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DESIGNING PSI: AN INTRODUCTION TO THE PSI FRAMEWORK

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Abstract

The PSI spaces are a framework for studying designing as practiced in the real world: framing and solving technical, social or organizational goals embedded in the existing socio-economic and institutional cultures and practices. Given the interconnected nature of the design product, knowledge and activities, we should anticipate that understanding designing is at least as complex as designing itself. Consequently, understanding designing involves mobilizing multiple knowledge sources, with different perspectives and diversity of participants orchestrated to achieve an effective outcome. We call the study of the PSI spaces the PSI framework. We introduce the PSI spaces, and their language resting on diverse disciplines such as psychology, engineering, economics, and sociology. We introduce some of its methodological tools; how the PSI spaces might be used to explain design challenges through misalignments of the spaces and how these misalignments could be resolved. The PSI framework has significant implication to the development of design science; it demands that design science be a trans-disciplinary endeavor, in need of a flexible community that will study it.

Keywords: Design management, Design theory, Organisation of product development, design science

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1 INTRODUCTION

Contemporary products are designed by people, from different disciplines, performing different tasks that require different perspectives, using diverse knowledge. To accomplish their objectives, these people operate in a particular way and interact with their extended lifecycle chain. The environment in which these designing processes take place changes continually; primarily, as a result of our previous designs that interact in complex, often unforeseen, ways.

Observed performance of designing in different situations, varies significantly, whether reflected in the quality of the product or the execution of the process and the natural and economic resources it consumed. What then distinguishes between the better and the worse forms of designing? Can we characterize which factors are central in a particular situation? Can we tell if we are in a bad situation or even beginning a downward slope? Can we prevent failure and succeed to reinvent ourselves?

It turns out that most of the tens of thousands new products introduced every year in the world fail (McMath & Forbes 1998). Further, there have been many studies that found numerous internal and external factors differentiating between the successful and failed projects; more than 80 according to Hauser (2001). However, most studies on the subject are not useable to practitioners: 'Many (managers in industry) are aware of the scientific literature that studies the antecedents and consequences of metrics in multi-firm studies. But to fine-tune the culture of their firm, these managers need a method that adjusts priorities based on measures of their firm' (Hauser 2001: 135).

Significant failures occur also in working systems after years of operation, resulting from the dynamic nature of our environment as well as the stagnation or deterioration of organizational systems.

One method to address such failures is to anticipate and prepare for them explicitly before they happen (resilience model). This is a *proactive* approach to preventing catastrophic failures – perhaps utopia sought by those developing safety-critical systems. Such a system is largely considered *technical* even if it includes operators or other users. Dealing with them is done through engineering, ergonomics and marketing. The system is designed by designers from different disciplines, using their knowledge to satisfy given or formulated requirements. The designers themselves, the way they interact in their organizations, or their social network, are not considered parts of the quality of the product and are certainly not mentioned in the product specifications.

The second method to address failures is to wait for systems to break down and then change them (reactive model) as well as the relevant organizational procedures and structure. This requires a reflexive organization capable of adaptation to changes in the environment. Considering the organization and the system it develops as an extended system, all factors become part of the specification of the extended resilient system. How then do we take such complex systems and understand their failures or successes?

Our long-term study of designing (e.g., Davis et al 2001, 2005, Konda et al 1992, Monarch et al 1997, Subrahmanian et al 1991, 1993a,b, 1997, Reich et al 1996, 1999) suggests that *all* designing of all man-made products have three common threads and that if these threads are woven carefully into a quilt, they support and nurture an endeavour, and if not, they lead to their demise or deteriorated performance. We call this quilt the PSI space and its threads the P (product) space, S (social) space, and I (institutional) space. We call the study of the PSI space and its ramifications – PSI Framework.

This paper motivates and introduces the PSI Framework. Section 2 defines the PSI space. Section 3 introduces the PSI Framework and describes how the PSI space is used. Section 4 summarizes with future work and prospects.

