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Spatial design and communication for Improved Production Performance

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ABSTRACT

The paper present research results on how a spatial design can communicate and support production performance in relation to lean production. The main concern of this paper is to discuss the role of interior design and its affect on humans in a production system and to contribute to a more profound understanding of lean production from a communicative aspect.

This paper is focusing on three case studies: a *project studio*, a *prototype workshop*, and a *development workshop* in manufacturing companies. The study in the development workshop is conducted during a period of two years, with an ambitious survey as follow up. The two others are context cases to exemplify and investigate the role of interior design in an industrial environment, with project studios as the main subject.

The research method chosen is case study methodology including a literature review related to examples from the industrial case studies.

In industry, spatial design in interaction with visual artefacts can be used to reduce the 8th waste by supporting effective communication, cross-functional work, decision-making processes, reinforcing the project identity, facilitating project management, save time, shorten led time for development projects and inspire employees to a positive view of the company and the project.

Keywords: Visual Management, Production Performance, Obeya, Spatial design

1. INTRODUCTION

The main concern of this paper is to discuss the role of spatial design and its affect on humans in a production system and to clarify its connection to production performance, in the context of lean production.

Especially in times of low demand of products, in order to stay competitive, companies strive for increased production performance. Continuous improvement is one of the keys to surviving and flourishing [1]. Lean production is the most obvious example where continuous improvement is integrated into the production philosophy and has a large impact on the production system [2]. The manner in which many companies in Western countries have applied lean production earlier can be seen as using isolated techniques without understanding lean production as a whole. This is, however, beginning to change. It is now understood that lean production is more of a philosophy than a set of techniques and tools [3]. Lean production aims at using

the resources in production in an efficient way through continuous improvement and the reduction of waste.

Taichi Ohno considers an 8th type of waste adding to the seven usually mentioned types of waste. The 8th waste is, more in detail, loss of "time, ideas, skills, improvements, and learning opportunities by not engaging or listening to the employees" [4] within an organisation. The ambition to diminish the 8th type of waste can be supported in different ways, where visualization is considered to be one approach. In industry today a lot of effort is made to continually improve the technical and organisational processes, but still there is a lot of potential for improvement in the field of spatial design. One argument for that, in line with lean thinking, could be the following: in choosing to work with continuous improvement, why concentrate on improving the production only neglecting improvement possibilities in the places where the communication and meetings take place?

From an industrial perspective knowledge presented as *visual management* [5] can be useful. It mirrors lean production in factories from a visual communication viewpoint. Visual management focuses primarily on visual control in form of boards, andon signals, kanban systems but also the intricate relation between visual communication and management. Visual communication should not be isolated from management according to Grief [5]:

The objective is not to introduce a system of visual communication, but to create a visual mode of organization. Visual communication gives groups of people more accurate perceptions of reality. [6]

The aim is to integrate visual communication and organisation in an industrial context, which Grief [6] successfully does. Here, the spatial environment, the interior design, is not taken into special consideration when exploring the field of visual management.

The relation between architecture, management and organisational theory has been treated earlier but not in combination with visual communication [7, 8]. The research presented in this paper makes a contribution in the intersection between those fields. Management *and* visual communication is always situated in a spatial environment. A useful model to show to the special field of this paper is created by Lorenc et al [9] where Visual communication (in the original model called Communication Design) meets the built environment. This overlapping area is called *communication environment* (see fig 1). The purpose is to show that the merge between the areas creates “environment that communicate” [9]. The spaces presented in this paper are considered as *communication environments*. The management perspective is included.

