ICED13
INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN, ICED13
19-22 AUGUST 2013, SUNGKYUNKWAN UNIVERSITY, SEOUL, KOREA

SPATIAL DESIGN SUPPORTING THE MANAGEMENT OF RADICAL IMPROVEMENTS WITHIN THE MANUFACTURING INDUSTRY

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ABSTRACT
It is important for the manufacturing industry to become more innovative. Doing what we always have done is not enough. External pressure and the required speed of change, requires industry to improve the management of incremental and radical improvement work. There is thus a need for new methods, tools, and processes to improve the innovative capabilities.
In this paper we discuss the use of spatial design to support the management of radical improvement within the manufacturing industry. The designs of the physical spaces are in the paper presented as frames that are cultivating, facilitating and enabling radical improvement without imposing a regime of control and forced change. The spatial design enables the process and contributes to an ecosystem supporting radical improvement. To better manage radical improvement processes, one option suggested in this paper is to create five dedicated places - five enabling frames - for five phases in a radical improvement process, firstly to bring attention to the different phases of the process and secondly to support the actions in each part.

Keywords: innovation, organisation of product development, spatial design

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1 INTRODUCTION

Economic growth and future jobs is largely dependent on how the manufacturing industry can generate new ideas as well as develop and turn these into competitive and sustainable products and services. The ability to develop products and services has become more and more important as the competitive pressure within industry has increased as a result of globalisation. Still, it is not enough to only offer new products and services, it is also necessary for companies to continuously improve their operations to stay competitive. The mass production paradigm, based on manufacturing of high volumes and standardised products, needs to be replaced by a more flexible and responsive approach, with the ability to change and develop operations to suit new demands.

The ability to quickly turn ideas into successful products and services, as well as improving production systems, requires innovative capabilities. Repeatedly innovative companies outperform their peers in terms of growth and financial performance (Tidd and Bessant 1997/2009). Thus, the industrial challenge is to incorporate and manage innovation in the development of products and processes in a strategic and cost effective way which includes managing both radical- as well as incremental improvements within the manufacturing industry.

Based on the above, it is clear that there is a need to support and strengthen innovative capabilities in industry carried out in a number of different ways. Radical- and incremental improvements in products and processes could e.g. involve improving business models, developing new and improving existing products, or reducing costs through improved productivity within operations. In order to strengthen the innovative capabilities, it is important to integrate different disciplines as e.g. engineering as well as design into the development processes.

To summarize, it is important for the manufacturing industry to become more innovative. Doing what we always have done is not enough. External pressure and the required speed of change, requires industry to improve the management of incremental and radical improvement work. There is thus a need for new methods, tools, and processes to improve innovative capabilities. Using spatial design in order to support the management of radical improvement within the manufacturing industry is not very common in industry today. Why? There can different reasons for that, both the in the culture, organization of work, and in the design of the space. For example, there can be a gap between the design of the space and the working process in the organization supporting innovative capabilities. Additionally, people can often be occupied by the ongoing operations and day to day affairs. It does not matter how much money you are investing in creative spaces if your business is not prepared to receive or produce new ideas and innovations. In this article we will argue for the combining of development process with physical space, which we think can support management in the difficult balance between “running the factory” with the management of incremental improvement work and “innovating the factory” with management of radical improvement work. Our focus in this article is to discuss how space can support people and processes to make radical improvements.

2 PROBLEM AND OBJECTIVES

In today’s competitive market and strive to survive, the manufacturing industry must become more innovative. There is thus a need for support to manage both radical and incremental improvements in the manufacturing industry. Moultrie et al (2007) suggest that a physical innovation environment should be a conscious aspect of any innovation strategy. In this article, the role of the physical space when supporting people and improvement processes will be discussed. The overall research question is: *How do we better support the management of radical improvements?*

We will, in the article discuss the following three areas in more detail;

1) Physical PLACES, to support improvement work
2) The PROCESS, how do we organize the development work and the structure the process of generating ideas / solutions leading to radical improvements
3) The PEOPLE, management and mindset enabling improvements in industry

