Battleships: An Industrial Use-Case of 'Playful' Teaching IPS^2 Concept Generation

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Abstract. The promise offered by industrial product service systems (IPS^2) for lasting customer retention is well known. In order to enable this potential solution providers have to use new development methods. Furthermore the cross domain thinking has to be set in the developer's mind. Providers must establish a product-service culture in their development department. This leads to the fact that new ways of teaching such an IPS^2 mindset has to be found in addition to the research of new development methods. This paper describes one such a teaching approach. Based on elements of business games it teaches engineers not to think in separate service and product domains. Furthermore it helps to overcome typical difficulties which occur in IPS^2 development project. For this reason main barriers in establishing an IPS^2 mindset are listed in this paper. Based on these difficulties a playful way of concept generation and teaching cross-domain thinking is presented.

Keywords: Teaching, IPS² mindset, conceptual design.

1 Introduction

Industrial product service systems, shortened to IPS^2, are highly complex systems which combine a wide range of different products and services in one integrated solution. This kind of integration has not only the potential of an innovative and customer-oriented way of problem solving, it also allows the adaption of system partitions during the adduction stage in case of changed requirements. Thus providers may differentiate their product portfolio from competitors by the development of IPS^2 instead of traditional solutions. This trend of transforming from a traditional to an IPS^2 provider is well known. It already has been analyzed in various contributions [1].

However, this transformation poses to be a big challenge. One barrier is located in the development stage of novel systems. The new paradigm of seeing product and service as an integrated solution requires new methodological support in order to overcome the engineers' traditional thinking patterns.

This leads to the fact that the application of new development methods must be promoted, especially in the early design stages, planning and conceptual design. Here, the tasks are dominated by the engineer's creativity instead of the product structure in its various appearances. Furthermore it is essential to describe a holistic way of

H. Meier (Ed.): *Product-Service Integration for Sustainable Solutions*, LNPE, pp. 53–62.
DOI: 10.1007/978-3-642-30820-8_5

problem solving as early as possible. According to the 'Rule Of Ten' this should minimize changes in downstream lifecycle [2]. But the provision of methodological support in the IPS^2-conceptual design process is problematic. Developers from traditional solution providers separate strict between product and service. They are not able to see problems at an abstract level. As a result, solutions are designed which integrate services just as an addition to existing benefits in kind. Consequently, the innovation potential of IPS^2 solutions might not be fully exploited.

The problem of providing methodological support may be split into two subproblems. On the one hand there has to be a modeling approach that allows a holistic view on an IPS^2 concept at an abstract level. In particular, the paradigm of separation between product and service has to be realized. On the other hand there has to be found a more efficient and also effective way of teaching a product developer this modeling approach. How can developers in the context of industrial product service systems learn to describe such a solution without thinking in traditional product and service domains?

2 Conceptual Design of IPS^2

2.1 Modeling IPS^2 Concepts and Product Service Interrelations

The conceptual design stage's goal is the generation of a solution architecture which shows potentially realizations of the customer's needs. Thus, it has to describe the structure and the interrelationships of its system-elements [2].

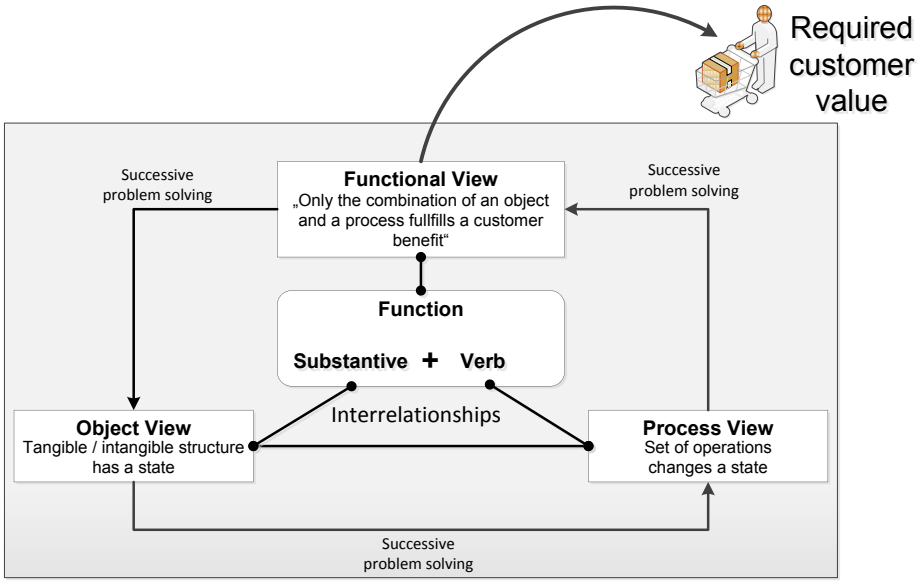

Fig. 1. Main structure of the heterogeneous IPS^2 modeling approach [3]

