COMMUNICATION SPACE

SPATIAL DESIGN IN MANUFACTURING INDUSTRY

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ABSTRACT

The main concern of this licentiate thesis is to discuss how built space is used for communication in the manufacturing industry, from a visual communication perspective. The thesis presents and develops the notion of 'communication space' and presents a model to describe the relation between different factors in the communication space.

In a multiple case study, six different cases from the manufacturing industry are described and analyzed to highlight how built space is used for communication in a lean production context. Research results on how built spaces such as improvement places, meeting places and a development workshop affect improvement processes and communication are presented. What the studied improvement areas, meeting places and workshop can be said to communicate about the improvement processes is analyzed.

The research results show that the built spaces in manufacturing industry are used for communication on two levels, both as places for interaction between employees and as a part of a communication process. The study also shows a relation between architecture from a specific time and the relation to the improvement work in the industrial context.

How the results can be used to facilitate communication in the built spaces used for improvement processes in manufacturing industry is suggested in the thesis.
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The errors and inconsistencies in the thesis remain my own.
LIST OF PAPERS

This thesis is based on the following papers, which are referred to in the text by the letters A, B and C and a Technical Report.


Additional paper


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ABBREVIATIONS AND TERMS

5 S  A workplace organization methodology in lean production that uses five Japanese terms (seiri, seiton, seiso, seiketsu and shitsuke), which can be translated into in English as sorting, straightening, systematic cleaning, standardizing and sustaining.

DRM  Design Research Methodology

R&D  Research and Development

TPS  Toyota Production System

Kaikaku  A Japanese term for radical change in a lean production context (Liker, 2004; Yamamoto, 2010).

Kaizen  A Japanese term for the continuous improvement work in order to achieve a lean production. It affects the process, people and partners as well as problem solving (Liker, 2004).

Obeya  A Japanese term for “big room”. In TPS, it is used for cross-functional team work (Liker 2004).
1 INTRODUCTION

Built spaces are used in and for communication in working life everywhere, and also in the industrial context. On one level, the built space is used as an environment for verbal communication and interaction between human beings. In this function, the built space should support the communication going on there. On another level, the built space itself also can be used for communication. Both levels affect the users. The possibility that the built spaces can support or disturb the improvement process is overlooked in the manufacturing industry. Operators, engineers and managers work together with their customers to improve the products, production and organization in manufacturing industry. However, this process does not take place in a vacuum. Users face numerous challenges in their built space. Consider that our experiences and communication are not happening in isolation. Everything is experienced “in relation to its surroundings, the sequences of events leading up to it, and the memory of past experiences” (Lynch, 1960; 1). This accentuates the complexity in the relation between a user and built space used in and for communication. A strive in the thesis is to acknowledge this complexity and to find suitable notions to describe how built space is used for communication in manufacturing industry. Therefore, this thesis presents and develops the notion of 'communication space' and presents a model to describe the relation between different factors in the communication space situated in manufacturing industry.

In industry today, substantial efforts are being made to continually improve the technical and organizational processes. Yet still there is much potential for improvement in the field of spatial design in an industrial context. One argument for that, in line with lean thinking, could be the following: in choosing to work with continuous improvement, take the opportunity to integrate improvement possibilities in the built spaces. Improve also the spaces where communication regarding improvements in production and development takes place.

Although the implementation and development of lean production is a subject for research in industrial context, spatial design is not well-developed as a supporting variable. The role of spatial design often involves the efficient use of floor area for machines, ergonomics, the organization of workspaces or back-
grounds for visualizations. In practice, engineers often design the spaces themselves, and the design of the built spaces is not the highest priority.

The research presented here is based on empirical studies, in the form of case studies. Six different cases from the manufacturing industry are described and analyzed to highlight how built space is used for communication in a lean production context.

1.1 BACKGROUND

In general, the manufacturing industry in Sweden and worldwide works to a large extent with the introduction of lean production as a philosophy. Therefore, companies for this study were chosen among those companies in Sweden that are in a transformation process towards a lean production. There is a rising interest in lean production to support communication regarding improvement with the help of built spaces and visualizations, although the design of built spaces is not yet fully integrated in production strategy. As we will see, in some writings published on lean production, there is a relation between lean production, visualization and to some extent, the built space.

Communication with the help of built spaces and visualizations is the core of the field of Information Design – Spatial Design, where the informative (communicative) aspects of built spaces are emphasized. Design is here defined as both a process and the outcomes of the process. One way to describe the focus in Spatial Design is that the design of the spaces is performed through a filter of communication. This is reflected in the choice of the design methods, the dialog with the customer, how the proposal is presented, and the outcome of the design process. Information Design – Spatial Design is not solely concerned with graphic materials, signage systems for guidance, or exhibitions in the spaces. It also deals with shapes, spatial elements, colors, and lighting and how human perception and experience is affected by the built spaces as a whole. In terms of both theory and practice, the discussion in Information Design – Spatial Design, since 2003, has been focused around issues related to communication, perception, atmospheric conditions, space, form, functionality, signs, symbols and artifacts. In order to communicate the role of built space used for communication in manufacturing industry and to give adequate education in Information Design – Spatial Design, there is a need to discuss the role of the design of built spaces, its relationship to communication, and its effects on the user.

1 The Bachelor program Information design – Spatial design at Malardalen University changed its name in 2003 from Expo-Event to Spatial design, based on a suggestion by the architect Håkan Wannerberg, later responsible for the program.
1.1.1 Lean production

In order to stay competitive, companies strive for increased production performance. Continuous improvement is one of the keys to surviving and flourishing (Jackson and Petersson, 1999). 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 (Liker, 2004). The manner in which many companies in Western countries have previously applied lean production can be seen as using isolated techniques without understanding lean production as a whole. This is, however, beginning to change. It is now understood in manufacturing industry that lean production is more a philosophy than a set of techniques and tools (Bellgran and Säfsten, 2005). Included in what is called the 'lean production context' in this thesis is companies that strive to implement lean production and the thinking relating to lean production.