3 THEORETICAL FRAMEWORK

3.1 Physical places to support improvement work

As human beings we are experiencing the world around us when we live it. That means that the world does not “form itself around me and begins to exist for me” (Merleau-Ponty, 1962). We are in the

world with our multi-sensory body and we interpret meaning being in the world. Our existence moves towards physical and social environment and sustains them (ibid). This way of treating the space – as necessity for experience, i.e. that we are understand the world around us *with* the environment has its theoretical grounding in phenomenology - but also more recently and interestingly, in the field of distributed cognition. In any process and action a well-tuned interaction between biological brains, bodies, social factors and artifacts is at play (Clark 1998). The immediate work environment can provide support for actions and development to happen and prevent others.

Previous research performed on the relationship between immediate spatial context and innovation shows that innovation demands a closely linked process of ideation, creation, design and delivery, supported by appropriate management. Spaces in which creative and innovative activities take place are an essential part of the innovation process in an organization (Moultrie et al. 2007). Previous research also shows that, to experience successful innovation processes, the organization and the physical space must be configured to support communication that spurs innovation (Allen and Henn 2007). That can be communication for cooperation, trust, collective learning, brainstorming, ideation facilitated by personal interchanges, time proximity and space proximity (Moultrie et al. 2007, Simmie, 2010). Communication demands physical or virtual contact between people. Informal meeting places are pointed out in research as such places that support communication (Dixon, 1999).

Spaces that stimulate creativity and innovation can be divided into three types: 1) spaces for divergence, 2) spaces for incubation, and 3) spaces for convergence (Leonard and Swap 1999). According to Leonard and Swap (ibid), examples of these three types of supporting places can be well-designed, flexible places for noisy divergences and brainstorming, spaces intended for refection, and well-equipped and easily accessible meeting places for convergence that link people and ideas together. To promote innovation, those spaces additionally have to balance three characters: proximity, privacy and permission (Fayard and Weeks 2011).

Companies are beginning to reflect on how the work infrastructure supports effective group work and communication, other companies have developed devoted spaces to support group creativity and promote creativity as a key element of innovation. In Moultrie et al. (2007) the design consultancy IDEO is one example of a company that make strong claims about the way in which their environment and infrastructure enhances their creativity and innovation performance. "The whole workspace not only reinforces their corporate values, but supports innovative activity through the provision of appropriate resources, visualization and model making facilities and the ability to reconfigure for new projects. " (Ibid. p. 53).

3.2 Processes for incremental and radical development

The process of developing and improving products as well as production systems is not a straightforward process. The paradox is how to decide on the whole (without knowing the parts), while the parts in turn depends on decisions regarding the whole. This challenge is often described as being met by a constant iteration between the whole process and the parts. How is this solved in a large organisation, designing complex technical systems? The use of work structures, explicit processes, and efficient tools is often emphasised.

The development and improvement of products could be considered as a process of transforming different stakeholders' needs into output information, from idea to a product that can be manufactured, see figure 1. This process includes e.g. scenario planning, idea and technology management, product planning, product development and production development including logistics, maintenance and recycling. The challenges with implementing an efficient development and improvement process can generally be explained by the high number of different phases, and thus disciplines, that all have to collaborate (Siriam, 2002).

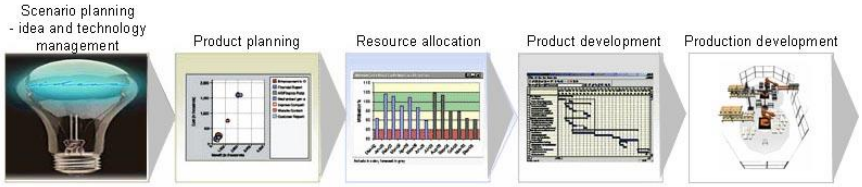

Figure 1. The process of developing and improving products

Several researchers have concluded and specified success factors for efficient and effective product development. For example, Balanchandra and Friar (1997) have made an extensive survey and mapped success factors in product development literature (Balachandra and Friar 1997). Categories such as market, technology, environment, and organisation are often found to impact the success of product development.