In this context Sadek provides a model-based approach which allows the description of the architecture [3]. The so called heterogeneous IPS^2 modeling approach supports the determination of a structure of performance artifacts that are assigned to a certain customer benefit. Because performance can be viewed from both, technical and economic viewpoint, performance artifacts are seen as a combination of an object and a process. Within an extended methodology provided by Sadek a developer is able to build structures on the functional, object and the process layer. Relationships between elements of different layers can be described afterwards. Furthermore a variation in the level of abstraction to describe elements on each single layer can be done. For this reason the approach is called heterogeneous modeling approach. Fig. 1 exhibits its main statements. Since there are various contributions to this approach, it is not an aim of this paper to explain all details in depth [3]. It has been proved to be a reliable model to describe IPS^2 in early stages of a development process. But the industrial application has shown that developers who are new to product-service applications have problems in using this approach. As a consequence there has to be special teaching approach which enables cross-domain thinking in the conceptual design stage of IPS^2. In order to generate a holistic teaching approach the difficulties in this stage are given in the following section.

2.2 Difficulties in Establishing an IPS^2 Mindset

It is brought forward the argument that using the heterogeneous modeling approach to describe IPS^2 concepts is an appropriate appliance [4]. Though, an industrial use case as it is described in [5] has shown difficulties that arise out of the circumstance that a company is new to the field of product-service systems. For this contribution it is necessary to know that this use-case is a network based development. Each network partner has no experiences in the field of IPS^2 and the goal of the development project is a highly integrated product-service system with the possibility of changeability in case of changed requirements. In the following section the main difficulties during that development are listed.

Companies which try to get into new markets by offering product-service solutions have not established an IPS^2 mindset in their developers' heads. Traditionally service is seen as a necessary evil to improve or fix technological solutions. As a consequence IPS^2 concepts do not show up with the claimed interrelationships of products and services. This leads to less innovative solutions. A new culture of product and services has to be established.

As mentioned before IPS^2 are highly complex systems. This leads to the fact that different knowledge holder have to build a team in order to make deployed competences available. Consequently, a high number of stakeholders is involved in the decision making process. Though this diversity of knowledge builds the base for innovative problem solving, it is difficult to stimulate communication between different stakeholders because each single stakeholder has a different understanding of the problem. Consequently, an approach to get in touch with the IPS^2 mindset has to support the communication within an interdisciplinary team. If there are different stakeholders involved in the conceptual design process it is essential to find higher level

interrelationships as a base for communication. Furthermore an initial step of abstraction is required to reduce the complexity and emphasize essential features and properties of the problem and its environment. For this reason the team members need to get a problem perception on a higher level of abstraction. In the context of interdisciplinary teams in IPS^2 conceptual design this issue also addresses the ability of single members to communicate with each other.

The ability of each team member to describe the development problems on a higher abstraction level enables also the integration of superior viewpoints in the conceptual modeling process. Since an IPS^2 architecture also addresses strategic questions e.g. the business models that need to be integrated in the decision making process. The teaching approach has to create an awareness of these superior viewpoints. This assumes also a systemic understanding of integral solution elements. Each team member must understand the solution and possible relationships to one's own domain.

Due to the fact that an IPS^2 should provide an individualized problem solution it is very important to direct activities in the conceptual design stage towards a stringent customer orientation. Consequently, each functional element of the solution has to aim at customer benefit. Since this is a crucial key factor in the IPS^2 development the awareness of the customer's needs is a central aspect in the learning approach.

	General challenges	IPS^2 specific challenges
Group Skills	Identification of competences	Consideration of superior viewpoints Stringent customer orientation
Individual Skills	Problem abstraction and problem perception Systemic understanding of the whole solution	Consideration of the whole lifecycle Cross-domain thinking

Fig. 2. Aims of an IPS² mindset teaching approach for conceptual design

Fig. 2 summarizes the aforementioned challenges. Since there are issues which addresses the development team and individual skills it is proposed that a teaching approach for the IPS² mindset has to be realized in form of a workshop. Furthermore the high degree of individualization of IPS² solution requires the possibility of problem specific adaption of that workshop. In the following section such a teaching approach to realize these requirements will be presented.