2 THE PSI SPACE

Designing as described in the first paragraph, takes place within multidimensional contexts. Characterizing designing in the PSI space took almost 30 years to crystalize, through study and close collaboration with industry in addressing their design processes. The PSI space reflects the desire to understand real design processes rather than toy or laboratory design contexts. The characterization echoes observations made by others: Several management scientists have emphasized the importance of social, cultural and institutional aspects of design and production of products (Takeuchi & Nonaka 1986, Clark & Fujimoto 1991). Pavitt (2000) made the case that the assumptions of early evolutionary economics theories could not anticipate the failure of technology transfer to developing countries, as they did not account for the state of the countries' social and institutional skills and knowledge. In the domain of Open source software, Weber (2005) points out that not all open source projects succeed as they are dependent on the organizational structures that manages participation and the co-ordination of the project. Here the product, the participants and the organizational structure are intertwined in determining the success and failure of the project. In light of these observations, our goal was to characterize the design problem in full, beyond the artifact itself. We have identified three aspects (spaces) that characterize the position in the space in which designing of a product takes place within its larger socio-economic-cultural context.

2.1 P – Problem/product-space[1] – what kind of product is being designed?

The Problem/product space characterizes what is being designed as a three dimensional space. The dimensions are disciplinary complexity, structural complexity and knowledge availability.

2.1.1 Disciplinary complexity

Disciplinary complexity is the number of disciplines and their relationships that are required to understand and create the product. The notion of disciplinary complexity is important as for each of the disciplines there are models, vocabulary and languages that need to be stitched together to design the products. One can observe this trend from the industrial revolution to date. Machines and theory of machines were sufficient from mechanics point of view to build wide range of products and equipment. Even the design of these products required knowledge of production techniques, material properties and processing of materials, context of use and so on. In recent times, disciplinary complexity is increasing in many products. Cars are not just electro-mechanical systems any more. They integrate computer hardware, software and electrical and mechanical systems working together with ergonomics, environmental studies, sustainability, economics, law and other disciplines much more tightly. Each discipline plays a part in the whole of the product and the part and the whole needs to work together.

The relationships between disciplines are often intricate. Some disciplines share concepts and even governing equations (as presented in the IEKG, Reich & Shai 2012) and some are rule based or narrative based (history). A "purely" technical product, that involves 3 disciplines (e.g., brake system with mechanical, electronic and software), would be less complicated from a product with only 2 disciplines, technical and economics, for example, transportation for commodity distribution.

This suggests that disciplinary complexity is a model of the complexity of weaving the required disciplinary languages. While integrating disciplinary languages into a concerted whole, parts need to be maintained carefully to allow the depth of each discipline to bring its power and benefit to the whole design.

2.1.2 Structural complexity

Structural complexity is the decomposition of the product or problem into parts and their relationships. Structural complexity is what Simon (1972) had in mind in his article on "Architecture of Complexity". However, Simon's notion of complexity is limited as it only deals with the idea of near decomposability and hierarchies for dealing with complexity. To address current models of structural complexity we would need to address the inter-dependence of the parts in their functional performance. An example from the evolution of cars is the difference between a car from 20 years ago and now. In current cars, the brake system, the engine control system and distance perception, which were left to the driver to resolve, are interconnected and do not form a simple hierarchical system. Products such as aircrafts have more tightly integrated subsystems and components that could better be understood as a network and not a hierarchy. A network of inter-dependent functions does not conform to near hierarchical decomposability making the system design a harder and complex problem in terms of failure modes that can be normal, emergent, and unknown (Perrow 1999).

2.1.3 Knowledge availability

Knowledge includes formal, tacit and informal knowledge that are embedded in the models, theories and practice. Its availability for designing a product or service within an organization and outside it is another important aspect. If all knowledge is available, then the product requires no new searches for

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[1] We use problem and product inter-changeability as we see design of process, policy, service and products as fundamentally a similar problem of design and implementation. Only the context and goals change.

knowledge; on the other hand, if not all the knowledge is available, the unknown part of the knowledge has to be generated and fitted into the puzzle. Unknown knowledge will not always fall under a single discipline; it will often cross disciplinary boundaries. The approach to dealing with different disciplines requires diversity of experiences and dialogue between them to bridge the gap. Filling the gap means also integrating the new with existing knowledge. This creation of knowledge has to be designed through either experiments, or specific research and development explorations. So designing of product recursively involves designing of the search and creation that is required to discover the new knowledge and its relevance for future products.