The field of knowledge concerning production development has gained momentum ever since Skinner (1969) pointed out the "design of the production systems" as a key to success. A production system should be designed according to its technical and physical characteristics, its human resource requirements, and organization of work (Bennett, 1986) and (Bellgran, 1998). This system complexity is often highlighted in literature indicating the need for a holistic perspective and a systems view.

Different research traditions have contributed to the current state of knowledge concerning production development and improvement. What is then innovation in a production context? In general, two approaches towards production system improvements are commonly recognized: (1) incremental / continuous improvements and (2) infrequent and radical improvements. Incremental and continuous improvement (called Kaizen in Japanese) is a well-known approach for improving production. Kaizen became widely known to the world after the introduction by Imai (1986) and is widely used within the lean production paradigm. The key characteristics of Kaizen are often described as continuous, incremental improvement in nature, participative, and process-oriented. The concept has been extensively described, and a number of supporting methods and tools have been developed and widely applied in industry.

The other approach, radical improvement or "Kaikaku" in Japanese, has also been conducted by many companies. However, it has been less documented and less conceptualized compared to continuous improvement. Radical changes are conducted infrequently, involving some fundamental changes within production and causing dramatic performance gain, and they are often initiated by top or senior management (Yamamoto, 2010). In this article we will focus on the aspect of radical improvements.

When firms have to deal with a number of different problems without knowing the outcome – i.e. when they have to deal with uncertainties, which is one characteristics of radical improvement, they tend to continue along given trajectories based on previous decisions. They might be successful or it might lead to decline. One example is the decline of heavy industries in old industrial areas that failed to innovate and find new types of production. This so-called "path dependency" can make it difficult for companies to create new opportunities (Lamboy and Boschma, 2001; Simmie, 2010).

Sawhney et.al., (2006) argues that many companies see innovation only as synonymous with new product development or traditional research and development. Companies within industry tend to pursue the same customers with similar offerings, using undifferentiated capabilities and processes. The authors propose a focus on creating new value both for the costumers and the firm by creatively changing one or more dimensions of the business system. The authors above further presents an "innovation radar" comprising a total of 12 key dimensions. One of these dimensions focus on redesigning core-operating processes to improve efficiency and effectiveness. We suggest that the actual process to start creative and innovative processes in the product realisation process can be seen as one core operation process. To make those processes effective, both a redesign of the process but also a redesign of the places to support creative and innovative thinking and communication is needed.

3.3 People and radical improvements

Both physical space and management are enablers for a successful innovation process. Manage innovation is a challenge since the process of innovation consists of uncertainty, novelty, and complexity. Peschl and Fundneider (2012) put forward that innovation and creating new knowledge cannot be managed in a mechanical manner. Peschl and Fundneider (ibid) suggest that we instead should create an enabling context where the processes of creating new knowledge and innovation can emerge. This enabling approach requires attitudes, values, and practices of openness, being able to reflect, to radically question ourselves and to let go, to (re-)learn, listen and observe closely and to remain open to something that is changing us. The authors also put forward that we create a context where we can train our patience, our skill to wait for the 'right moment', to listen to weak and fragile signals and cultivate/incubate them. In conclusion, to manage radical improvements "[…], we have to learn how to provide an ecosystem or 'living ambiences' of cultivation, facilitation, incubation and enabling, rather than a regime of control and forced change." (ibid., p. 64)

4 METHOD

This paper is based on a design perspective. In the methodological stance it means that we have used tools from design research to do a descriptive study exploring the relation between places- people- and process within the manufacturing industry. In Design research methodology (DRM) (Blessing & Chakrabarti, 2009) the work process in a descriptive study, consists of iterations between current research, empirical studies and conclusions. We have followed that pattern. The empirical studies done for this article are threefold. During 2010-2012, we did a study at IDEO in Boston, one study within some manufacturing industries in Sweden focusing on spaces for innovation, and two explorative studies developing a physical innovation space at the university and at a manufacturing company.