3 Playful Teaching of IPS² Concept Modeling

Based on the initial situation portrayed in the industrial use-case, the composition of the intended teaching approach is explained in the following. In this regard one has to clarify what kind of teaching approach is suitable and what teaching mechanisms are promising to meet the defined requirements. Basically the approach avails on the idea of participatory design. Research implicates design to be necessary to support an organization to really change towards the demanded mindset [6]. Furthermore this kind

of teaching implies the active involvement of the multiple relevant stakeholders within the value system, which is necessary in order to really create innovative and holistic solutions for hidden customer needs [7]. So off-key, the participants collaborate, communicate about the relevant topics and learn about the IPS²-development *"on the fly"*. However there are barriers concerning successful group performance related to psychological and social issues [8]. Especially the industrial use case describes the need for involving stakeholders both in- and outside the company who vary e.g. in view points, culture, managerial practices and domain specific languages. Therefore the considered teams mostly need support for communicating and sharing ideas and knowledge [8]. For this purpose *playful approaches* are seen to be of value. This expression subsumes a set of novel practices called gamestorming, which are commonly applied in the business world as well as design games used to support collaboration in multidiscipline design tasks [9],[10]. Brandt defines games as a play with props following specific rules, often with an element of competition between players and decided by chance, strength, skill or combination of these. Though within the addressed IPS² design task the aim is not to compete but to take advantage of the various skills and expertise´s represented in a game setting [10]. In general the concept of teaching approaches depends on the scope, the participants and the available resources [10].

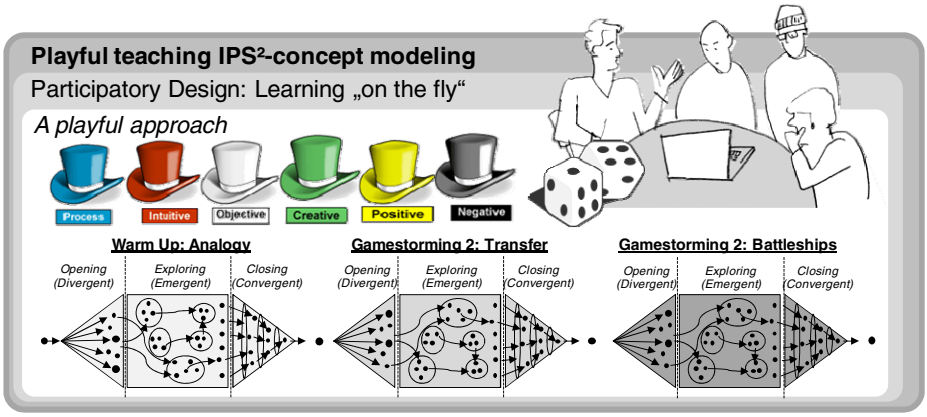

Fig. 3. Structure of the playful IPS² teaching approach

Considering the initial situation mentioned above, generic characteristics of powerful design games identified by Brandt [10] are applied and concretized to identify beneficial mechanisms for the IPS²-teaching approach addressed in this paper. Figure 3 presents the general structure which is characterized by three game phases (*Warm Up: Analogy; Gamestorming 1: Transfer; Gamestorming 2: Battleships*) played back-to-back. Each of these games follows the core principles of any gamestorming technique including an opening, exploring and closing phase [9]. The promoted teaching approach uses game boards to collect, structure and organize the information noted on multicolored post it sheets. The certain game phases are guided by a moderator, who is in charge of managing the discussion and the game rules. To ensure an efficient

discourse about IPS² and to take all relevant viewpoints into account, the use of the six hats method is proposed. So the participants have to adopt the various roles (Objective, Intuitive, Negative, Positive, Creative, Process) during the certain game phases as described subsequently.

3.1 Warm Up: Analogy

Learning about the really new paradigms and dimensions of IPS² requires high cognitive effort [11]. Therefore it is suggested to combine the provision of information with mental learning mechanism [12].