2.1.4 P space summary

All 3 P-space dimensions, moving from simple to complex, involve increasing quantity and relationship across them, whether it is product components, disciplines, or knowledge gaps and their relations. In addition, each of these dimensions themselves also trigger change in the other dimensions. Increased complexity in one dimension, tend to increase the complexity of the other dimensions, meaning, more the components, more the chances that multiple disciplines are needed and more the knowledge gaps that will emerge. Today's aircrafts are very different from the aircrafts of 50 years ago while the basic function has remained the same but they operate in a very different system of disciplinary complexity and technology (knowledge) availability space.[2]

Over time, a product/problem positioned in the P space could move along all three dimensions. For example, knowledge that is at the cutting edge, scarce, and not integrated with other knowledge becomes common practice; and product once innovative becomes obsolete. Historically, products tend to involve many more disciplines, and become more complex to reflect the changes in social needs and requirements that are imposed on the product. The problematic is that increasing complexity is not linear and new complexities add up creating unintended consequences and unforeseeable failures.

2.2 S – Social-space – with whom do we address the product?

The social space characterizes the social entity that attempts the problem/product space. It has significant effect on the outcome of designing; our characterization defines its three dimensions.

2.2.1 Number of perspectives

A perspective here is a "point of view" that is critical in executing product related activities throughout its life cycle. This idea of perspectives is interesting if one observes the evolution of computing. Early, it was all about computing algorithms, theory and programs that were the focus due to the use by narrow set of people. The idea of bringing the needs of the user perspective as the computer became individualized was first illustrated by Xerox and commercially by Apple. This has led to new field of design of user interfaces over the last 20 years. Consumer perspectives, maintainability and numerous other abilities are perspectives. There is no limitation on different perspectives even within a discipline. Perspectives are not just views form the disciplinary knowledge but also practical perspectives derived from practice as well as those affected by the product as it is being developed; the need for such perspectives is not often a priori known. Perspectives may interact with each other in complex ways.

2.2.2 Inclusion

The definition of the inclusion in the social space as limited or open is in terms of the inclusiveness of participation of the different perspectives. For example, if current participants in the social entity believe that in the problem space all the knowledge is available to them, they will assume a limited inclusion (closed). In the case of lack of availability of all knowledge, the social space should assume an open world characteristic with the lookout and intension to possibly extend the perspectives and the

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[2] John McMasters (2004) pointed out that the number of disciplines needed to create an aircraft changed dramatically from aerospace, material and mechanical engineering to the need for environmental, computational, chemical engineers and others. He also makes the case that the future of aircraft design would require people with cross disciplinary skills who he classed "deep generalists" in greater number than ever before. His estimate was that it has to go up from 10% of workforce to about 40% of the workforce.

respective languages that need to be incorporated. To illustrate, if the problem is to optimize the route from a point A to B and all the knowledge is available, a closed world with only optimization experts and the corresponding mathematical language is sufficient to address it. However, if the problem is to figure out the complex interaction between road traffic, pollution and potential health effects of a traffic interchange in a neighborhood, the problem requires an open social space with respect to the people and skills to be included in both defining and solving the problem. In open source software development, the social space is inclusive in the sense of self selection – anybody may choose to join the development effort but need to establish their credentials to be integrated (Weber 2005).

2.2.3 Capabilities/Skills

By skill we mean an ability to do something such as disciplinary thinking, creative thinking, critical thinking, and system thinking. Similar to a product having parts, a design process has tasks requiring different skills: careful management of requirements, creative generation of concepts, systematic analysis and test of concepts, and their selection. Skills could be considered as parts in the whole process. One could think of this dimension as a composition of notions of competence, capabilities and skills in business and evolutionary economics literature (Dosi et al 2002).