Lean production has its roots in mass production, and the focus on eliminating every second of inefficient motion in production dates back to scientific management, starting with Henry Ford in the 1920s (Liker, 2004). Today, lean production is often seen as a more refined version of earlier management strategies such as Taylorism and Fordism. Toyota was a principal developer of the lean production philosophy. The aim of lean production is to preserve value with less work, having maximal flexibility while meeting the customer’s demands. Toyota is the manufacturing company that is seen as the promoter of what later became known as lean production. A key difference between Taylorism and what is called Toyota Production System (TPS) is that the worker is the most valuable resource, an analyst and a problem solver (Liker, 2004).

'Kaizen' is the continuous improvement work that in small steps takes place to achieve a lean production. It affects the process, people and partners as well as problem solving (Liker, 2004). In line with its aim, lean production uses the resources in production in an efficient way through continuous improvement and the reduction of waste. All the companies studied work in a lean production context. Therefore, a goal for their improvement process is based on using the resources in production in an efficient way by continually improving production while reducing waste.

There is a 8th type of waste, adding to the seven usually mentioned types of waste in lean production. This 8th waste consists of time, skills, improvements, ideas and learning opportunities lost by not engaging or listening to the employees within an organization (Liker, 2004). Engaging the personnel though visualizations is said to be one way to reduce the 8th waste. The companies studied in this thesis have developed their own variation of lean production. Another kind of improvement process in a lean production context is the radi-
The ambition to diminish the 8th type of waste in production and to reinforce the communication in an obeya can be supported in different ways. As mentioned earlier, visualization is considered to be one approach in a lean production context, and it is further developed in a subject called Visual management, presented below.

1.1.2 Visual management

In manufacturing industry, attempts are made to let visual tools support the improvement work. One reason for this is the dignity given to visual communication in lean thinking, in what is called visual management. In the book *The visual factory – building participation through shared information*, Greif (1991) shows that modern management methods do not work well with authoritarian leadership. Visualization stimulates cooperation between workers, specialists and technical staff. In the lean production context, visual communication is seen as “self-service information – it makes the same information commonly available and understandable at a glance to all who view it” (Greif, 1991, p. xviii). With increased use of visual tools, the autonomy of the workers also increases (Greif, 1991). The effectiveness of visual management reoccurs in different sources. For example, in Bicheno (2004), it is suggested that visual management should be implemented in standard work and 5S. 5S is a workplace organization methodology in lean production focusing on sorting, straightening, systematic cleaning, standardizing and sustaining. Standardiza-
tion in 5S aims to organize the workspace in a similar manner throughout the company, with markings where tools, furniture and equipment should be placed. Boards, instructions and displays should follow a standard (Bicheno, 2004).

The visual management is used in a lean production context as a way to share information and to have control over the production. The control is related to what can be instantly seen in the factory environment. For example, Bicheno (2004) states, that if schedules, the problem solving process, quality or maintenance are not updated and immediately apparent, the production does not meet the standards of lean production. Additionally, high functioning visual management is said to provide real-time information and feedback regarding the status of the plant. The aim of visual management is to allow all employees to understand how they affect the factory’s overall performance (Bicheno, 2004; Greif, 1991; and Scotchmer, 2008).

The goal of visual management is to have maximal control and to be informed without leaving the shop floor, both from a management and worker perspective. As a consequence of the determination to be informed and have control with the help of visual artifacts or sounds, the built space in manufacturing industry is interlaced with various tools for communication. For example, to make improvement visible to everyone, a solution in lean production is to write information on a board, publish the success in the internal bulletin, or have a celebration. Updated and easy-to-follow schedules should be up on the board in the factory. With the use of displays (both analogue and digital) in the factory, the sales data, costs and quality can be visible and could encourage involvement according to visual management ideas. The improvement meeting held around a board in the production is in line with visual management thinking in lean production. Despite the focus on the visual artifacts mentioned above, which are indeed placed in the built spaces, the spatial design itself is an invisible condition taken for granted for information flow in several sources, with the obeya as one exception (see, for example, Groover, 2001; Greif, 1991; Lindeke et al., 2009; Rosa et al., 2008; and Sullivan et al., 2002). This is an indication that spatial design used to facilitate communication is not an integrated part of the production strategies in many of the companies that apply lean production today.

1.2 Objectives and Research Questions

In order to analyze if and how built space is used for communication and affects improvement processes in a lean production context, the studies are made in the manufacturing industry.
The overall objective is to analyze how built space is used for communication in the manufacturing industry and, specifically, how built space affects improvement processes in a lean production context. With this as a foundation, a further objective is to suggest how to ameliorate the design of the built spaces used for improvement processes in manufacturing industry. The following research questions address the objectives:

RQ 1: How is built space used for communication in the manufacturing industry and what can the built space be said to communicate about the improvement processes?
RQ 2: How do built spaces affect improvement processes in a lean production context?
RQ 3: How could built spaces used for improvement processes in manufacturing industry be designed to facilitate communication?

Table 1. Objectives related to research questions and papers in the thesis.

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Research Questions</th>
<th>Papers and Reports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyze built space used for communication in manufacturing industry</td>
<td>1. How is built space used for communication in the manufacturing industry and what can the built space be said to communicate about the improvement processes?</td>
<td>PAPER A, PAPER B, PAPER C, Technical report</td>
</tr>
<tr>
<td>Specifically, how built spaces affect improvement processes in a lean production context</td>
<td>2. How do built spaces affect improvement processes in a lean production context?</td>
<td>PAPER B, PAPER C</td>
</tr>
<tr>
<td>Suggest how to ameliorate the design of built spaces used for improvement processes in manufacturing industry</td>
<td>3. How could built spaces used for improvement processes in manufacturing industry be designed to facilitate communication?</td>
<td>PAPER C, Thesis</td>
</tr>
</tbody>
</table>

1.3 Scope and Delimitations

How built space is used for communication and affects improvement processes in lean production in manufacturing industry has directed the choices for theory, descriptions and analyses, and the thesis work. Additionally, it has been the rationale for the sample of the six built spaces analyzed. The companies have been chosen in the manufacturing industry. All the companies have an organization that strives to implement a lean production. The built spaces studied
are potentially subjects for improvement work; they are involved in Kaizen or Kaikaku processes.

