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THE PSI MATRIX – A FRAMEWORK AND A THEORY OF DESIGN

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Abstract

Real life design situations often involve addressing complex multidisciplinary problems that are hard to formulate and solve, attempted by a diverse group of people, working in different organizations with different cultures, collaborating through a variety of contracts. Many design efforts fail due to incomplete understanding of design contexts. Can we create a framework that will help us unpack this complexity into a structure that allows us to explain, predict, and control failures and improve such situations to help organizations design better? We present a framework, called the PSI matrix that was developed by combining knowledge from diverse disciplines; following numerous case studies with industry to address the above-mentioned challenge. We describe the framework and its evolution from an earlier version, demonstrate its applicability to several diverse design examples, and mention several other cases on which it was tested. We have found it to be robust in supporting its objectives and continue to develop it to improve its added value to design by conducting multi-case, transdisciplinary, multi-context study with numerous partners.

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

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1 INTRODUCTION

Consider the following story, remote from engineering, but nevertheless, a representative of *design* situations. You have a relationship with your spouse; you live your daily life in a way that evolves naturally without thinking about it. Over time, problems surface and communication is not working ideally; you and your spouse do not manage to resolve the differences, (1) in Figure 1a. You consider breaking up the relationship. As a last resort, you decide to approach a professional relationship counselor to help you (2). Your meetings with the counsellor are set outside the daily life situations, through an informal contract that explains how the counselling process will take place (3). In the sessions, after an introductory meeting, the counselor asks the two of you how would you like your relationship to be, what is your fantasy relation or your vision. The counselor may do it at a meeting with both of you or separately, but finally, with the counselor's help, you arrive at a consensus about this vision (4). From thereon, the counsellor will propose a process through which you and your spouse can check the possibility to rearrange your life (5) and decide to continue your relationship according to new agreements (6). If there is no agreement between you and your spouse about the vision of your relationship, the counsellor may propose (7) or any one of you (8) may decide to break the relationship. During the process you may seek another counselor because you do not find a common language with the counselor (9). There could also be different scenarios that this process could unfold.
Consider a different approach to setting up a relationship. After a period of acquaintance, you and your friend decide to formalize your relationship and you sit with friends, family, and other people of your choice to set up your relationship through a contract. You make your vision explicit, (1) in Figure 1b, and following explicit dialogue and agreement, you describe how the daily life would look like including how controversies would be settled in a written document (2). You then continue life according to your agreements (3).