2.2.4 S space summary

As in the P space, the S space has 3 dimensions that involve increasing quantity and relationship among them. A change in one dimension often triggers change in the other dimensions. A need for additional perspectives or skills will probably lead to opening the space to more participants. Inclusion of existing participants with new perspectives or skills might prevent the affordance of additional knowledge and it would have to be traded off against time or other resources. However, in the design of a product, non-inclusion of a perspective can lead to failure of the product. Examples are many in the literature, and in the case of inclusiveness of the knowledge of the user, Von Hippel (2005) has made the case for its necessity in his work on democratizing innovation.

2.3 I – Institutional-space[3] – how do we work it out?

Assembly of participants with the right skills that cover the needed perspectives to develop a complex product that combines numerous disciplines with state-of-the-art knowledge is insufficient for success. Key to implementing any realization of a product is setting up the rules by which all the participants will work for an extended period of time. A complex product, requiring extended participation with multiple perspectives, requires flexible procedures that allow for continuous evolution, maintenance of shared memory, evolution of the team, and the evolution of the product requirements. It actually requires that the rules allow procedures to evolve in response to new situations. The 3 dimensions of the I space below characterize the rules of the system that govern the S and P spaces.

2.3.1 Ties: social network

Social networks are characterized by the strength of their connections; weak or strong (Granovetter 1983). Weak ties are characterized by the small number of transactions with very low exchange of knowledge and co-operation between the parties. Weak ties are often market-based ties but could also reflect weak knowledge connections within a firm due to institutional routines, processes and structures. For example, in the days of sequential engineering, the ties between different departments were weak as the knowledge transfer and its reconciliation was not made routine in the process. In the transition to concurrent engineering, the ties were made strong by changing the process of knowledge exchange and reconciliation between different functional departments (Clark & Fujimoto 1991). Strong ties require (and are created by) procedures and commitment to communication and sharing.

One can see similar differences in the strength of a network of suppliers. For example, the Japanese have four levels of suppliers who range from providing parts as per standardized design to those who co-design characterizing the nature of interactions and the transactions that are based on the needed level of knowledge exchange (Liker et al. 2006).

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[3] The use of the term institution here may raise objections as it does not seem to distinguish between organizations and institutions. We have chosen the term Institutions to include both kinds of structures as from a design point of view they deal with different kinds of products/goods (Ostrom 2005).

Existing ties are challenged in contemporary practice of mergers and acquisition where organizations move from one context to another. In some cases, transition is made slowly and in others a revolutionary change may destroy the company. Example such as the Chrysler and Daimler merger and others provide evidences of failure to achieve organizational alignment while the Nissan Renault alliance has worked well to the advantage of both companies.

2.3.2 Knowledge accessibility

Within an institutional structure, the knowledge is dispersed in different individual and different parts of the organization. These are resident knowledge in the form of institutionally codified formal knowledge, other informal knowledge that is tacit, and knowledge that is recorded in personal notes, etc. While this knowledge is accessible, it is often not accessed as seen in the contrast between over the wall engineering and concurrent engineering. In many organizations, people at the cross roads of information flow have unique knowledge at the interfaces (Davis et al 2005). It is only accessible through them as it is not often public. This analysis demonstrates the recurring phenomenon we find in the previous dimensions. They all have a "quantity" and a structure associated: number of parts and their interconnections, number of disciplines and their integration, inclusion/exclusion but also the way these inclusions are distributed among participants, perspectives, etc. Here also, knowledge accessibility manifests itself in the connections between perspectives and disciplines.
A similar problem can occur in networked organizations at the interfaces between original equipment manufacturers (OEM). The knowledge of the supplier is only accessible to the OEM under contract with the supplier and otherwise, inaccessible. The arguments made for product modularity are the separation of knowledge and the ability to outsource and operate without the detailed knowledge of the module; that often does not work due to overlapping knowledge (Dosi et al 2004, Hart-Smith 2001).

2.3.3 Institutional complexity

The institutional space is different from the social space as it concerns the design and use of rules, norms, routines and other formal and informal organizational structures. In the case of markets, the rules will be the market rules and regulations that govern the market. Within an institution, the rules and norms can both hinder and enhance the possibility of using the social space. For example, the American car companies and Japanese Car companies had more or less the same capabilities in the seventies when the Japanese firms started making major inroads into the American market by improving the quality of the products far beyond the American products. The key difference between them was written up as over the wall engineering vs. Concurrent or Simultaneous engineering (Clark & Fujimoto 1991). The fundamental difference was in the institutional rules and norms of how information and knowledge was processed and exchanged in these organizations. Movements such as Quality circles, Quality function deployment, that changed the dynamics of routines in Japanese organizations for fast elimination of failures and errors in the design and production processes were the key.