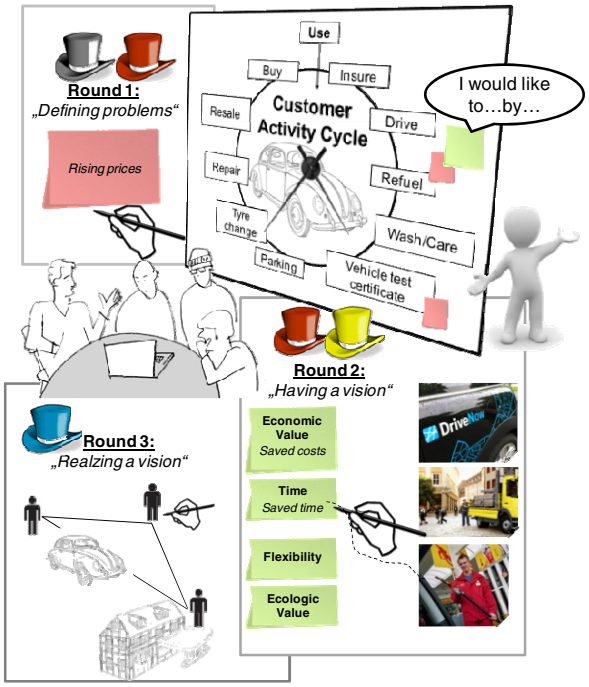

Fig. 4. Structure of the Warm Up

As shown in figure 4 an analogy of the everyday life is used to warm up the participants. So the moderator envisions the activity cycle of a fictional customer using a car. In round one it is the task of the participants to *define problems* concerning the shown activities (e.g. drive, parking, refuel). Therefore they should “wear” the black as well as the red hat, which means that they have to encourage their feelings and emotions belonging to the critical judgment of the certain activity. To overcome old habits and experience something new, the game mechanism of chance is implemented. So the participants do not know about what activity they have to think about next [10]. After identifying the emerging problems along the customer activity cycle the participants are requested to *have visions.* They have to match so called value

cards, suggesting categories of IPS² specific value types (e.g. economic, ecologic, social, flexibility) with stimulating pictures showing services the participants are familiar with. By composing the appropriate pairs the participants have to complete open-ended questions (e.g. "I would like to...by…") which are estimated to lead to more open and creative dialogues about products and services supporting the customer activities and eliminate the predefined problems. This directly refers to the thinking of the red and the yellow hat which stimulate looking for benefits and positive thinking. In the last round of the warm up, the participants are asked to discuss about stakeholders who have to be involved to *realize the desired values*. So they have to decide about the relevant stakeholders and conclude the structure of the actor network including their interdependencies. In this round the goal is to teach the complex composition of the stakeholders, required to realize customer value. To sum up the first game phase of warming up teaches the awareness of the customer view, which is important to encourage the participants to gain insights into both views (product and service) in order to achieve the potentials of IPS² [7]. In addition the certain game levels are supposed to stimulate the "value thinking" which is indispensable to teach the needed IPS² mindset.

3.2 Gamestorming 1: Transfer

After introducing IPS² specific aspects in a comprehensible scenario, everybody can identify with, this mental learning mechanism is used to manage the transfer to the use-case related challenges like visualized in figure 5. Therefore in the first round the participants have to *translate the scenario activities and problems*. The white and the green hats provide the needed creative and informational viewpoint. So participants are asked to build causal loops and tell a story about the activities, the use-case customer has to deal with, problems that may occur and customer support to provide during the whole lifecycle. In round two the generic values depicted in the first game are transcribed onto the actual game board. Now the participants have to *match* their new found activities and problems with the generic value categories and hereby find some new customer values to realize or problems that did not occur before. After identifying all relevant values, the underlying problems that have not been obvious before and support activities declared to be helpful to create the focused values, the participants have to decide about the actor network needed *to realize the visions*. Thereby it is possible to rethink the composition of the participants of the upcoming game. For example it can be necessary to invite some additional partners to assure the best findings. Summing up the second game called "Transfer" the participants are confronted with the real situation of thinking about a customer in the field of galvanizing high quality sanitary fittings. The teaching approach strengthens the consideration of the relevant lifecycles, the understanding of contributing a value instead of a product as well as the need of involving certain stakeholders to really innovate.