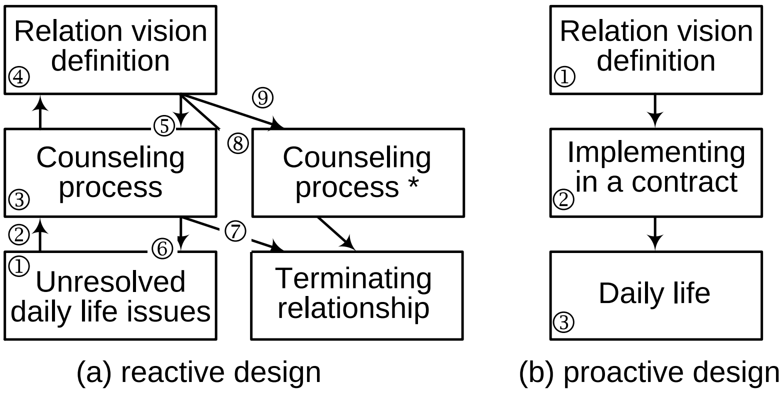

Figure 1. Couple relationships

These two stories, the reactive and the proactive approaches to designing (life) are depicted in Figure 1. They are ideal models as in real life, problem definitions and their solutions coevolve (Braha and Reich, 2003) leading to intertwining reactive and proactive processes. You may ask now what do these stories have to do with engineering design or any other type of technology development? We offer two responses. First, we conceive of designing as an information-centric activity. Designing brings together diverse disciplines, making use of different languages, knowledge and models about the world that require dialogue to form shared meaning and mutual agreements. These models evolve and accumulate to a shared body of understanding we call the theory of the artifact (Monarch et al., 1997). Its proper management over time is necessary for a design project to be successful. From this perspective, there is no difference between designing a couple's relationships and dealing with daily life situations to dealing with office situations and developing technical products.
The second response will be apparent as we proceed in this paper; it will become clear that what we have articulated are universal patterns of designing that can be modelled through a framework called the PSI matrix which is composed of PSI spaces (Reich and Subrahmanian, 2015; Meijer et al., 2014). The PSI spaces are a culmination of 30 years of research and development projects aimed at understanding and supporting designers (Subrahmanian et al., 1997).

"The PSI spaces are part of 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 (Reich & Subrahmanian, 2015)." The framework is composed of three spaces, each addressing a key question: P – problem space – addresses the what of designing; S – social space – addresses the who of designing; and I – institutional space – addresses the how of designing.

In the couple story, the P could be daily issues to resolve, the contract, or the vision, depending on the situation; the S could be the couple and other people with whom the couple engages in daily life, the couple and the counselor; the I could be social norms of marriage/relationships, informal culture of the couple's home or the counseling agreement. There need to be some alignment or equilibrium between the spaces for a design activity to be successful. A couple with particular personalities and issues would have to find a suitable counselor to be able to guide them to a safe place.

In the last few years, we have applied PSI on numerous case studies; we were actively involved with some of them and others appeared in the literature. We found PSI to be valuable not only in unpacking a complex situation and understanding it, but also for drawing insight about its future improvement.

Initially, we presented a single-level PSI framework (in the couple story this would be only the daily life situation). Nevertheless, our analysis of other cases made it clear that two levels are necessary. Examples of failures of projects or organizations (e.g., Kodak or Polaroid) and of companies recovering from such situations (e.g., Boeing and the Dreamliner project), led to a 2-levels framework wherein the first level, the usual work is done and at the second level, a reflexive examination and design of the organization and its operation and products is taking place. This work describes the extension to a three or higher level framework which we call the PSI matrix.

This paper describes the initial PSI framework (Sections 2) and its extension to a matrix (Sections 3). Section 4 briefly presents the PSI matrix as a design theory and Section 5 concludes the paper.

2 THE PSI SPACES

Designing is a complex activity taking place within a rich context of diverse competing conditions. The PSI spaces is an attempt to understand this complexity by creating a model that will be rich enough to model the scope of designing yet not too complicated to be useful. As designing touches upon all aspects of life, diverse disciplines such as engineering, sociology, psychology, management, and economics, have taken it as an important subject for inquiry. These disciplines use diverse languages, methods, and tools leading to *different* perspectives. By and large, these perspectives are not integrated together and mostly do not converse with each other, leading to a partial and even distorted view of designing that lends credibility to the statistics that most products conceived by designers fail by the time they reach or diffuse into the market. These partial and incomplete views of design also manifest themselves in many failures of systems of all kinds.

Consequently, the first motivation of PSI is to bring together the major aspects in designing into a single model. The PSI integrates the variety of disciplines mentioned above and others. This assemblage of disciplines is set to address three fundamental questions about designing:

What problem is being addressed? The problem space – P – requiring knowledge from disciplines including engineering, science, social sciences, R&D, and marketing; these disciplines are required to understand how to assemble knowledge to formulate the problems, and to transform it later into a product;

Who is included in designing? The social space – S – requires knowledge from disciplines including sociology and psychology; these disciplines allow understanding how stakeholder personalities and teams makeup determine their interactions and their ability to deal with the complexity of P and I;

How is designing executed? The institutional space – I – requiring knowledge from disciplines including economics and management; these disciplines provide the necessary background to understand different institutions cultures, structure and relationships, and the way that context and market impact their operation.