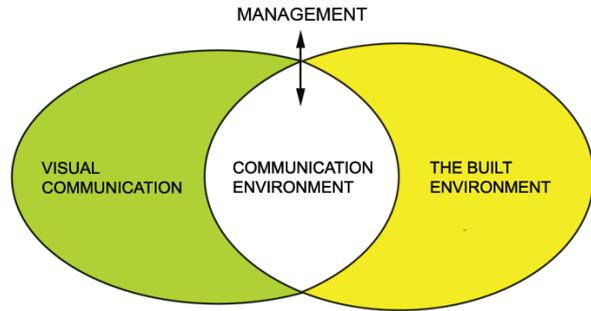


Fig. 1: Communication design meets the built environment and creates communication environment. (Model modified from [9])

The research in this paper is aiming to show that in industry, the spatial design in interaction with visual artefacts, i.e. the *communication environment*, can be used to reduce waste in the form of unused creativity, long PDCA cycles, low motivation, complicated communication, low dedication or weak representation of the company identity. In companies that organize their work according to a lean production philosophy, different places are often created where the team of personnel in operations, R&D, leading positions and continuous improvements could gather. The first place that comes to mind is maybe an improvement place in the production floor for weekly meetings in the working groups. However, improvements, idea generation, learning and communication are dealt with in other spaces in industry too. Spatial design in production also includes factory layout, offices, meeting rooms, and other places/rooms in the production process (see fig.2).

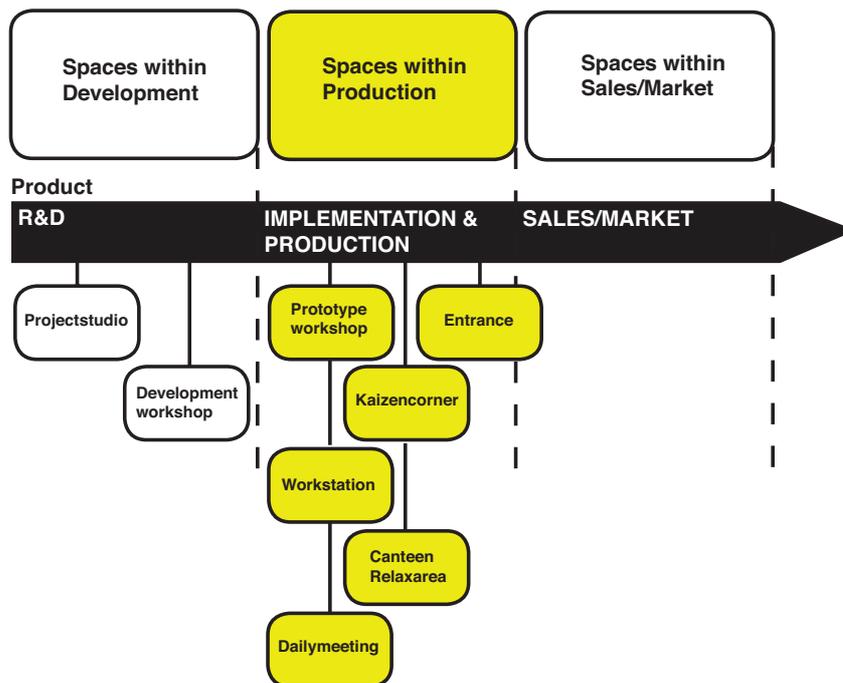


Fig. 2: Different spatial designs in the production process (raw outline).

1.1 Methods and materials

This article is focusing on three case studies: a *project studio (case A)*, a *prototype workshop (case B)*, and a *development workshop (case C)* – all in the manufacturing industry. The study in the development workshop is conducted during a period of two years, under and after a major interior design change with an ambitious survey as follow up. The results presented here are from the survey with the 34 shop floor workers. The other two are context cases to exemplify and investigate the role of interior design in an industrial environment.

The research method chosen is case study methodology [10] including a literature review in relation to examples from industrial case studies. The case studies include an architectural analysis [11], one survey and interviews recorded and transcribed. For a detailed description of methods, target groups, and the statistics see the technical report [12].

1.2 Obeya

Can the design and the size of a room make an impact on communication? Findings about distance and communication show that “attractive, useful common spaces may effectively increase members ‘proximity’ or exposure to one another, reducing their effective distance and thereby result in a greater face-to-face communication” [13].