The area of application is visual communication in manufacturing industry. The built space is analyzed as a part of the visual communication. However, the choice is made to not include the notion of built environment in the thesis. It has a wider definition than built space since man-made landscape is also included in the term. Man-made landscape is not in focus in the thesis. (The use of the notion 'built space' is defined in section 2.1 below). The aim of analyzing built spaces used for communication in manufacturing industry and the constraints in time and resources limit the number of cases in the study and excludes an overview of industrial history, manufacturing, and production system that could have contributed to the interpretation of the results.

1.4 AREA OF RELEVANCE AND CONTRIBUTION

The areas where the research results are relevant are in the field of visual communication and lean production (see Figure 1).

![Diagram](image)

FIGURE 1. Areas of relevance and contribution.

These areas are the ones that are essential for the topic. Information theory, perception, semiotics, industrial architecture, and scientific management are useful in order to explore and analyze the area of the research, but the contribution of the thesis is not in those areas. Rather, the area of contribution is in specific Information Design and visual management in lean production. Addition-
ally, the research contributes to the doctoral program in Innovation and Design.

1.5 Previous Research

Research on built spaces in manufacturing industry from a visual communication perspective in Sweden is not fully developed. Some research results have been found in a dissertation by Brunnström (1990). In Brunnström’s study of the rational factory between 1900-1930, it is shown that functionalist architecture was inspired by Taylorist ideas. The work and the factory were organized according to new principles, which included organization, standardization, and the reduction of work movement. The industrial work and the factory building were transformed into a well-oiled engine and had a strong influence on the development of functionalist architecture (Brunnström, 1990).

Granath, researching the field of production and spatial design, argued in 1986 that image and work environment issues needed to be taken into consideration in manufacturing industry. He pointed out that a new vision of work, organization, new production technologies, and to create a corporate image was a need to change the conditions of industrial architecture (Granath, 1986). For decades, industrial buildings in Sweden have been designed for simplicity. The open, one floor, hangar-like industrial building has been dominant. Work environmental initiatives have not influenced how to design buildings as a whole. Granath contended that the causes are found in the traditional and limited rational approach to work. Work is not pleasurable and stimulating, it is instead seen as fulfillment of duty (ibid.). Granath was a part of the social-technical approach to manufacturing that included the design of spaces for work described and discussed in Sandberg, (1994) and Ellegård et al., (1992).

In production research, there has been an interest in the relationship between built spaces, productivity, communication, experience, and motivation in industrial production since the 1930s (Mayo, 1933). At that time, industry psychology incorporated methods to create working places that could affect the productivity in a positive direction (Sundin, 1981; Brunnström, 1990, p. 92). One example is the Hawthorne studies. They were conducted in the 1920s and 1930s at Western Electric in Chicago. The most famous Hawthorne study was a lighting experiment. It was found that productivity was increased when lighting conditions were made worse or better. The study was expanded, and the result confirmed the previous conclusions; the results came to be called the Hawthorne effect. The results showed that the employee, even if the physical

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2 Professor Emeritus of Architecture at Chalmers University of Technology in Gothenburg, Sweden.
environment deteriorates, appreciates that management was paying attention in their work situation. This interest will increase accountability and job satisfaction. It affects productivity positively (Mayo, 1933). The attention management has given has been discussed as the common determiner. For example, it has been argued that it was a threat that was the common determiner for increased productivity, and not the attention (Hansson, 2009). Moreover, disturbing noises and monotonic rhythmic sounds were found to disturb the attention and diminish the performance (Brunnström, 1990, p. 104).

Outside the manufacturing industry, but in visual communication and other research areas close to visual communication, it is possible to find some results relevant for this thesis. Previous research concerning earlier experiences, aesthetic factors, colors, excitement, complexity and calmness has shown that people gain information through built spaces, because people code buildings and elements in buildings with meaning (Devlin and Nasar, 1989; Janssens, 2001; Lozano, 1974; Nasar, 1994).

In management theory, some writings seem to treat built space as information material, discussing the values of companies and their representation in the built spaces. For example, built space (called physical structure) is mentioned as “at once a substantive form of practice as well as a nonverbal communicative act” (Zahn & Trexler Proffitt, 2006). Findings show that attractive, useful common spaces increase members’ exposure to one another, and the greater face-to-face communication contributes to an efficient information flow (ibid.). When relating these findings to the improvement work performed in an obeya, it is worth noting that the design and size of space has an effect on communication.

There are models and notions created to attempt to describe the relationship between communication, experience, built space and the humans’ reactions or actions. None of them has its ground in the manufacturing industry. For example, 'Perceived servicescape', 'Physical environments', 'Environmental images', 'Physical Surroundings' and 'Physical context' (Bitner, 1992; Lynch, 1960; Moores, 1993; Warren 2002).

Spatial design affects users. Mossberg (2003) presents a model that shows the relationship between the environment and the user in the service landscape. Mossberg’s model suggests that different stimuli in the environment cause different reactions. The reaction to this perceived experience-space is divided into internal reactions and behavior. Internal reactions can be emotional, cognitive, and physiological, and affect both customers and employees. The behavior can be individual. Examples include staying longer, avoiding going there, spending more money (the customer), returning (the customer), or engaging in social interactions between customers and employees. Mossberg’s
model aims to create a framework for how the stimuli in the experience space leads to certain reactions and actions.

An extensive model, based on findings concerning communication and the urban city, is Communication Action Context (CAC) (Cheong et al., 2004). CAC includes the following: the ‘physical makeup’ of the area (such as the configuration of streets), the presence of ’incipient communication places’ (that is, places that bring people together and encourage communication, such as parks, churches, or cultural artifacts), 'psychological features' (for example, the perceived safety of the streets), 'socio-cultural characteristics' (such as the degree of class, ethnic, and cultural similarity, individualism, or collectivism), 'economic features' (such as the time and resources available to engage in everyday conversation and community activities) and, finally, 'technological features' (such as access to communication technologies or transportation system features). Depending on the degree to which the CAC encourages or hinders communication, it is said to vary along a continuum, from open to closed (Kim & Ball-Rokeach, 2006). This research shows the amount of factors that can be taken into consideration when describing the relation between communication and a supportive environment.