2.1 The PSI spaces dimensions

Each of the spaces, P, S and I is further characterized with several dimensions. The dimensions are meant to provide more expressive power to represent the complexity of design situations. In order not to complicate the model too much, we offer 3 dimensions to each space.

The P space is characterized with the following dimensions:
Disciplinary complexity denotes the number of disciplines and their relationships that are required to understand the problem and design the solution. The notion of disciplinary complexity is important as for each of the disciplines there are models, vocabulary and languages that need to be weaved to design. The more disciplines and more interactions between them are necessary for addressing a problem, the more intricate the process, the theory of the artifact, and the solution are.
Structural complexity is the decomposition of the problem into issues and their relationships. As problems involve more issues and as their relationship approaches tight networks rather than hierarchies, the problems become more complex. Managing the information related to their solution becomes an issue of balancing the different knowledge sources, their constraints and contradictions. Without proper capabilities and practices, such management could fail in modes that can be normal, emergent, and unknown (Perrow, 1999). We make here the first connection between the P space, the skills that will be described in the S space and the practices from the I space – these have to match each other for the management of the artifact theory to be successful.
Knowledge availability for designing is another important aspect. Available knowledge makes designing easy while knowledge that is presently unknown may be linked to several disciplines leading to gaps that need bridging by later dialogues. This may require complete design situations such as designing R&D projects, experiments, and integration facilities.
We note that complexity arises not only due to more disciplines, parts or missing knowledge but also due to the relationship between the elements. This nature of dimensions appears in all the spaces and dimensions. Also, increasing the complexity in one dimension has a tendency to complicate the others: more components will likely be involved with more disciplines and the chance of missing knowledge for designing some of them will increase.
The S space characterizes the social entity that addresses the design problem. This characterization uses three dimensions.
A *perspective* is a "point of view" required to formulate the problem and design the product. Marketing, conceptual design, testing, packaging, and maintenance are all perspective required to design a product to function well throughout its life cycle. Perspectives may interact with each other in complex ways. Due to the division of labor and professional specialization, different people may be needed to present the required perspectives in the design.
Inclusion describes who could participate in the design process. Closed social space may keep necessary perspectives outside, leading to failure, but may be easy to manage and keep intellectual property safe. In contrast, open space may complicate the process management leading to failure from a project management perspective but will make access to all knowledge available open. We see here again the tight relation between the S and I spaces.
Capabilities/Skills are different notions than perspectives. Skill is an ability to apply different ways of thinking such as creative thinking, critical thinking, and system thinking. A problem that does not require high level of systems thinking and creative thinking is bound to be simpler than one that requires high level of such skills.
As in the P space, 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.
The I space represents the rules, methods, procedures by which all the participants will be designing the product; it is also characterized by three dimensions.
Ties are the connections between actors in the social network addressing the problem; these could be weak or strong (Granovetter, 1983). Weak ties are characterized by the small number of transactions with very low exchange of knowledge and cooperation between the parties. Weak ties are often market-based ties involving low volume of knowledge transfer and dialogue. In contrast, strong ties may involve significant knowledge exchange and reconciliation between different perspectives and disciplines; as such they require careful procedures and commitment to dialogue and sharing.
Knowledge accessibility determines who and how different parties involved in the design can access knowledge available in the organization. Obviously limiting knowledge may harm or even fail a design.
Institutional complexity reflects the rules, culture, procedures and other formal and informal organizational structures. These could support or hinder the effectiveness of participants. They clearly have to match the nature of the problem being addressed.