In lean production there is a space called *Obeya*, the *big room* or the *war room* [2]. The *Obeya*, in its physical unifying aspect, makes the communication flow more efficient as a home for a cross-functional team comprising for example engineers, designers, suppliers, assembly workers and representatives from the sales department. Liker (2004) characterize *obeya* like this:

One of the most important results of the Prius project from an organizational design perspective was the creation of the *obeya* system of vehicle development, which is now the new standard for Toyota. *Obeya* means “big room”. It is like the control room. In the old vehicle development system, the chief engineer travelled about, meeting with people as needed to coordinate the program. For the Prius, Uchiyamada gathered a group of experts in the “big room” to review the progress of the program and discuss key decisions. The project team found a room outside the fray of normal day-to-day affairs, which became known for housing a weird, top-secret group (G21 project) endorsed by top management. During the development process, Uchiyamada documented in real time the experience, a new breakthrough design from scratch. This led to a very confidential 200-page document that can be reviewed only with a special high-level permission. [14]

There are different advantages with the *obeya*. The PDCA [Plan, Do, Check, Action] cycle could be done in one day in the *obeya* but in the traditional separated spaces (where actors and sub suppliers situated even in other countries) it can take several weeks. The communication is effective, and the technical equipment supports the process: “The *obeya* works well because of a combination of face to face human contact and computers with software with which it was possible to

both design and virtually assemble the components before producing them.” [15].

The actuality of a specified room for meetings with groups of different competences is marked by the role it may play in times of recession. New York Times reports in May 13th 2009 how Toyota deals with crisis and it is clear that *obeya* is used in this process for cutting costs.

But with the global automobile industry mired in its worst crisis in a quarter-century, even Toyota’s latest standards for lean manufacturing are not good enough.

Now, employees are huddled in a war room at the plant — called an *obeya* in Japanese — charged with finding upward of \$100 million in annual savings from the Woodstock factory, where Toyota builds RAV4 crossover vehicles, and a nearby plant in Cambridge, Ontario, where Corollas, Matrix hatchbacks and Lexus crossovers are produced.

Among the ideas: instead of spending \$16,000 to hire a contractor to build a conveyor belt for delivering bins of parts to a section of the assembly line, workers designed and installed their own, for \$700. [16]

In the descriptions above it is clear that cross-functional teams are meeting in the room in order to cut costs. It also shows the polyvalent function of the room. The *obeya* stays the same but the purpose of using it can be to develop a new vehicle model or to deal with the low demand of new products.

The *obeya* supports:

- ◆ Shortening of the PDCA cycles
- ◆ Effective communication flow
- ◆ The process by having adequate technical equipment
- ◆ Idea generation for cutting costs

2. RESULTS

2.1 Example of *obeya*: Project studio

Case A, *The Project studio*, was created in 2006. The project studio was originally created in order to let different development projects sit closely to each other and to the production. The aim was to improve the integration between construction and production in order to develop better and more production-friendly products. When a huge factory project started this development project took over the project studio. It was developed to a place where effective project work could be done. In 2007-2008 the studio was hosting this development project with over 50 participants, of which 20-25 worked fulltime in the project [16]. As in the Prius project mentioned above a new model was going to take form, in this case a radical change of the mode of organisation. The room was especially designed as a cross functional workspace with features very similar to the descriptions of an *Obeya*. *The project studio* could be described as an office area placed closely to the production on the first floor. In order to go to the room you had to pass through the production. The layout of the room was dominated by an open conference space

called *the project central* in which a table for standing meetings dominated the space. (see Image 1).

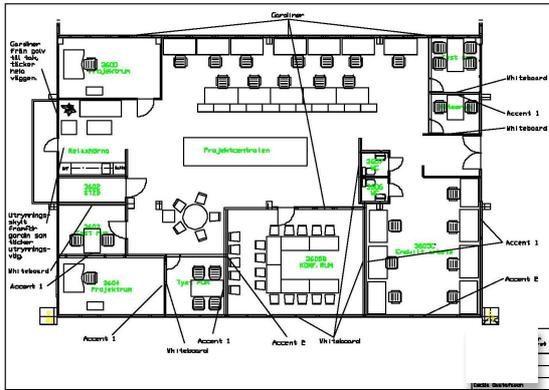


Image. 1: Project studio

The project studio consisted of temporary office work-places, computers, printer and a library, which was a silent workspace for reading and writing reports. The area was flexible with whiteboards on wheels surrounding one side of the project central. The long table in the centre consisted of smaller tables on wheels, also easy to move. The legs of the table were adjusted to create a table for standing meetings. The project studio and especially this table were supposed to be a space to see layouts, parts from the production and other documentation. The whole area also included six smaller conference rooms, a meeting area for a relaxing cup of coffee and two toilets. Each room had Japanese names. The relax area was equipped with a sofa, a coffee table, a suspended lamp and a kitchenette. One of the conference rooms had a table, comfortable chairs in red and curtains in red and yellow. The technical equipment consisted of computers with suitable software, telephones, projectors and projector screens. The walls were covered by visualizations of different phases in the project and information about the project [17].