2.3.4 I space summary

The economist Ostrom (2009a) argues that design of institutions should be done in the same manner as engineers deal with complex products, i.e., using empirical and theoretical tools. Her work on institutional analysis and development of management of public goods has led to a grammar for analysis of such public institutions and to describe the potential design of new institutions. While Ostrom (2009b) is talking about public goods, our attempt here is to use her framework on design of institutional structures to other types of goods. This view makes designing recursive as we need to design effective organizations to be able to effectively design products and often institutions to regulate the behavior of the producer of these products. But to be more precise, all the spaces are interlinked in a recursive sense with respect to designing. The product may be managing the use of natural resources, public infrastructure development and many other products and services that the governmental, non-governmental and private organizations provide. In all of these cases, the product space, the social space and the institutional spaces are linked.

3 THE PSI FRAMEWORK OF DESIGNING

We have shown how three spaces characterize the scope in which designing takes place in a situated place and time along with their history, culture and geography. Place and time define a broader social, political and cultural contextual frame (situatedness) within which the act of designing is defined and located in these spaces and evolves over time. The study of these spaces and their implications to designing research and practice define the PSI framework.

3.1 Methodology of the PSI framework

The PSI framework is both empirical and analytical. It rests on observations of design cases and their analysis by multiple research tools available primarily in engineering, social sciences, and management. These include simulation and modeling of various aspects of the PSI framework. Its central objective is not only understanding designing, but improving designing in practice. In fact, there is no separation between the two. Understanding designing comes from engaging and intervention (Reich et al 1999, Subrahmanian et al 1997, Davis et al 2001, Reddy et al 1997). Practice is the ultimate validation of new knowledge about designing.

The PSI framework is part of the science of the artificial, it is designed! If we want to continue designing and improving the PSI framework, we have to treat it as a product and understand its place in its own PSI space just as we claim that any designing act can be described in the PSI framework. Figure 1 illustrates this analysis. Part (a) depicts the 3 PSI spaces; it is part of the product generated by the PSI framework as described in Section 2. Part (b) depicts the location of the PSI framework in the 3 PSI spaces. It is neither common nor easy to analyse an entity with itself but it demonstrates that the framework is reflexively consistent if it can be done (Reich 2006). In the P space, the PSI framework as an artifact is very complex, consisting of the 3 spaces but also of all the related knowledge and tools used to advance it; these are constantly changing.