2.2 The Kodak PSI case

To illustrate the framework, consider the case of Kodak's failure to properly participate in the digital camera market leading to its bankruptcy in 2012, while in fact, Kodak invented the first digital camera back in 1976 (Lloyd and Sasson, 1977). As the new technology had nothing to do with Kodak's film products, and in fact, went against it, management wanted this invention to be kept silent (Deutsch, 2008). Later, Kodak even had a product, Advantix Preview, that allowed users to view their shots digitally and decide which one to print. This product cost more than $500M to launch but was a failure – why would one buy a digital camera if the end result is printing (Carroll and Mui, 2009)? Finally, in 2003 Kodak released their EasyShare family of digital cameras that allowed taking pictures and easily sharing them online (Economist, 2016); Kodak nevertheless, did not foresee the ability to turn this into a "Facebook" type customer experience; it did not understand the social nature of pictures. Kodak had the technology; it was a leader in many technical aspects and first to market; in 2005 it had the largest digital camera market share in the US, yet this reign lasted for a short time only. Kodak in fact, lost money on its cameras. They were developed towards a hi-end market and competed against consumer photography market products. When the digital camera market begun to shrink due to the appearance of cellular phones with cameras, Kodak had no response. Several years later it filed for bankruptcy. Kodak, once among the most valuable brands in the world virtually collapsed while its Japanese rival Fuji succeeded to reinvent itself (Economist, 2016); it took Kodak several additional years to come out of its bankruptcy and become profitable again.

Let us try and use the PSI framework to unpack this story. In the P space, Kodak failed to define the problem properly as history unfolded. It kept the same problem definition of taking pictures without paying attention to the consequences of emerging technologies. Perhaps Kodak was missing some disciplinary knowledge in areas outside technology or perhaps the problem was located in the S and I spaces. From the knowledge perspective of the P space, Kodak was position perfectly with all available knowledge and technology to address all future markets that turned out to be critical. In the S space, Kodak was missing managers with foresight and openness skills, systemic thinking, and change leadership (Barabba, 2011). Observing the technical ingenuity of Kodak’s technical people, these skills were not necessarily missing at Kodak but they did not play a role in determining the fate of the company. Kodak was missing some perspectives also: of the users and their evolution. At times it was focused on women as the majority of the customers and when this changed, they found it hard to respond. The Advantix Preview project suggests it was developed without much customer perspective. The I space had its problems also. For example, trying to hide the first digital camera project, preventing knowledge access, did not help; it may have prevented clever minds in the company to move it forward into the market in a different strategy than the one subsequently adopted. The culture of the company also was harmful. Kodak believed in perfect technology. This opposes the more current culture of consumer products that produces and sells products and then develops better ones by fixing and further development. In addition to managers' inertia, such approach also prevents from quick response to market changes. Kodak monopoly over the market for years made it think it knows the market rather than immersing itself in the trends as they unfolded. The deficiencies in the different PSI spaces, separately, are sufficient to explain Kodak's failure, but there were other clear indications also. Without proper skills and wrong culture, it is impossible to sense the market and define the problem well. Kodak seems to have entered into an unstable company position where missing disciplines or skills cannot be addressed due to incompatible culture or other skills and perspectives.

3 THE PSI MATRIX

3.1 Extending 1-level to a 2-level PSI framework

In another case, C, a transformer company expanded from a local producer and supplier to a global producer and supplier of the product. To achieve this goal, the company bought several transformer companies in several parts of the world. These companies had their own practices worked out well and their PSIs were aligned in the context of their local markets. C's expansion was predicated on leveraging economies of scale by integrating these different companies. But this required understanding that the new product is different than the collection of the previous products developed separately and is changing the operation of the combined company including sharing knowledge across companies and for that, moving from paper-based mechanisms to computerized support for distributed work. What exactly had to be done to align the new combined S space with the new P and which I should be created was unclear. The situation at that point was a collection of PSIs waiting to be changed as depicted in Figure 2 in the 1st level.