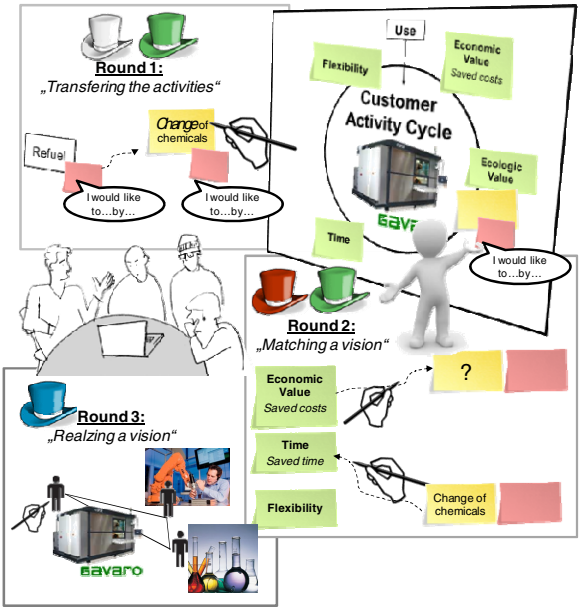

Fig. 5. Structure of the Gamestorming 1: Transfer

3.3 Gamestorming 2: Battleships

After the optional reconfiguration of the participants, the last game phase intends to identify innovative solution principles for the desired IPS² in a creative manner. In the first round it is task to draw conclusions from the game phase before and define the main functions that are necessary to satisfy the customer needs and so realize the aspired values. Therefore the participants have to collect already existing information and identify further information that may be needed. The final identified functions are transcribed onto the game board like shown in figure 6. For each function there are two possible categories, solution principles can be attached to. Either the function is fulfilled by a technical object or a human activity. So this game phase is about the "battle" of *"technical objects"* versus *"human activities"*. For the example of the analogy a car can be washed (function) by an automatic washer system (technical object) or specialized personnel cleaning the car (human activity). So at the beginning of the second round the participants have to find as much solutions principles as possible by thinking creative addressed by the green hat. Following it is requested to find flaws related to the solutions played before. Thereby the participants create barriers against the identified technical objects or human activities to hinder their chances of success. This kind of competition is considered to stimulate the debate among the certain stakeholders and to establish the needed transparency of the distributed knowledge. In order to further support this cross domain thinking, so called incentive cards e.g. force the participants to find solutions by changing their viewpoint or to reframe

the function into another field of knowledge. As a result of the second round, solution principles and alternatives have been identified for each function predefined. Finally the participants have to decide about the different solutions and now are able to arrange these elements into a systematic order in round three.

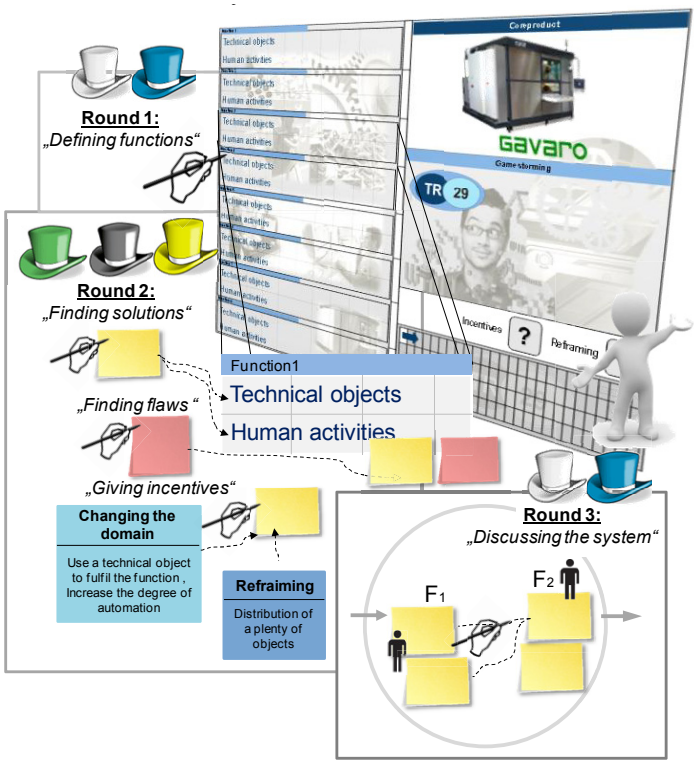

Fig. 6. Structure of the Gamestorming 2: Product vs. Service

The final aim of the addressed teaching approach is to encourage the participants not to think about products and services in a separated manner but to create a system consisting of both material and immaterial elements that are related to each other and their interdependencies have to be considered already during the concept development to really realize the desired customer values.

4 Summery and Outlook

The transformation towards offering industrial product service systems requires a change within the whole organization. Especially technology oriented thinking patterns of developer need to be broken. This is a big challenge and it already occurs in early stages of the conceptual IPS² design process. For this reason a kind of teaching new development methods is proposed in this paper. Using playful learning mechanisms the approach tries to overcome the barriers of distributed knowledge and teaches

the new IPS² paradigm which is obligatory to understand if a company wants to really innovate with customer and value oriented solutions. The teaching approach is composed of certain "game modules" which can be expanded or newly arranged for various use cases. So, it is possible to consider and adapt to different stages in the transformation process (servizitation) of the particular companies. The next step is to evaluate the proposed teaching approach. It will be applied for the addressed use-case in an industrial workshop. Furthermore the "battleship" design game is tested among students to explore the potentials in the context of creativity methods. This allows a comparison of industrial and academic viewpoints. As result it will lead to new scientific questions and findings.

Acknowledgements. Financial support from the German Research Foundation (DFG) through SFB/TR 29 is gratefully acknowledged.

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