There is a research interest in organizational theory and space. In a recent paper, Salier and Penn (2010) offer new perspectives on the spatiality of organizational theory. Salier and Penn suggest a start to a fruitful and critical ongoing discussion that includes scholars of diverse backgrounds, advocating various organizational, social, psychological and spatial theories and aiming to understand organizations and space. It is interesting to recognize their attempts to make a model to describe the relationship between the organization and what they call 'the spatial structure', and also to follow further discussion of what is included in the spatial structure in future publications.

A conclusion made from the research presented here is that the design of built spaces is important for how people perceive, communicate, act in, and reflect upon their environment. From the previous research on the relation between humans, built space and communication, found and presented here, it can be said that more research is done outside the manufacturing context than within the same. The ideas and models presented are a part of the research background. This thesis joins the effort to describe relations between users, built space and communication, here focusing on the manufacturing industry. Studying how built space is used for communication in improvement work contributes to understanding the relationship between organization and built space in manufacturing industry.
1.7 Thesis Structure

Below is a short summary of the contents of the chapters.

CHAPTER 1 (Introduction) outlines the background and the problems concerning the relationship between built space and improvement processes in a lean production context. The chapter includes research questions, scope, unit of analysis, area of relevance, previous research, and outline of the thesis.

CHAPTER 2 (Theoretical framework) presents a visual communication perspective on the description of the existing situation in industrial spaces. The chapter includes the theories applied to the results to discuss built space used for communication.

CHAPTER 3 (Method) describes the research design and the methods used to analyze and describe the cases studied. Discussions of validity, reliability, and the role of the researcher can be found in this chapter.

CHAPTER 4 (Case studies) presents the results of the case studies and expands the content of the appended papers.

CHAPTER 5 (Analysis and Discussion) analyses and discusses the results. Here, a discussion regarding the relationship between the results, the research questions and theory can be found. A suggestion for how to use the results to improve the design of the spaces to facilitate communication is also presented.

Finally, CHAPTER 6 (Conclusions and future research) summarizes the conclusions of the thesis and gives suggestions for future research.

APPENDIX: The thesis has three appended papers (appendix 1-3), all of which were produced in collaboration with co-authors. The papers are appended in full, with an elaboration of the content provided in Chapter 4. Jennie Andersson Schaeffer is the main author of the papers, and had the main responsibility for data collection and analysis. Appended is also the inquiry form used in case study 1 (appendix 4).
2 THEORETICAL FRAMEWORK

The theories used to study the relationship between the design of built space, users, communication, and improvement work in lean production are in the visual communication field. Visual communication focuses on the relationship between the individual and her environment. To the environment belong, among other elements, built spaces, interiors, images, and texts. The built space can be used for communication, and affects the users in the places studied.

Already the feelings and ideas concerning place and space are found to be particularly complex in the human being, a view put forward by Tuan (1979/2001). Describing the impact of built space and its effects on human beings in action is an intricate task that can be analyzed and studied from different perspectives. In this thesis the built spaces are studied from a visual communication perspective. In addition to the theories presented, some terms will be defined below, used to describe and analyze how the built space is used for communication in manufacturing industry.

2.1 COMMUNICATION SPACE

We live in a visual culture. The images, photos, texts, interfaces in our working places, and the built spaces surrounding us, have a visual quality. Since we interact with visual objects in the working sphere, visual communication takes place in the working sphere in industry. Diverse kinds of images and texts occur in the industrial workplace. In visual management in lean production, visual artifacts are used for communication. This is evident in for example how the material is arranged on a board or when creating special places for the improvement work. In a simplified form, lean production strives to reduce waste and engage the personnel, and the visualizations and occasionally the built space are used in that strive.

Industrial spaces treated in this thesis are in the category of built spaces. A 'built space' is here defined as a man-made three-dimensional structure with three planes: base plane, an overhead plane (defining a volume of space between the overhead plane and the base plane) and a wall plane. A surface on the
base plane (having a detectable change in color, tone, or texture) can alone be used to define a 'zone of space' in a larger context (Ching, 2007, p.100 ff.). One example of a zone of space is an improvement place at a shop floor, where the zone can be marked by scotch tape.

Space holds a more abstract quality than 'place', but space can transform into a place as we start to add value to it. What starts as an undifferentiated space, later becomes a place. This is happening as we get to know the space better and when we endow it with value (Tuan, 2001). In this sense, when space transforms to place, it can become a symbol. In the case studies, industrial spaces were studied, but they are found to be places for improvement work and symbols for change. The term built space is used in this thesis, and here the focus is to study the built space used for communication. A visualization, similar to the one presented for the special field of this thesis, was created by Lorenc et al (2007). Visual communication (called Communication Design in their model) meets built space (in their model called the Built environment)\(^3\). The overlapping area between visual communication and the built space is here called 'communication space' (see Figure 2).

![Figure 2: Visual communication meets built space and creates communication space (model modified from Lorenc et al., 2007.).](image)

In this thesis, the notion communication space is used for the intersectional area between built space and visual communication. The term is useful in describing the target of this study since it emphasizes parts of the built space used for communication and combines it with other visual representations. The built

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\(^3\) The alteration from built environment to built space in the model, after publishing Paper B, was done to better describe the field of the thesis applied in manufacturing industry. (For a definition of built environment, see Burden, 2005 and Chudley and Greeno, 2004.)
space, the furniture, fixtures, other objects, graphical material, signals, handwritten texts, and signs are a part of communication space. A model including the built spaces and the field of visual communication opens the possibility to enlarge the field of study to concern not only built spaces, but also, for example, the graphical artifacts within them. It also implicitly includes a user of a message (a sender, designer, or receiver, not necessarily in separate roles). Studying the role of built space used for communication in manufacturing industry from a visual communication perspective implies an inclusion of relationships between people, organization, and visual material.