IDEO, one of the leading design and innovation firms in the world, has become successful through the systematic use of tools and methods that stimulate creativity, new ideas, and diversity. This brings innovation to the very heart of the organization. IDEO has been included in Fast Company's list of the top 25 most innovative companies, has been ranked as one of the most innovative companies in the world by Boston Consulting Group, and has won more IDEA awards than any other design firm. These merits justify choosing IDEO when seeking to understand and analyze innovative capabilities and development processes. One part of the IDEO study focused on the development process used within IDEO, and the other part on the innovation spaces within IDEO.

The case study at IDEO involved interviews and visits in Palo Alto, California, as well as in Boston. The specific goal of the study was to analyse IDEO's development process and, specifically, how such an innovative culture has been built which has generated many different innovative products using design and creativity. Thus, the empirical data about the innovation PROCESS is based on verbal interviews.

The empirical data about the PLACES for innovation was done by photo elicitated interviews both at IDEO (Company 1) and the manufacturing industry at three SME´s, (Company 2, 3, and 4). The photo-self elicitation interview was used in the way that the informants photographed the physical spaces, encouraged by the request "Think about physical environments or parts of environments at your company that, from your perspective, support innovations! Photograph five of them." and the same request about spaces hindering innovation. In a second phase, the task was to fill in a written form followed the photograph session. The form had the following questions: What did you take a photograph of? and Why? In the following verbal interview about the photos a question exploring what the informants read into the word "innovation" was added. At IDEO, in Boston, the photo-elicitation interview was held for seven informants; one director, two designers with more than 20 years experience in the company and four designers with less than two years in the company.

In the three SME's, the photo-self elicitation interview was also conducted with 19 individuals. There were six informants on the manager level (two in each company) and 13 on the operator level. They all work in production or are connected to production. The employees had between 35 years and 6 months experience of working in the companies. Eleven informants participated in a group-interview, and eight in individual interviews. Our choice to use this method was not, as researches analyze what places that were designed for innovation, but to understand what places the users perceived supported innovation.

We have additionally worked in co design project with industry and experimented with a first suggestion of a full-scale prototype of a flexible innovation and creative meeting place at our university. In that co design project we did a two year long design project where the a manufacturing company (Company 5) together with spatial design students and one of the authors of the paper created visualizations for meeting places at the production floor. The full-scale prototype of a flexible space at the university was created as a response to the observations and discussions we had with our co-working industrial companies in our research project for radical improvement in industry.

5 RESULTS

5.1 Study at IDEO and manufacturing industry

5.1.1 Places

The result of the photo elicitated study at IDEO and manufacturing industry showed that places perceived as supporting innovation in manufacturing industry where orderly workspaces, storages and new machines. The material from the manufacturing industrial companies shows processes and places

supporting continuous improvement but not radical improvement. Manufacturing industry lacks places that support divergent thinking, while such places are prioritized in design firms at least from the perspective of the people using the spaces. Clean and orderly places are put forward in the material from the manufacturing industry, and the informal, collaborative and visually simulative from the design company. Foremost, there is a lack of physical spaces supporting divergent thinking and a lack of organizational knowledge of a radical innovative approach in the material from manufacturing industry.

In contrast, in the photographs of the users at IDEO, displays showed inspirational "fun stuff", a possibility to bring in other thinking and lots of ideas into play in the design unit. The possibility to have unpredictable meetings to support innovation was also formalized by the non-demanding informal breakfast meetings in the kitchen area, the placement of people together in project spaces and the freedom to re-design spaces for the group needs at the moment. The prototype workshop was also perceived as supporting the innovation process (for detailed presentation of the results, see Schaeffer & Eriksson, forthcoming).