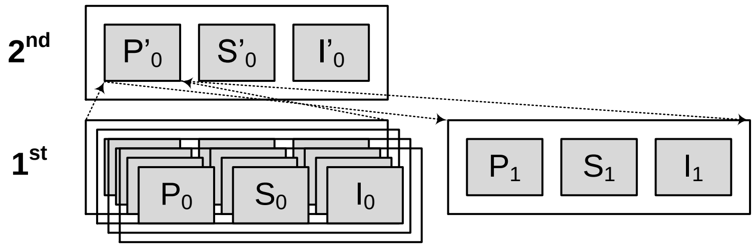

Figure 2. Two-levels PSI: The move from a local to a global company

To align the spaces, the company created a team that included people from the different merged companies, such as R&D managers, production managers, and marketing managers. The team also recruited people from the academia, including us, thereby created a well-rounded S_0' space. The mode of operation of this team, its I_0' space, was subject to the company procedures and contracts made with the external participants. The problem given to the team, its P_0' space, was to align the PSIs of the organization; this is depicted with the dotted arrows from the PSI at the 1st level to the P_0' at the 2nd level PSI.

The team created a new shared product structure model, including computer-aided tools that modeled the physics of the transformer using collective empirical data from the acquired companies. A new design environment was created that captured the shared memory as the design progressed. The end result of this team work was a new and aligned PSI $[P_1, S_1, I_1]$ shown in Figure 2.

Consider another case of a company growing from a startup developing a new vision sensor, to transform into a multinational company involved in developing devices for control of autonomous cars (e.g., Mobileye could be such example). Clearly the initial narrow problem and corresponding product that was designed and the design team and its practices are very different from the set of devices and clients, the multinational team, and its institutional rules and culture. The practices of the large company will not work in the startup and those of the startup will fail the large company. There needs to be alignment in the PSI spaces. How could we conceive of the process of company growth through aligned spaces? The answer could be by moving through intermediate stages in which alignment is achieved, after every change, through some design activity. For that design activity, the problem to be addressed is the misalignment in the PSI spaces. As in the case of company C, we need a 2nd level PSI whose task is designing the solution to intermediate misalignments in the organization's PSI. Figure 3 shows such company evolution. The 1st level PSI, $[P_0, S_0, I_0]$, shows the first time the company needed to grow, perhaps when receiving the initial pre-seed funding. A team, probably very small, or even only the investor, S_0' at the 2nd level, determines the new focus of the product, whether new people have to be recruited, and the mode of operation, leading to a new $[P_1, S_1, I_1]$ at the 1st level. When the next major development occurred, a new PSI is formed at the 2nd level $[P_1', S_1', I_1']$ to align the spaces again leading to a new PSI at the 1st level and so forth until the $[P_{n-1}', S_{n-1}', I_{n-1}']$ PSI at the 2nd level created the last PSI at the 1st level, $[P_n, S_n, I_n]$.

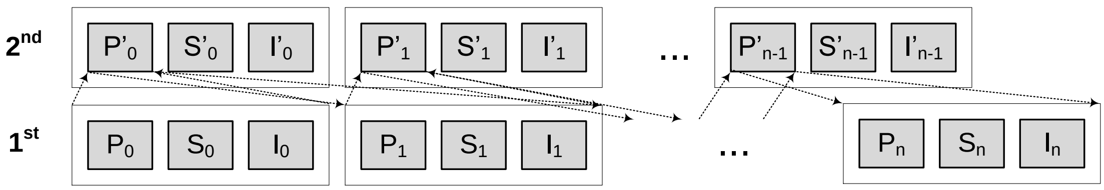

Figure 3. Two-levels PSI: the move from a startup to a multinational company

We anticipate that the team and its practices at the 2nd level would not need to evolve often compared to the pace at the 1st level. We also contend that once formed, the 2nd level team could redesign itself if necessary to address new PSI alignment challenges. The reason is that the team at the 2nd level has skills and knowledge to perform alignment and could use these resources in a reflective mode to correct

itself. Since each issue that arises can be dealt with by invoking PSI, the team at the 2nd level is actually also reflexive (Reich, 2017).
The two last cases demonstrate that a change in a PSI characterization, whether proactive or reactive requires a second level PSI where the move towards alignment is being designed. At that level, the whole 1st level PSI becomes the problem and the *S*' and *I*' spaces are designed to allow addressing it.