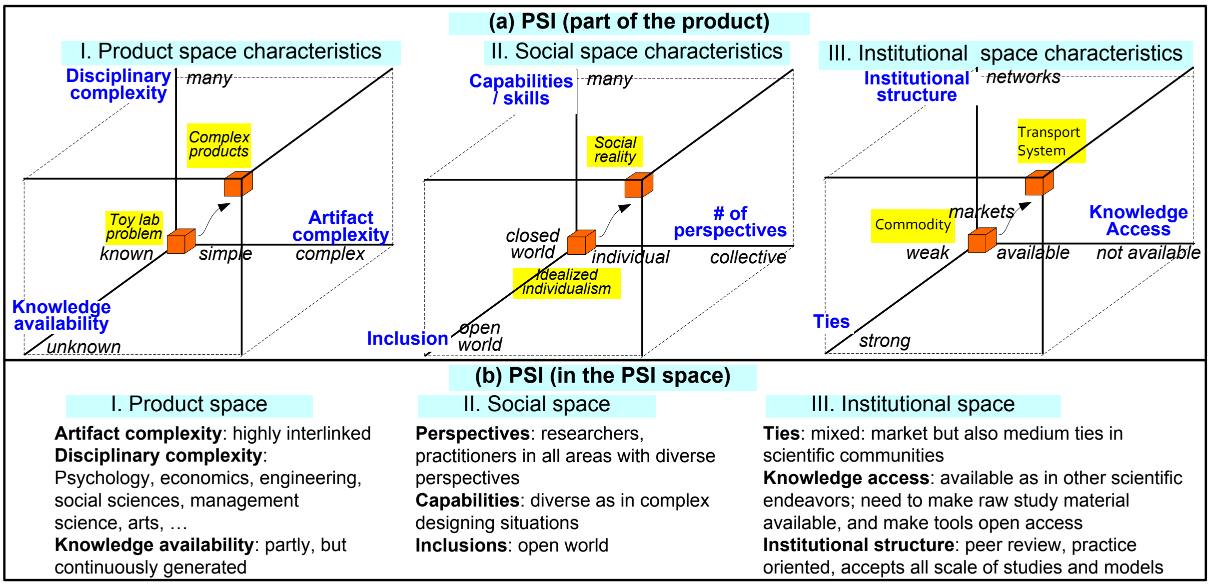

Figure 1: Designing and the PSI space

The PSI framework involves the collaboration between numerous disciplines including: psychology, anthropology, sociology, economics, management, history, and art. In fact, there is no discipline that could not contribute. As a scientific field, knowledge about the PSI framework is available in different sources but much practical experience is proprietary and inaccessible. One could argue that knowledge about, and the ability to move in the PSI space results in competitive advantage to an organization.

In the S space, the PSI framework requires multiple perspectives to develop, including researchers, design practitioners, users, and all other design stakeholders. The skills required are equally diverse in order to observe, analyse, document, synthesize, implement and test creatively and systematically the products generated in the PSI framework. As a research program, the elaboration and population of theories and practices in the PSI framework will be inclusive of multiple disciplinary perspectives.

In the I space, the PSI framework as other sciences works through mixed ties. Theoretically, the ties are both strong and weak, allowing relations or research activities to form in an ad hoc manner while social networks such as scientific societies and other alliances create stronger ties. As in science, access to knowledge is supposed to be given but as significant part of the PSI framework is case studies, some knowledge might be proprietary. Science culture also prevails in the PSI framework; it is a comprehensive way to study the varieties in design. If we call the study of design 'design science', then the PSI framework is part of design science.

3.2 Using the PSI framework

The world is littered with failures of products, services and policies. Some could be explained by missing key technological elements, some by missing expertise, outsourcing, crowd sourcing, bad knowledge management practices, or loss of expertise, and others by organization culture, leadership, or poor supply chain qualities. In most cases, studies are conducted on sample of cases, attempting to reveal key indicators by analyzing the dependence of parameters on independent set of inputs. Such results are difficult to apply in a particular situation that does not fall well into the models (Hauser 2001). They might also be limited since they take a narrow view of the problem into account.

3.2.1 Location in the PSI space and explaining failures and successes

Given that the dimensions are not directly measurable, we can only relatively locate an organization in the space and characterize it. Extensive studies might be necessary to form a more precise characterization. For example, information flow analysis can be used to detect the organization’s implicit structure and its match with organization rules; supply chain analysis to detect the nature of ties with collaborating entities; product planning to understand the extent of disciplines that might be involved; and technology forecasting the maturity and availability of future technologies and methods.

All aspects of a design situation must be aligned. A startup company working in a high paced product market must move fast by limiting its inclusion, managing only the necessary perspectives, and have the culture that foster quick turnover of ideas, knowledge, and decisions. Some of these choices introduce risk due to missing perspectives or even lack of maintaining shared memory. When such a company begins to generate revenues and builds customer portfolio, different culture has to be exercised, ties should be developed based on the nature of the product and new perspectives such as marketing or maintenance, become critical. Such evolution is natural (Dosi & Nelson 2002); it even occurs within a large company since its environment is changing and the location in the PSI space is relative rather than absolute. If the company is not able to evolve, it often does not survive as it does happen with mature firms where the routines and norms are already set in place. They face a harder problem of evolving to new routines and structures due to a variety of resistances. This behavior can be seen in the supply chain behavior of American Car companies vs. Japanese Car companies. Liker & Choi (2004) show that even though the knowledge of operation of the Japanese car company institutional structures is known to American Car companies, they continue to operate in more or less the same as they always did before. Their strategic focus on cost in the short run has not allowed them to change the routines to take advantage of learning and long term cost advantages that Japanese companies seem to exploit. Another example is Polaroid that had very advanced sensors and digital technology for it to enter the digital camera market but did not in favor of its existing market, and lost.