5.1.2 Process

IDEO has developed an approach to innovation that is based on design thinking and focuses on user experience and the situation of the phenomena to be improved. The approach is based on observations, visualisation, and the modelling of ideas. This approach was something that we did not expect to see. We went there to understand the process. However, according to the informants, an explicit and normative process for managing development and innovation does not exist at IDEO (regarding the practical work in projects). In spite of this, when communicating the approach to others, they talk about a process of several steps. Referring to a quotation from the interviews, "the idea of process does not exist". Consequently, they are following a design process, but they don't label it when doing the practical work. What is important are the iterative steps involving observations, visualisation, and the modelling of ideas (for further information see Wikström & Jackson, 2012).

5.2 Co-design work

In company 5, a vision in the company was to create a space for enabling ideas at the shop floor, an idea workshop [idéverkstad]. The project was initiated by the company and they were looking for inspiration in the design of the space [e-mail correspondence with Company 5, 2010-08-26 and 2011-08-29].

The construction of the idea workshop were intended to create a forum that, among other goals: was flexible, visual and a natural part of the business, facilitated and stimulated unexpected and spontaneous meetings, but was also inspiring for planned and schedule meetings. The hope was that its design should create valuable meetings with new innovations and ideas that lead to new approaches utilized and developed. It was thought to be a forum to create impact and results that contributed to achieving the strategic challenge in the organization.

The vision was coming from the top management and the design process incorporated interviews, observation and alteration of the design in dialog with both shop floor workers and management. The company allocated resources, time and enthusiasm in the project that were ongoing for 2 years and resulting in two design challenges with 10 different design suggestions for the idea workshop.

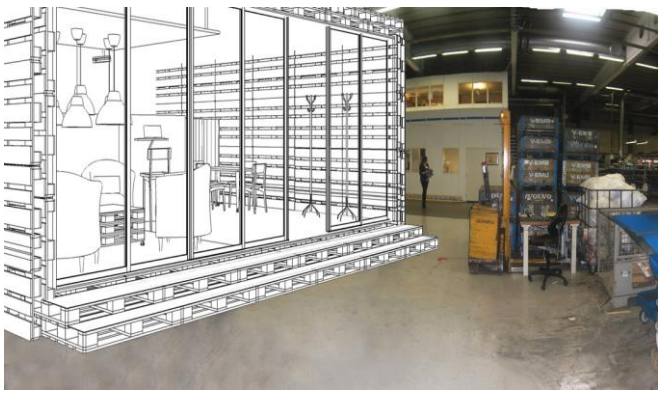

Figure 2. The idea workshop at company 5. (Visualization M. Axelsson, L. Jakobsson and M. Norrlander)

Company 5 decided to implement one of the design suggestions in the second year of the project (see fig.1). It was a space designed to be flexible, easy to redesign, with variation in material, forms and functions. There was a possibility to have a sound level enabling conversation in contrast to the surrounding factory and a possibility to have bigger group meeting but also shorter informal meetings. The company jury thought it was a spot on and on a good level, with a lot of flexibility, easy to access from shop floor, possible to realize and cool with pallets as construction material. In the following discussions the cost was taken into consideration in the planned budget. But in November 2011, due to constraints in the budget and a layout change the project of the idea workshop was postponed.

5.3 Prototype

The design exploration work also included testing a full scale place prototype at the university. This prototype was a developed as a place for creative meetings, an enabling context for the process of creating new knowledge and innovation. The place intended to support divergent thinking, brainstorm and provide a place to practice openness and reflection in groups. The goal was to create a space where there was a possibility to explore alternative ways of creative cooperation, to move, touch and feel the effect of a different designed space then a meeting in a conference room or at the shop floor. The place has features as screens on wheels, with a whiteboard and magnetic board and a sound damping side, a table that can be split into three small tables, chairs of different variety, storage boxes with material for idea generation and rapid prototyping, a wall painted with whiteboard paint and a whiteboard on wheels.

For the inauguration, a workshop was held where manufacturing companies were invited. The users were welcome to modify the space for their needs, and come up with ideas and comments on the changes and improvements. A workshop to train openness within groups as well as to build ideas on others ideas was performed. One result was that a company started to redesign their conference room by painting their walls with whiteboard color, to be able to write on the walls during meetings, but also woke a demand to learn more about methods, culture and space for radical improvement.