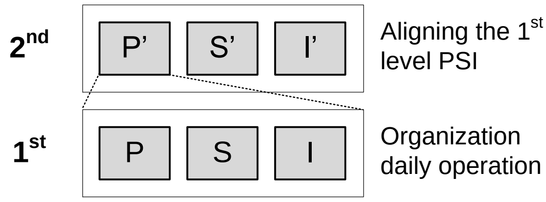

Figure 4. Two-levels PSI: the 1st level describes the daily work of the organization while the 2nd level aligns the 1st level PSI

3.2 Moving to the 3rd PSI level

Going back to the case of C, it is clear that the whole move from local to global was based on significant deliberation at the company and a final decision to adopt this move. We may call this decision a new vision of the company that was a result of addressing some need or desire to grow and increase value, all of which could be considered to be part of some *P*" space; addressed by some team, company major shareholders, the CEO and others key stakeholders, forming the *S*" space; through some process, represented as the *I*" space. Where would we position this vision definition activity? We contend elsewhere (Reich et al, 2017) that vision, ethos, or the meaning of an organization or community is a product that requires its own level; this level is the most abstract PSI level. The case of C makes it easy to defend this view. The process at this company was proactive therefore successful (although it is not always like that). The conclusion of the 3rd level PSI with a new globalization vision for the company, led to forming a different team, *S*', at the 2nd level PSI that planned the integration of the acquired companies into the mother company, leading to a new PSI at the 1st level as already described in Figure 2. This overall process is shown in Figure 5.

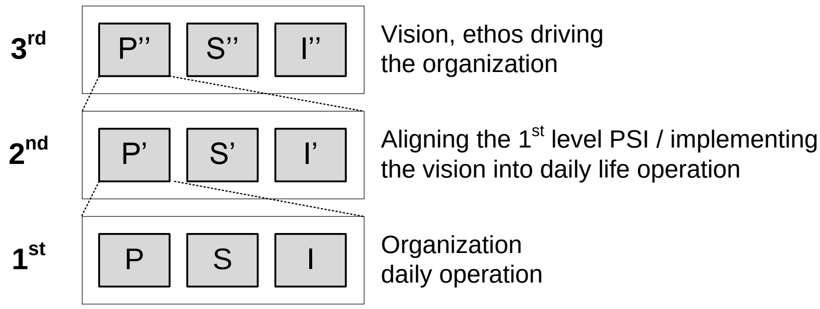

Figure 5. Three-levels PSI: from vision to working company in a proactive process

We clearly see the similarities between the story of company C and the couple story in the introduction and consequently the similarity between Figure 1 levels and Figure 5 levels. Figure 5 now becomes the PSI matrix which is a model of our design framework. Why is it a model? because it does not display all the possible interactions between the spaces in the different levels. For example, although we have three separate S-space cells in the matrix, *S*, *S*', and *S*", it is clear that there are people, such as the CEO, whose perspectives are represented in all three S spaces. We can attempt to draw the PSI spaces as a complex network of relations to be more precise. The choice of model boils down to level of understanding, ease of use, and functionality of the model.

3.3 Working with the 3 levels

The PSI matrix carries the properties of a single-level PSI framework – all spaces need to be aligned. For the levels, we need that they be synchronized for the organization to function properly. We use synchronization and not alignment because alignment is a property that is maintained at the same time in the spaces while synchronization allows for significant time delay as we see later. A company that develops products that sell in the market but that do not correspond to the company values and vision will not last long. All levels have to be synchronized. The case of C where a new vision, mission statement and strategy was developed at the 3rd level, that drove the process of aligning the organization at the 2nd level, so that it could improve its performance at the 1st level, is only one simple example of aligning and synchronizing. But there could be many ways in which the PSI matrix is put to work. We achieve the alignment and synchronization by thinking about designing from an information management perspective.

