connected with the shower equipment company. Note the different characteristics of the newly introduced product element in this PSS compared to a camera in the Female Shoes PSS case. The ecosystem of the Shower Equipment PSS has been expanded to include various capsule companies as shown in Figure 4 (c). The service unit of *Information Provision* as well as *Diary* has been included the interaction graph shown in Figure 5. More stakeholders like companies of shower-related products are involved in the ecosystem.
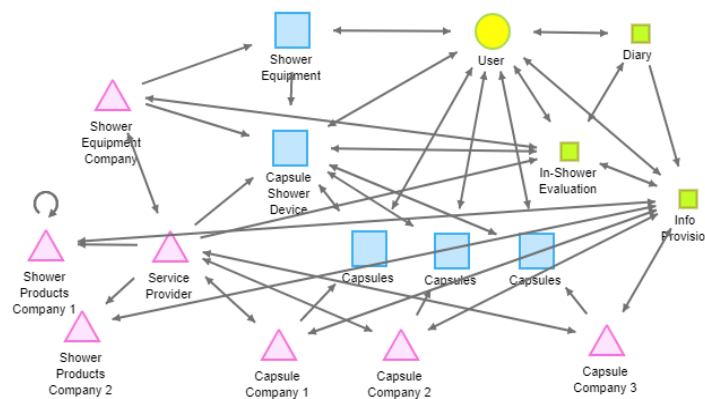

Figure 5. Interaction space of shower equipment PSS with ecosystem expanded

3.2 Digital Transformation Types of PSS Cases

In this section, three different strategies for digital transformation are introduced considering the characteristics of interactions that enable transformations of physical experiences to digital service experiences. Note that the strategies in digital transformation reflect the levels of digital technology of the company and the core product of a PSS.

The first type is the direct transformation strategy as used in the LED Lighting PSS case conducted with a leading LED lighting company. The digital technology profile of the company is very high. Thus digital transformation strategy used in the PSS design is the straight transformation such that the key digital service element of the PSS is directly involved with the core product. Note the direct connection of the *My Spot Customization* service to LED lighting product as shown in Figure 4 (a). The ecosystem of this PSS case is simple.

The second type is the indirect transformation strategy by introducing existing generic product element as used in the Female Shoes PSS. Note that the new product element, a *camera* in this case, is not relevant to the core physical function of the product. The digital technology profile of the shoes company is very low as this is typical in the industry sector where the company belongs. Note the indirect connection of the *My Shoes Looks* service to shoes product as shown in Figure 4 (b). The ecosystem of this PSS case is simple.

The third type is the indirect transformation strategy by introducing a newly devised product element as used in the Shower Equipment PSS case. The newly devised *Capsule Shower Device* is relevant to the core physical function of the shower equipment. The digital technology profile of the company is not high although the company's technology in the basic function of the shower equipment product is solid. Note the indirect connection of the *In-Shower Experience Evaluation* service to shower equipment through the new product element *Capsule Shower Device* devised by the shower equipment company as shown in Figure 4 (c). The ecosystem of the new PSS has been expanded to include capsule companies as in Figure 4 (c) and further other shower-related product companies as shown in Figure 5.

4 DISCUSSIONS AND CONCLUSION

Three different types of digital transformation strategies have been described in this paper reflecting the PSS design cases conducted in the MSSF project. The first type is the case where the company has high digital technology profile, direct transformation of physical experiences to digital service experience has been designed in PSS and the ecosystem has not been expanded with digital transformation. The second type can be characterized that the company has low digital technology profile, indirect transformation of physical experiences to digital service experiences has been designed and the ecosystem has not been expanded. The newly introduced product element is generic and is not relevant to the primary functions of the product. The third type is where the company has low digital technology profile, indirect transformation of physical experiences to digital service experiences has been designed and the ecosystem has been expanded. The newly introduced product element has been specifically devised and is relevant to the primary functions of the product.

From these cases, a classification can be postulated with three primary dimensions and two supplementary dimensions. The primary dimensions are (1) digital technology profile of the company, (2) direct or indirect transformation of physical to digital, and (3) ecosystem expansion issue. For the indirect transformation strategy, 4 different sub-categories are made depending (4) whether the newly introduced product element is generic or newly devised and (5) whether the new product element is relevant or not to the primary functions of the core product. Using these dimensions 8 basic different types of digital transformation strategies could be conceived as a framework in determining digital transformation strategies. As supplementary dimensions are relevant only when physical to digital transformation is made indirectly, four of the main 8 categories will be further divided into 4 sub-categories. Thus a total of 20 different types are possible.

Future research would include identifying more digital transformation PSS cases which fit the above postulated classification. Also tactics to be used in determining the strategies for digital transformation with PSS design should be identified to propose a framework for digital transformation strategies. Together with the PSS representation framework (Kim, 2020) and PSS development process representation (Kim and Lee, 2021), the digital transformation strategy guide that could be devised based on this paper with continued research will be applied in designing and classifying many PSS cases in industry.

ACKNOWLEDGMENTS

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