Effects of the spatial design: informant 1, an engineer and project participant who worked in the project studio in the part with "guest working places" during spring 2007, described the project studio in the following way:

My first impression was that this is a modern, creative company. In the project studio you had a feeling of belonging and that you were involved in something important partly because there was an effort made to make the project place aesthetically appealing. The impression I had was WOW- NOVELTY -SUCCESS. When our part of the project grew we were moved to another office space. There it was different conditions, randomly chosen furniture, very hot when the sun shined in and no air-condition. We were also more isolated. In the project place on the other hand, the spatial design facilitated close cooperation and discussions. [17]

The project leader of the development project, informant 2, described *the project studio's* crucial importance from a project management perspective. The project studio gave the project a "home" which made it easier for project participants who were recruited from the line organizations to prioritize the project. From the

project leader perspective it was clear that in this way the project were run more efficiently. The group identity was reinforced by the project place and a strong group was needed when the project met resistance in other parts of the organisation. The advantage of the project place was that it was easy to communicate and share information. All information was located at one place. It was easy to gather around a drawing or document if something had to be discussed. To stand beside the visualisations on the wall looking, discussing and showing the different parts of the project made it easy to illustrate the project. It was also here guests quickly were introduced to the project [17]. In short the project studio supported the following:

- ◆ Effective communication, cross-functional work and decision-making processes
- ◆ Reinforcing the project identity
- ◆ Facilitating the job as a project manager
- ◆ A timesaving way to present and discuss the project through the visualizations for guests and visitors
- ◆ A possibility to live and breath the project
- ◆ To shorten the led time for development projects
- ◆ Inspire the employees to a positive view of the company and the project

The importance of the interior is not so much considered in industry, according to informant 2. In this project they had a visionary project member focusing on the interior. The project leader points out that in the manufacturing industry the usual reasoning is that you need space, you find an empty room, put a table there and then you can start work there. The final step to design the space in order to achieve support for the work is not so common but important [17].

2.2 Example of a "small obeya" the Prototype workshop

In Case B, a meeting area in a prototype workshop was created (see Image 2). The designers were two students from Spatial design – Information design. The design was made in close cooperation with two operators supposed to use the area. It was inaugurated in summer 2006 and is still in use 2009.



Image. 2: Meeting area in prototype workshop

(photo Sara Göransson)

The meeting area in the prototype workshop is placed in a corner with view over the factory floor. One door leads out to a small garden. There are five windows letting the light in. A table in light coloured wood is placed diagonally over the floor and chairs are placed around the table. The surface of the table is big enough for drawings and sketches. A small placard is placed there to keep documents in. A projector screen is placed on the wall. A lamp, possible to see from a long distance, is placed over the table. The roof is lowered and the new wooden floor is slightly elevated from the surrounding floor in order to contrast the space from the surroundings. The colours are also chosen in order to distinguish from the surrounding area with a lot of different colours. The company's graphic profile was used as a base for the colour scheme. As a communicative environment all these items and design choices tell the user and visitor that the milieu is differing from the traditional factory floor environment (see Image 3 below).



Image. 3: Meeting area in prototype workshop, view from the factory floor (photo Sara Göransson)

One of the informants working with the project was informant 4, a toolmaker with 10 years of experience in the company. He explains the start of the project in the following way:

The initiative that formed the basis for us to create the meeting site was that we looked at the costs to make the prototype around the world. The question was: Can we make it as cheap or cheaper at home?