3.2.2 What binds or breaks the alignment of PSI spaces?

Designing a product requires an orchestrated balanced dance, with many diverse participants in a highly multidimensional interconnected space. This requires bridging many gaps between different entities pushing in different directions. This is a fragile situation prone to failures as any bridge needs maintenance and upgrade to sustain environmental changes. These changes tend to have a cascade effect. These bridges have to be flexible, malleable; they need to be maintained and traced through their evolution. These bridges consist of words, concepts, language elements as well as their assembly into sentences, ideas, models. This embedding of inner structure of parts and wholes and their interrelations manifests everywhere. The problem of decomposition and synthesis operates in different dimensions across the spaces leading to conflict between division of labor and knowledge.

This situation is further aggravated in a globalized context by the fact that the modules themselves may be produced in different countries and cultures adding to the socio-linguistic and competence alignment that is required around the cognitive artifacts that serve as boundary objects to mediate

among the parties. The striking examples of failures are in the aviation industry. Airbus in its production of A380 had problems because the models produced by one version of the software were not compatible with one of its supplier's version of the same software (Wikipedia 2014).
In the case of Boeing 787, the extensive outsourcing of its components led to the delay of the release of the aircraft. The institutional structures and routines created to deal with their outsourcing model were not compatible with knowledge structures required to integrate them leading to mismatches in understanding the needs and requirements across different suppliers (Hart-Smith 2001). A lead engineer in Boeing recently admitted that Boeing had to have the knowledge of all the parts and their manufacture even that of others to manage the design and production of an aircraft (Hiltzik 2011).
A different failure, often discussed in the design community, is the lack of transfer of many results from research into practice, representing two social communities with different cultures. Using the PSI framework, we can explain how an approach like the Fraunhofer Institute (2014) succeeds in bridging the culture of these communities. The Fraunhofer Institute, a network of 67 institutions distributed all over Germany and outside it, presents itself as a large-scale example. It has a matrix structure with overlapping competencies that are applied to different technological areas. The different institutes may compete, collaborate, and complement each other in different projects providing a mix that evolves to be highly resilient. They maintain their organic structure of routines and skill development healthy and interconnected. They work well with local industry creating strong local ties. They work through permanent cultural mediators in different countries to bridge cultural and market orientations. All these make the Fraunhofer Institute a highly well aligned, and continuously evolving model of change in the PSI spaces.

3.2.3 Establishing alignment

One cannot simply look at a design situation, determine its location in the PSI space, and analyse its efficacy and deficiencies. Such insights come from engaging with a variety of research, intervention, and participation tools which are part of the PSI framework (section 3.1). Such tools are also the key to addressing misalignment by analysing the alignment status, proposing a change, and enacting it. Alignment does not work in large steps. While aligning, one has to keep in mind that ultimately, the changes are to be implemented in practice. Hence, there need to be a plan to gradually bring an organization and a social setup into harmony with a given problem. One can implement this strategy by promoting changes via games, scenario analysis and other methods that encourage exploring alternative trajectories and promote reflexivity to be able to anticipate changes and implement them (Meijer et al. 2014, Subrahmanian & Reich 2006). The guiding principle of the PSI framework is its reflexivity, any particular outcome that needs to be achieved, even reflection, requires the use of the PSI space and its methodological stance.

4 EPILOGUE

We have only begun to explore the PSI framework, introduced its terminology and some of its methodological approach and benefits. While its development rests on over 20 years of study, as additional studies of design situations accumulate, whether successes or failures, we will start to uncover patterns of successes, create models and theories to explain and predict outcomes of using the PSI space. In view of reflexivity, the PSI Framework involves extended participation of disciplines outside of traditional engineering design and requires cultural flexibility to evolve into a broader enterprise that could seriously address contemporary design challenges.

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