In numerous studies we accumulated experience in actively participating at the 2nd level PSI to help organizations align themselves to their vision and to their market needs (Davis et al., 2001; Sitton and Reich, 2016; Subrahmanian et al., 2015). These alignment processes included detailed analysis of the organization vision and its derived core processes; information flow studies to identify stakeholders, bottlenecks, and responsibilities for these processes; and defining support infrastructure to allow smooth information access and sharing. In some cases, the 2nd level PSI was operated as a project to get the organization on track and in others, a new department was formed in the organization to continually monitor the health of the day-to-day operations thus giving permanent shape to this level by building expertise, skills, and knowledge inside the organization and fixing the *I'* space as the charter given to the people involved in the *S'* space of this level. Details of these studies appear elsewhere; here we only illustrate intuitively how our experience in these projects translates to knowledge for aligning and synchronizing the PSI matrix.

Let us start with a healthy organization where all its 3 levels are aligned within and synchronized across. Reality changes all the time, often accompanied by challenges. The first task is to detect existing misalignment or lack of synchronization. From an information management perspective, any issue that arises in the smooth flow of relevant information on time to whoever needs it in the organization may be a sign of a problem. It could mean rules that prevent access of information in the I space, missing perspective that is detected in the process (S space), gaps in knowledge (P space), failure of a product due to lack of openness to customers (S space), weak ties between company and suppliers leaving critical information outside the transaction, or procedures demanding a long authorization of decision that hampers quick response (both in the I space). These problems could be detected and their sources identified. Each fix may mean a change in a space leading to cascading events. Such changes at the 1st level have to be reflected upon at the 2nd and 1st levels. The task of the 2nd level would be to make sure that cascading events do not occur without careful path evaluation and plan adaptation.

Let us try to explain how this multilevel synchronization works through a mechanical metaphor. Consider that each space in each level is represented by a spring, red for P, blue for S and green for I as shown in Figure 6. At each level, these different springs have different properties and therefore different stiffness. When a vision is developed for an organization, it looks like stretching the springs to the right direction. The springs have to be in equilibrium to be stretched together even if not stretched by the same amount. The influence of this layer on the lower level is through some friction layer. Some of the energy from the top stretch dissipates but some is passed to the implementation layer. Again, its spaces are stretched depending on their flexibilities; some are easier to change and some are less. The same process continues for stretching the 1st level. In order for an organization to develop a product P (modeled as the red spring at the lower left), all the system has to be stretched in a particular manner and all the system has to be in relatively stable equilibrium.

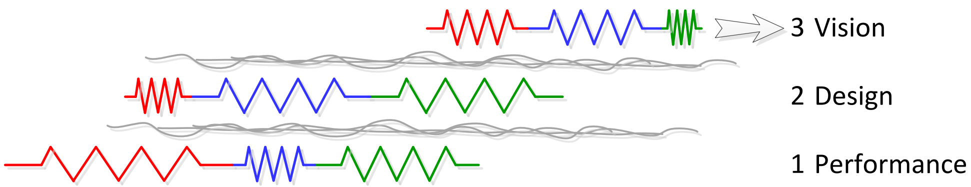

Figure 6. Aligning 3 levels

We can use this metaphor to penetrate much more into the PSI matrix. For example, the friction layer between levels makes sure that the top level is only an approximation of what is going on at the lower level. Also, if the springs at the same level are not connected well to each other they might not be aligned and significant effort or resources might get lost in the process.

3.4 Examples

We can revisit the Kodak case and enrich the description into 3 levels. At the top level we could discuss the company vision, being a photography end-to-end solution with the slogan: "You press the button, we do the rest." Taken seriously, the central activity was not the camera but the film and its processing to photos which Kodak led. It meant creating an elaborate vertical integration that provided films and got them and processed them effectively. The digital camera was going to eliminate this part but Kodak came up with the EasyShare feature in its cameras. This however did not capture the market. There were other alternatives and the consumers wanted more than a click and pictures. Pictures became a social interaction anchor, but Kodak stuck to its original role and vision by further improving its digital cameras and also moving more into digital printing. The skills we previously described as missing in the S space (foresight, openness, systemic thinking, and change leadership) could now be associated with the 3rd level - S". Kodak leaders were unable to change the vision at the 3rd level.