Here we have closeness to everything and this is the condition for proximity design. When we should communicate with someone in Spain in rough English there is loss of time and possibility for misunderstandings. At the meeting area it is easy to come down and show a plan or discuss and develop an idea. But we had never done like this if we had not included the university. It was the students that came with the holistic approach. I had probably set a place like this table and some chairs. But it had never been as good. We also painted the machines and the floors so that it became a common colour scheme. A large machine was painted in a light colour and suddenly there was a lot of light in the room, in combination with the new lighting. It is

a much nicer workplace. It especially looks more professional. [18]

The challenge for the designers was to create a meeting place on the shop floor where operators could work with some administration and at the same time it should be attractive to take visitors to. It should also be a place where operators and production technicians could meet to produce prototypes in house instead of placing orders elsewhere in order to save time and money. Some keywords for the meeting area were modern, order, 5S (and in order to support this a clear place for each item had to be created) and creative. This was a meeting place where the production technicians could go to show their sketches, discuss them and do testing if the ideas worked. The response on questions concerning the development was immediate when operators and technicians sat together [18]. The meeting area in the prototype workshop is like a small *obeya* in the sense that different competences gather in a well destined spot to facilitate communication and shorten the time to develop a solution for a new feature and a new product.

Effects of the spatial design: The responsible manager and one toolmaker, informant 4 and 5, mention that shorter ways for the information flow, fast and accurate decisions and problems are localised immediately. They also captured and retained knowledge within the company by creating the project. The project results were not measured exactly but the prototypes developed in the prototype workshop were developed ahead of time from the outsourced projects. The toolmaker, informant 4, says:

When we compared with the companies that delivered the other items we were clear in advance. We did not reach deadline but we were by far not the last. We had also the most difficult items. There was a learning period in the beginning. Most of the parts and some special items that we had to learn to do but anyway the items were done weeks before other suppliers. [18]

The way the room influenced the work organisation was that operators and production technicians in the department came to socialize, to work with the project and obtain technical information. It became a natural meeting place, the employees wanted to spend time there. Informant 4 continues:

When we did prototypes, we had a very close connection to construction. I have never seen this speed in a project before from the production technician side. It was an upsurge when the meeting area was created. It made the place much nicer and the roof and the floor created a room within the room. We had the opportunity to sit down which created more contact with the production technicians. They saw our technical equipment and the potential to use the resources in-house for making parts [18]

The toolmaker mentions that the proximity saves time. The products did not have to be transported to a conference room, you had a face and a name to a person if you wanted to ask a quick question [18]

One of the designers' express that it is hard to tell how much the room changed the work organisation but the

new meeting place changed the attitude to work in a positive direction from what she learnt. In the designers view a change in the interior is a sign in order to attract costumers. It is connected to the profile of the company both for visitors, costumers and employees. She has seen many places where the interior has not been changed since 1970. It gives the impression that the company stands still. It raises the question how the products could be up to date when the interior looks like this? [18]. This question turns the *obeya* from a position in early stages in the product cycle to later stages near sales (see figure 2), which is an example of the different functions a communicative environment can have.

In short the meeting place in the prototype workshop supported the following:

- ◆ Minimised misunderstandings- fast and accurate decisions
- ◆ Facilitated developments of ideas and decision-making where problems were localised immediately
- ◆ Reinforced the impression of professionalism
- ◆ Shortened ways for the information flow
- ◆ Captured and retained knowledge in the company
- ◆ Made effective use of technical equipment and the potential to use the resources in-house
- ◆ Saved time

2.3 The Development workshop

The Development workshop is an industrial workspace, connected to the research and development department. The workshop is located at the ground floor. The dominant spaces are the assembly hall and two long corridors, five offices, meeting areas and a lunchroom. There is an open space divided with cupboards and walls where different occupations such as welding, storage and electrical construction take place. The meeting areas and the electrical workshop are built as smaller rooms in the big hall. In one end of the open space there is an enclosed department where the newest model of the product produced at the company, is assembled. In the case study, the first phase of an interior renewal of a factory workshop (including new orientation texts and signs, new colour scheme, new equipment and clarification of the company's value words by visual tools and photos) was studied during and after the first phase of changes in the factory workshop [12].