In the field of communication space, people can use both objects and the spaces around them to communicate. The building and everything down to the micro level can be used to communicate messages. In the manufacturing industry, the attitude towards the redesign of a factory interior sometimes come across as an ambition to communicate a message, in a manner alike what is called 'company branding'. This is a phenomenon that has its function in the same area as communication space, and is relevant in relation to the redesign of the spaces made in case studies 1, 2, and 3. The built space is not always altered by maintenance reasons. Branding is a part of advertising or embodying a value of a company by graphic material mixed with built spaces, a promise of value (Hultin, 2009). Branding is connected to the second level of how built space is used for communication in the manufacturing industry. The values of a company usually infiltrate the public sphere on a physical and an aesthetic level, a view put forward by Warren (2002). Warren states that the buildings are renovated for the purpose of making them look more attractive and not for maintenance reasons. In the communication space in manufacturing industry, examples of this aesthetic consumption can be seen inside workspaces. With the notion communication space, it can be said that built space is introduced to an extended form of analysis. To describe architecture as a conduit for information in relation to behavior, actions and perception is, for example, proposed by Wallenstein (2010).

The use of visual communication is not always conscious in manufacturing industry. Rose (2007) argues that whatever form they take, the visual representations are not innocent. Different users give them different meanings, and they structure the way we behave in our everyday lives (ibid.). 'Vision' is what is physically possible for the human eye to see. 'Visuality' is what we allow ourselves to see, how we see it, and how we are able to see, what we choose not to see. Those are examples of the 'visualities' the spectator brings with her to the viewing (ibid.). The visualities are influential on how the built space is used for communication, how users react, express and experience built space in manufacturing industry. The actions, expressions, and experiences of the user con-
connected to the communication space were studied and contributed to one of the results of the thesis, the model discussed in the analysis in Chapter 5.

2.2 Visual Thinking and Perception

To understand and be an active part of the improvement processes in manufacturing industry, communication with human beings and understanding information artifacts are needed. Ware (2008) discusses the importance of the cultural context for information processing. This can be expressed as interpreting signs in our environment through the glasses of earlier experiences and context.

In open industrial settings, the emergence of things in the visual field is common. Research shows, that it is difficult to avoid looking at moving things, and even harder to avoid looking at things that emerge in the visual field (Hilstrom A. P. and Yantis, 1994, referred to in Ware, 2008).

The board and other signs are central tools in visual management, and are found in all the cases studied. The design of those tools is not always the most supportive for the user’s information processing. The user can be distracted and disturbed in several ways. The brain works with just-in-time visual inquiries, and we direct our efforts with the help of attention (Ware, 2008). The reason we react to differences in color, form, and motion is that they are connected to different channels in the primary cortex. In order to support efficient visual queries for things that are similar, we can use different channels. The “pop out” effect is achieved if we use no more than three different steps available on each channel (Ware, 2008, p. 35). The theory regarding information processing by Ware has been used to discuss how the information artifacts and the improvement places function, for example, in relation to forms, colors and how to distinguish an improvement place from its surroundings.

2.3 Fundamental Forms of Information

The communication space in manufacturing industry includes built spaces as part of the flow of information. Bates’ (2006) theory about information is applied to the results and is used to develop the model presented describing the communication space in Chapter 5. Bates “Fundamental Forms of Information” include both the built spaces and the graphical material, and the information acted out, expressed and experienced by workers, managers, and designers in the industrial workspaces. In this thesis, the categorization of information into the Fundamental Forms of Information is useful since it deals with the ele-
ments in the communication space both as information and in relation to communication.

According to Bates (2006), a source of information can be anything human beings interact with or observe. The forms of information taken into consideration here are the ones that Bates (ibid.) categorizes as 'Experienced information', 'Enacted information', 'Expressed information', 'Embedded information', and 'Recorded information'. The Fundamental Forms of Information were used to investigate, for example, the values (enacted information) that took form in the expressed information (how the goals for the redesign were presented, for instance) and affected how the built space and photos, texts, and signs (the embedded and recorded information) were formed. Logically, when applying Bates's (2006) information theory to the empirical material, the user’s perception and expression of the other forms of information in the experienced and expressed information is taken into consideration.

**Table 2. Five Fundamental Forms of Information (adapted from Bates, 2006)**

<table>
<thead>
<tr>
<th>Types of Exosomatic Information</th>
<th>Embedded information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information stored in durable form external to the body</td>
<td>is the effect of a living being’s action, created or altered by it. Embedded information may be planned or formed spontaneously. It can be a tool, an object, or a building.</td>
</tr>
<tr>
<td></td>
<td>Recorded information</td>
</tr>
<tr>
<td></td>
<td>is communicatory information, preserved in a medium. Examples are written language, symbols, drawings, photography, film and audio recordings.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Types of Neural-cultural Information</th>
<th>Enacted information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neural-cultural information is encoded in the brain and nervous system.</td>
<td>takes form when humans act out their behavior and values, individually or in interaction with other humans and the environment. For instance, if an industrial workshop is unclean, it can be seen as the effect of enacted information.</td>
</tr>
<tr>
<td></td>
<td>Experienced information</td>
</tr>
<tr>
<td></td>
<td>is the pattern of organization of the subjective experience of life. Experienced information includes the experience of remembering.</td>
</tr>
<tr>
<td></td>
<td>Expressed information</td>
</tr>
<tr>
<td></td>
<td>is the pattern of organization in human communication by our spoken and body language, which we can use in order to communicate a variety of messages with each other and our environment.</td>
</tr>
</tbody>
</table>
These information forms dynamically interact with each other. For instance, enacted information may be expressed as embedded information, or expressed information may turn into recorded information.

Bates (2006) discusses the question of meaning, and this divides the definition of information into categories that are on a higher level than the Fundamental Forms of Information. Information is a pattern of organization of the matter and energy (Information 1), but some of these patterns is given meaning by a living being (Information 2) (ibid.). Bates has been criticized by Hjørland (2007, 2009) for this view of information. Hjørland finds that information can never be context-independent. Hjørland argues that Bates, by introducing Information 1 and 2, “can be said to have it both ways” (Hjørland 2007, p.1450) (in other words, including both the objective understanding and the subjective, situational understanding of information in one theory). For the relationship between perception of information in and of a whole communication space in manufacturing industry, Bates definition of information is well-suited. At first, the information is initially received as Information 1 by a sound or colors, signs on walls, etc. This information is meaningless until it becomes Information 2, where the patterns are given meaning by the receiver’s interpretation.