In the digital era, the elaborate vertical integration of Kodak to "do the rest," was not needed to enter and compete in the market; it became a burden. Using the springs metaphor, the springs were not connected well at the 1st level. Kodak missed changing its vision at the 3rd PSI level; and therefore, it had done little at the 2nd level, only exercising reactive response to the market, and mainly laying off people to address the downsizing felt needed in the social space.

A sample of other examples of using the PSI matrix to explain designing situations include: (1) The metro station in La Défense, Paris (Reich et al., 2017); (2) Resident market design in economics; (3) The design driven innovation approach (Verganti, 2013); and (4) Enterprise systems engineering of an organization and a collection of organizations (Sitton and Reich, 2016). The diversity and details of these cases provide evidence of the validity of the PSI matrix as a framework for designing; unfortunately, their description is beyond the scope and space limits of this paper.

4 THE PSI MATRIX AS A DESIGN THEORY

The PSI matrix is not only a framework for understanding designing; it is also a design theory. We only introduce the topic here for lack of space. The role of a theory is to explain what has been observed in designing. PSI has taken a broader scope of explanation in examining the causes or success of designed artifacts. Within this perspective, PSI allows for explaining failures and successes in designing, predict them, and even could potentially be used to control and change the fate of designing situations. For example, we predict that misalignments in a PSI will lead to failure and could even set up experiments to test this. Hence, the PSI matrix has all the ingredients of a theory of design.

The PSI matrix does not claim to explain all of designing, e.g., it does not explicitly explain creativity; we do not believe in a single unified theory of designing. However, the PSI matrix allows us to create contextualized collection of local theories of designing artifacts while providing a framework to understand patterns of failures and successes in their design. This approach is similar to the one taken by Ostrom and her colleagues in their work on understanding institutional rules for managing common pool resources (Ostrom, 2009) to accommodate the variety observed in practice. The PSI matrix can be combined together with, and complement other, theories and it will be also subject to testing, scrutiny and elaborations. Let us take as an example the C-K theory (Hatchuel and Weil, 2009) or the KCP method derived from it (Hatchuel et al, 2009). Previous theoretical analysis using C-K determines that KCP addresses four dimensions of collective creativity "but in a very specific way (Hatchuel et al, 2009)." PSI can be used to explain and perhaps improve the KCP workshop structure and enable it to generalize to different situations. Also, since C-K or KCP may not work in all companies due to their culture or other contingent factors, the PSI matrix could be used to understand this and address remedies for such conditions.

5 DISCUSSION

We presented the PSI matrix, as a design framework and theory resting on significant work with industry and design research. The PSI matrix draws knowledge from diverse disciplines to be able to explain the complexity in real design situations dealing with diverse people in multiple teams working in organizations with diverse relations to develop products in diverse ecosystems. We briefly demonstrated in several cases and noted other cases on which it was tested. Nevertheless, the PSI matrix is in its early stages of development. While we see that the matrix as presented here is already valuable, we intend to improve it further by collecting many cases and studying them to understand the influences between the different spaces (cells) in the matrix as well as their specific characteristics. We are presently conducting multi-case, transdisciplinary, multi-context studies with numerous partners to provide more insight on the utility of the PSI matrix as guidance for design and also to test it as a theory of designing. While they are too early to report, we clearly see the benefit of constantly looking at the situation and its PSI matrix model and deriving guidance for the project. It is clear that many fundamental topics will arise in that process and new research questions be formulated. Dealing with designing in its full complexity requires such a study which is multi-layered but at the same time illuminating and fascinating.

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