Figure 3: *The opening of the lab the 13 January 2012. Design Eva Persson, former student in Spatial Design and the authors of the article.*

6 DISCUSSION

From the three companies in the manufacturing industry described in this paper, there are few places for divergent thinking and informal meeting emerging in the material. The places that were pointed out as supporting innovation where meeting places supporting continuous improvement and working environments structured according to the lean tool 5s. In practice, it brings a dominance of external rules for placement of artefacts, and placement and occupation of people. This control may be needed in a production system but is not an effective enabler for radical improvements.

The lack of money and space in Company 5, despite the dedication in the process and the design outcome, can be interpreted as that space for innovation was not necessary in the organization. Still, there were ideas at the company about how to use it, but no structured innovation strategy or approach that demanded an alteration of spaces. This may be a sign of path dependency. The prototype for a space for brainstorming and cultivating a listening environment at the university, worked well as an example and a possibility to experience working with a process in a appropriate designed space, but it's not integrated in processes at the manufacturing companies. Despite the eventual awareness of the

need for the manufacturing industry to be innovative it seems to be difficult to implement a space to support radical improvement if it is not rooted in a genuine process.
At IDEO the attitude to space included a freedom to cultivate the own work environment, facilitate meeting and project work by altering spaces or create your own space for incubation when you needed it to enable an innovative development process. The spaces and the design of spaces communicated possibilities rather than a regime of control and forced change.
How do we then manage radical improvement processes, that shouldn't be managed in a mechanical manner, in a quite mechanical and structure dependent context as many processes are within the manufacturing industry today? Previous research and our observations indicate that an integration of an innovation process and a physical place is needed to enable such a radical improvement process. From the material above we need to search for a holistic approach when making visualizations or prototypes giving support to people and the improvement process. A well thought radical innovation process combined with physical spaces that both enables a mindset of openness and provides a multi sensory support of the actual actions can be one way. The physical spaces then thought of and should be wisely designed as *enabling frames* for action, not as promoter of forced change or a regime of control.
In order to support creative work and to avoid path dependency we will here suggest that a micro processes of radical improvement is possible to implement in each one of the steps in a product realization process. We suggest that you should perform core processes within product realization differently and support the work with the physical spaces. The steps in these micro processes are based on the studies done in the manufacturing industry as well as at IDEO. They are defined quite clearly since the users in the manufacturing industry normally does not have an integrated design process competence in their work like the IDEO employees, but these steps is a not a description of reality but a simplified map for an iterative process that can be used for guidance. A micro process of radical improvement can consist of five phases; 1) Creation of an enabling mindset 2) Information gathering and analysis 3) Goal definition 4) Ideation, and finally 5) Prototyping and test. We are suggesting that dedicated places - enabling frames- in combination with these micro processes can influence the way we think and act. Additionally, we argue that there are two important levels where these enabling frames can support the radical improvement process. At IDEO the processes and the creative environment were perceived to support innovation by for example the exhibition of the "fun stuff". That can be referred to as the *symbolic level*. At the symbolic level the design of the space, the artifacts, and the graphical material can be a reminder of a step in a process. On this level the space and the artifact gives a visual and multisensory feedback to process or values. Therefore we will here suggest five dedicated spaces – five enabling frames - for each step in the process, which gives a possibility to move from one place to the other and through that movement, entering a new space also entering into another phase in the process. We also suggest labeling the space with the name of the phase, or creating an artifact in the space as a reminder of the actual step in the process.
Secondly the *functional level*, where the places support the action that will take place there. The suggestions are here to be open for alternative spaces and adjustments of the design of the space and the artifacts for the people and processes supposed to activate the place. Before designing each place questions for consideration are presented in table 1 below.
In figure 4 below, an example is presented for the design of five enabling frames in relation to the five specified phases in the radical improvement process.
In figure 4 there are a suggestion for 1) a frame that supports the phase of creating an *enabling mindset* for radical improvement. Entering in to this phase, different places can be used, but for example chose one that has space enough to do exercises, create informal meeting places, and design a place where you can work with visualization of the innovation strategy. 2) A frame that support the form of *information gathering* you choose. When designing the place for information gathering, ask yourself: How do we want to house a divergent team? Should they sit close together, with full Internet access, possibility to track back for silent reflection with alcoves, or own office places to working with defining goals? When the group then 3) entering the phase and the place to *define* the idea to work with, provide enough space for a whole group to move visualizations of ideas around make selections or use a conference room with a projector to have an overview of alternatives. When creating an enabling frame for 4) *ideation*, design for example a space with no table which is flexible with everything on wheels and with possibility to write on the walls. Provide easy access to pen paper or other forms of tools that can the document and elaborate the verbal communication. At last dedicate a