Bates discusses the link between the Fundamental Forms of Information and semiosis. In the view of Bates (2006, 2008), the Fundamental Forms of Information are the raw material that goes into the process of semiosis. Bates (2006) deems the linkage to semiotics promising and interesting, but doesn’t develop it further in her article. This link is developed further in the thesis by the attempt to combine both semiotic analysis and the Fundamental Forms of Information in the interpretation of the results from the case studies in the manufacturing industry.

2.4 Semiotic perspective

Thus, in order to understand and interpret how and what the elements in a communication space is given meaning, semiotics is used. The semiotic perspective used here is related to the way semiotics regard communication. It has not been the purpose to use the full potential of semiotics. When it comes to the industrial built spaces, the whole building is involved in the process of semiosis. Meaningfulness is a property of an architectonic code at all levels of its organization, from small variations in color, texture, and lightning to the big forms. This includes not only the shapes of objects themselves in relation to others, but also their relative placement, a view put forward by Preziosi (1979). But do elements in the communication space speak for themselves? No, they do not. Interpretation is the keyword here. The elements in the communication space
cannot speak. However, we can force them to give us messages and interpret them with the help of semiotics. We can also use objects in communication by speaking with their help (see Kjørup, 2004). The phenomena built space is interpreted as a sign, and from a semiotic perspective, sign has two sides or levels. They are the denotative and connotative levels, where the latter is dependent on the receiver’s/user’s earlier experiences by the sign’s connotation to an underlying content (Kjørup, 2004). In the simplified Peircean semiotic vocabulary, used here, an 'index' is a sign trace and a symptom, which gets its meaning from its physical connection to what it denotes. 'Symbol' is a conventional sign that establishes its meaning from rules in the society in which it is established (Kjørup, 2004; Cobley and Jansz, 1997). Presiozi (1979) argues that in an architectonic system, the signs will not be in just one category; rather, they will be naturally blended with respect to its symbolism and indexicality.

2.5 Architecture and Communication

The communication spaces studied in case studies 1, 2, and 3 were designed by architects or design students in dialog with management and the blue-collar workers. All the three improvement places in case studies 4, 5, and 6 were designed by the engineers and the blue-collar workers themselves. In Analysing Architecture (1997), Unwin puts forward that before we ask the question of how the architecture is designed, we must study what architecture is and why we create buildings and places. Unwin (1997) stresses that, normally, the definition of architecture is to design buildings. The core of Unwin’s theory is that architecture identifies a place. When we regard architecture as the identification of a place, it implies that we no longer regard architecture as an individual agency. That implies several creators of our working places, for example. When it comes to built spaces, there are places suggested by the designer and places created by the users (ibid.).

Unwin also asserts that we can choose to organize the world around us in an indefinite number of ways. People create places for their lives, for eating, sleeping, acting, learning, working, and so on. The way people organize their places is related to their convictions and hopes. Which use of architecture that dominates in different situations is normally a question of political and financial power, according to Unwin (ibid.). The organization and ideology behind industrial spaces (the enacted information according to Bates (2006)) have their impact on factory buildings and the improvement places. That is why, when studying communication spaces in industry, it is difficult to avoid the fact that the use and design of a factory layout depend on the formation perspective of
the person handling the planning of the layout or design. In addition, the location, the size of the company, and the field of activities affect the design.

From an engineering perspective, space is used for planning and visualizing a production system. The main concerns are where machines, equipment, and material should be localized, and how the flow of material is going to function. As one example of the technical perspective, Groover (2001) mentions that plant layout in material handling is an important factor as far as optimized material flow, arrangement of the equipment, locations for pickup, and deliverance of material and routes are concerned (ibid.). Here, space as a basis for human experience, orientation, communication, and action is not mentioned.

In an overview of space, organization, and management thinking from a socio-historical perspective, Chanlat (2006) finds space a key issue for organization. However, despite its importance, it has only recently become a central issue in management thinking (ibid.). Chanlat gives an overview of how main management schools (for example, Scientific management, Fordism, and Human relations) treat the spatial conception. He argues that “organisational space is best thought of as simultaneously divided, controlled, imposed and hierarchical, productive, personalised, symbolic, and social.” (Chanlat, 2006, p. 17f.)

The question of control and imposed space is relevant in the discussion of the function of built space and communication in a lean production context. The relationship between users, motivation, and the use of space for communication can be linked to the notions 'zero point of language' and 'zero point of space' (Barthes, 1953/1984). Lefebvre (1968/2002) developed the idea of zero point. Zero point can be defined as the neutralization and disappearance of symbols, contrast, and associations. It is a neutralized state that is characterized by the pseudo-presence of a witness and, therefore, a pseudo-absence. A zero point of space is space shown as display (Lefebvre, 2002).

Zero point is a transparency interrupting communication and relationships just at the moment when everything seems communicable because everything seems both rational and real; and then there is nothing to communicate!


Lefebvre discusses the existence of spaces with specific functions. For example, a holiday resort intended to be a place for happiness and freedom does not confer happiness and freedom (Lefebvre, 2002). In the manufacturing industry, a zero point of space can be where the communication space is shown as display, with a pseudo-presence of management and not integrated in the function of work. In this case, a consequence will be that the transparency in the communication space that seems both rational and real hinders the improvement work, because there is nothing to communicate.
When the chosen theoretical perspectives from information theory, semiotics, and architectural theory are combined, they shed light on how the elements in the communication space are used for communication. The elements are received as information, but then interpreted and experienced by a user. The communication space is socially constructed, dependent on the context where it is produced, and affects how the user act in the space and communicate the values in the context.
3 METHOD

In the thesis, methods taken from an anthropological tradition and used in case study research and visual communication are combined. The methods have an interpretive approach, and the interpretation has led to an initial design support. In this chapter, the choice of the different methods used is discussed. The aim of the chapter is additionally to describe how the methods were used. Discussions of validity, reliability, and the role of the researcher can also be found in this chapter.