Effects of the spatial design: Similar to the meeting area in the prototype workshop, case B above, there is a connection with the space as communication environments and the status for the department. This is the answer concerning status from the operators working at the factory floor. 28 informants of 34 agreed with the expression that the change in the interior increased the

status of their department relatively to the other departments [12].

From a management perspective it is interesting that the feeling of "joy of work" increased with the renewal. 27 informants of 33 considered that the change of the interior in the workshop had equal or more value for the "sense of joy in work" compared to the overall organizational change in the workshop. Managers thinking of a major change in the organisation could consider that a majority of the informants saw the actual change in the interior as a good way to show a change in the organisation structure [12].

In order to reduce the 8th waste by engaging or listening to the employees within an organisation communication environment can be supportive [2]. From this perspective it is interesting to notice that 16 informants out of 33 considered that the change in the interior increased their motivation to go to work. They also expressed the view that change of the interior had an impact on the fact that it made them feel important to the company. 17 informants of 33 agreed with the assertion that the actual change in the interior had an impact on work satisfaction. A majority also agreed that the actual change in the interior lead to more satisfied workers [12].

The relation between the interior in the workshop and the impression of professionalism is interesting considering the interior as communication environments. The people working in or visiting the workshop is the shop floor workers, managers, costumers, visitors, and after the renewal also people from other departments that with an increasingly rate booked the conference rooms. They perceived the entire surrounding environment as communication environments. 29 informants of 34 found a strong connection between the impression of professionalism in their products and work and the design of the interior [12].

3 DISCUSSION

The empirical findings based on the three case studies show the strong relation between the organisation and the use and benefits from visual communication. Why is it important to focus on the relation between the space and the user? Is it relevant to discuss user perceptions and experiences of the tree cases mentioned above? Is it not more relevant to measure the advantages of shortened PDCA cycle, the money you save and efficacy of communication? Yes, the last question is important, but for any serious study we also have to focus on the complicated relation between the phenomena we study and the user experience of it.

We cannot see the object (here the three different industrial spaces) as completely separated from the user's experience of them. Vivian Sobchack, a theoretician in visual communication states "[...] we should remind ourselves that the phenomena scrutinized by most rational and scientific approaches to the human sciences and the arts [...] are perceived as objects amputated from the persons for whom they exist, by

whom they are perceived, and from whom they acquire their meaning as objects." [19].

This is possibly an input for a discussion about space and perception of the room. Perceived space is seen as an object apart from humans for whom they exists and are given meaning. We can present the sentence "I look at a picture" where the preposition immediately implies a separation between the object and the viewer. In the case of spatiality you are in the room. It gives an indication of the enclosing factor of a room, which is affecting how we view space as objects. By entering a room, the room is surrounding us every side. It does not create that distance to the room as objects. At the same time, to let the object of perception be created in the subject is a difficult idea. In the empirical material, interviews from informants in industry mirrors the most common approach in industry, saying that if there is a place to be is sufficient. Not how it looks. The next level, to be concerned with what the environment communicates is secondary [17]. The interaction between space and man creates specific reactions in perceiving depending on the room's environment, the use of it, expectations and previous experiences of man.

4 CONCLUSIONS

The empirical findings based on the three case studies shows that communicative environments (for example *obeyas*, development workshops) equipped with technical equipment and possibilities for visualization support different types of performance. The communicative environments are closely integrated with management in the way that they can reinforce the project identity, facilitate the job for the project manager, give a possibility to live and breath the project and shorten the PDCA cycles and led time for development projects.

The communication environment can also support an effective communication flow, cross-functional work and decision-making processes, the development process by having adequate technical equipment and idea generation for cutting costs.

To visualise information in and by a room like an *obeya* is a timesaving way to present and discuss the project through the visualizations for guests and visitors, it creates shorter ways for the information flow, supports fast and accurate decisions and problems are localised immediately. By keeping competences close to production knowledge is captured and retained within the company.

The communicative environment can also inspire the employees to a positive view of the company and the project, increase the status for the project or the department, reinforce motivation, the "sense of joy in work", the sense of feeling valuable to the company and reinforce the impression of professionalism in work and products.

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