place for 5) *prototyping and testing*. That can be a prototype workshop or a place with material easily accessible for fast prototyping of your ideas. When testing, define accurate place to do that. Should you go out in factory or elsewhere to search a target group?

Table 1. Overarching questions creating enabling frames for radical improvement

Mindset	What do we mean by innovation mindset at our company? How do we support an innovation mindset? Do we have supporting management, processes and spaces? What are the values and convictions acted out in the design of artifacts and space?
Graphical material	How are the graphical artifacts designed? What do they communicate? Do we have any visual keys for the use of the space?
Verbal communication	How do we communicate? With whom? Distance? Placement? Informal and formal? Are different forms of communication supported?
The space and the objects	Do we provide spaces for divergent thinking, incubation, convergence? Who is able to alter the space? Do we balance three characters: proximity, privacy and permission in the spatial design? What is the relation to the values of the company?
Multisensory Experience	How to use sound, movement, light, colors, structures, scale, form, order, smell, proximity, distance, food and time? How to achieve an experience of immersion?

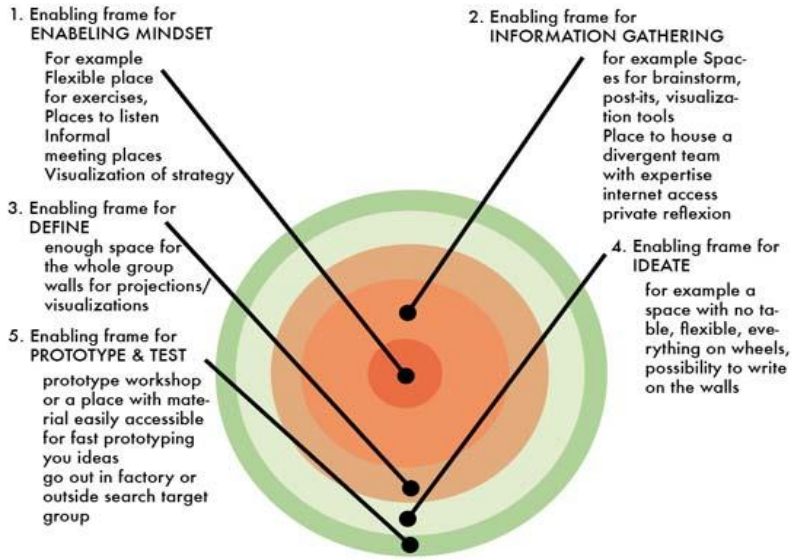

Figure 4. An example of five enabling frames in relation to the five phases in the radical improvement process.

7 CONCLUSION

If there are methods for creativity, enabling processes and leadership for radical improvement, the physical space can be a way to manifest and enable the processes and bring focus to the process and people. To better manage radical improvement processes, one option suggested in this paper is to create five dedicated places – five enabling frames- for five steps in a radical improvement process, firstly to bring attention to the different parts of the process and secondly to support the actions in each part. The place is here presented as a frame that enables the process and contributes to an ecosystem supporting radical improvement. This structured space-phase process has to be designed, used and evaluated in a production environment. Our aim is to continue the research with an explorative study how to design spaces that are cultivating, facilitating and enabling radical change without imposing a regime of control and forced change.

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