3.1 METHODOLOGICAL FRAMEWORK

Innovation and design consider design a research subject. In this thesis, the design of the communication spaces in manufacturing industries is in focus. In order to choose suitable methods to answer the research questions, there was a need for a methodological framework. The framework included methods that A) covered the research design, B) structured the empirical data collection, and C) supported the analysis of the communication space used for communication in manufacturing industry. Design Research Methodology (DRM) emphasizes that design research is a subject of its own, and was chosen for the research design (see below under Paragraph 3.1.1). Case study methodology was chosen to organize the empirical data collection (see below under Paragraph 3.1.3). The methods to support the analysis of the communication space used for communication in manufacturing industry were architectural analysis (Unwin, 1997) and semiotic analysis. To analyze the results, the approach was to use pattern matching to previous theory (see below under Paragraph 3.1.7).

3.1.1 The research design

Central for design research is the multi-disciplinary approach. As a consequence, several methods are used in the actual research. As a way of identifying relevant research questions, the first steps of DRM were applied (see Figure 3). DRM is a helpful framework made to support design research (Blessing & Chakrabarti, 2009). The research clarification process for the thesis is especially based on DRM. The goal for the Research Clarification (RC) stage is
based on the findings in literature and experience. The research design of this licentiate thesis follows DRM to the Initial Prescriptive Study (PS) stage. The initial PS should propose how the findings can be used to improve design (Blessing & Chakrabarti, 2009). The thesis addresses factors in the existing situation that would lead to the realization of the desired situation. The thesis includes a suggestion for how to use the results of the study to improve the design of built spaces. The limit of the thesis is marked with the colored background in the DRM model (see Figure 3). DRM is not a sequential process: iterations will take place, and stages can run in parallel.

![Diagram](image)

**FIGURE 3. DRM framework, with the limits of the thesis marked by the colored background (modified from Blessing & Chakrabarti, 2009).**

To clarify the overall topic of interest in the initial stages in this study, studies of previous research and lean production literature were combined with studies of contextual case studies. The contextual case studies were done in the RC-stage of the process. The findings from the studies gave support to defining the scope for the thesis, but were not included in the thesis (see Figure 4).

In context case Scania, an improvement place at Scania, in Södertälje, Sweden, was observed over a period of one day on two occasions in October 14, 2008 and February 2, 2009. Two managers were interviewed. The interviews were semi-structured and focused on the following issues: how the place were used, what it was called, which information was presented, what was the purpose of the place; if it was a part of their production system and, who was involved in the design of the current place. What was learned from this context case was that the organization structure at the company has an impact on the use and the design of an improvement place.

In context case Radio Aporee in Berlin, a mix between a private living room and a radio station, scene, and a gallery were studied for approximately four
hours on February 19, 2009. The manager was interviewed and asked the same questions as those posed at Scania. Radio Aporee is included in a network that connects sound and space by cartography, and it is open to the public as a collaborative project. The live emissions can be attended at physical places and through a map on Internet. It can be said to be a part of a self-organizing, communication network collecting sounds from environments, showing the different perceptions related to sound, space, and places. The choice of something as completely opposite to the industrial way of organizing as Radio Aporee helped underline the importance of the following issues: the relationship between organization and the physical space, the complexity of informal and formal information, participant motivation and the relationship between virtual and physical space.

In the Danish manufacturing company Unimerco, a two-day study was performed in October 2009. There, additional interviews of managers and employees clarified how the built space was as an important communication tool for the company. The material from this context case is as yet unpublished.

In order to enlarge the understanding of the current use of terms like space for improvement, spatial design in industry, obeya, and improvement places, several searches were made at the journal databases ScienceDirect and Scopus. A broad search was also made within the area of built space used for communication. Concerning Lean production and visual management several publications were studied.

3.1.2 Design of the multiple case study

In a multiple case study, each case study should serve a purpose in the overall topic (Yin, 1994). In this thesis the multiple case study serves the overall topic to explore the role of built space used for communication and in specific how the communication space affects improvement processes in lean production. Additionally, the built spaces selected for the case study differ in design, size, culture, phase in the product lifecycle and kind of improvement process applied. This in order to maximize what could be learned during the time available for the study (Stake, 1995).

In its lifecycle, a product passes through different phases. Each built space in the industry studied can be connected to research and development, production or sales and market (see Figure 4). The actual built spaces studied are marked out with red borders in Figure 4. There was a development workshop in the R&D phase involved in a profound interior and organizational change. The project studio can be placed in the R&D phase and the prototype workshop in the production phase. Both were created to facilitate radical change in the
product development and production. To study continuous improvement work in the production phase, the improvement places came in focus.

FIGURE 4. Built spaces within the product lifecycle, the studied built spaces marked with red.

The unit of analysis was built spaces connected to improvement work in manufacturing industry, intended to be used in either Kaizen or Kaikaku processes. In this study, the following places related to these notions were studied:

1) Places for radical change.
2) A place in radical change.
3) Places for continuous improvement.

Case study 1 concerned a radical workshop interior renewal that was the result of accumulated Kaizen processes. Case study 2 (the project studio) and case study 3 (the meeting area in a prototype workshop) were important in improvement processes since the places in themselves were places for developing a radical change in organization, a Kaikaku. The places had recently gone through a major interior change, like the interior of the workshop in case study 1, with designers involved.
Case studies 4, 5, and 6 were connected to the work on the workshop floor as places for continuous improvement. The companies themselves, with no designers involved, created the places for continuous improvement. That was found to be a common scenario in the manufacturing industry, according to the informants in case studies 1, 2, and 3. (For the design of the multiple case study, see Figure 5.)

In design research, concrete evidence of the effect on design practice may not exist. Nonetheless, the researcher, research group, or research sponsors may believe that a particular issue in a particular area is of interest (Blessing & Chakrabarti, 2009). In discussion with industrial representatives, a demand and an interest from industry in the area of Information design, has been noticed by the author. Lean production brings a focus to create places for improvement work, like an improvement place in the production or an obeya and to motivate the employees. A need to make changes in the interiors was expressed in case study 1, and changes were made. However, the impact of the
changes or the implications of design choices were not evaluated. Engineers, designers, or architects redesigned the spaces studied. From their understanding of the situation, the informants in the case study companies contended that the use of professionals in design was an exception in industry today.

3.1.3 Empirical data collection

Multiple sources of evidence were used in order to gain different perspectives on the unit of analysis. This supported the description and the analysis of complex settings like communication spaces and people’s experiences of using them. In a case study the researcher has the option to include theory, multiple sources such as documents, objects, and methods based on interviews, questionnaires and observations (Yin, 1994). An overview of sources of evidence in the data collection is presented in table 3.

Table 3. Overview of sources of evidence in empirical data collection.

<table>
<thead>
<tr>
<th></th>
<th>CASE STUDY 1</th>
<th>CASE STUDY 2</th>
<th>CASE STUDY 3</th>
<th>CASE STUDY 4</th>
<th>CASE STUDY 5</th>
<th>CASE STUDY 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERVIEWS</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>10</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>DIRECT OBSERVATION</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>ARCHITECTURAL ANALYSIS AND PHOTOS of the artifact</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>Photo</td>
</tr>
<tr>
<td>ARCHIVE MATERIAL</td>
<td>Internal Publication Sketch of the layout</td>
<td>Sketch of the layout</td>
<td>Sketch of the layout</td>
<td>Sketch of the layout</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>SURVEY</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>DEMO</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

The interviews took between 25 minutes and 2.5 hours. In the papers, the informants are called Informant 1, 2, and so on. The informants in the thesis keep their identification from the paper. In addition, they receive a number from the number of the case study to separate them from each other. For example, Informant 3 in case study 4 is called Informant 4:3 in the thesis.
3.1.5 Case study 1.

A radical interior change was initiated at a development workshop. The workshop was the subject of a BA-thesis work two information design students performed in 2007. They made a design proposal shown in a model developed in cooperation with the employees. The proposals in the model were then implemented. After the first year of changes, a semi-structured interview was conducted with the production manager, for two reasons: to identify the goals for the change in a lean production context and, from this information, be able to construct an inquiry. The 1.5 hour interview was recorded on January 16, 2008.

Sound and image from the interview were stored digitally on DVD and then transcribed. From the transcription, areas that reflected the company’s values that generated a radical change at the development workshop were sorted out. The method used was to write down every goal that was mentioned in the interview from the transcribed documents. The goals were then discussed and verified by the production manager. In the thesis, the production manager is called Informant 1:35.

In order to deepen the understanding of the current situation, a survey and additional interviews were made in the development workshop. The survey was designed on the basis of a pilot study. The pilot study tested the questionnaire and the issue with the help of a control group. After corrections, the inquiry form (appendix 4) was distributed to all 34 workers in the department on April 10, 2008. The answers to the survey are labeled with the number of the informant, from 1:1 to 1:34. The three interviews were carried out on June 13, 2008 as a follow-up to the questionnaire. The informants for this interview were randomly chosen from the list of the group that had completed the questionnaire. It was informants 1:1, 1:2, and 1:19. These interviews were semi-structured, took around 40 minutes, focused on questions from the questionnaire, and were audio recorded and transcribed. The result was published in a technical report, in Paper A, and as a part of Paper B. (For a detailed description of the results of the study and all the tables, see the technical report, Andersson, J., 2009.) Below, one example of questions from the survey shows how the results are presented in the technical report (Figure 5).

Question number 21 in the survey was about how the employees perceived the interior change in relation to the status of the development workshop, compared to other departments. The statement presented was: In my regard the interior change increases the status of the Development workshop compared to the other departments. 34 persons (all informants) answered this question. The informants marked their answers on a 10 cm long line, a VAS-scale (Ejlertsson, 2005). To analyze the results, the scale was measured in five two centimeter long parts and translated to a value between 1 and 5.
The text accompanying the result the technical report was: The numbers of answers were 34 of 34. Twenty-eight of the 34 people marked level 1 or 2 and agree completely or almost completely with the statement that the interior change increases the status of the development workshop compared to the other departments. Five of 34 people marked level 3, and 1 person level 4. A majority of the informants agree with the statement that the interior change increases the status of the development workshop compared to the other departments.

FIGURE 6. Sammanställning av svar, fråga 21. Jag anser att lokalernas förändring ökar utvecklingsverkstans status gentemot andra avdelningar. [English translation. In my regard the interior change increases the status of the development workshop compared to the other departments.]

3.1.5 Case study 2 and 3

Case study 2 (a meeting place in a prototype workshop) and 3 (a project studio) were two places for meetings in the manufacturing industry. The design of the places were done prior to the case study, so the case studies focused on evaluation and the experience of the built spaces.

The designers of the two areas were contacted and interviewed about the design and purpose of the areas from a designer’s perspective. Interviews with two managers at the companies and other users (an engineer and two operators) were audio recorded and transcribed. The questions, in all interviews, had an open-ended structure and were asked to encourage the user to talk about the meeting area, its functions, and the user’s experience of the built space. The questions followed the same manual as in the context cases (see section 3.1.1).
A literature review was made concentrating on cross-functional workspaces where people with mixed competencies meet and interact, especially designed for radical change and continuous improvement in lean production.

In case study 2, the interview with the engineer (Informant 2:1) was done on August 23, 2009, in the project studio. The studio was not used at that moment. The visit took two hours including the interview. The interview with the project manager (Informant 2:2) was done on the phone on August 25, 2009. An additional interview was made in March, 2009. In case study 2, the designer was an architect, at that time hired at the company, called Informant 2:3 here. The interview was held on the phone on September 16, 2009.

The meeting place in the prototype workshop was placed in a corner of the shop floor. In case study 3, the two informants working there had over ten years of experience in the company. A toolmaker (Informant 3:4) and the team leader/manager of the department (Informant 3:5) were interviewed on September 23, 2009. In case study 3, the design was done by two information design students as a job aside from their university studies in 2006. One of them, called Informant 3:6 here, was interviewed at the prototype workshop on September 24, 2009. The designers and the architect contributed with sketches and photos showing the initial design. It was especially important with the documentation in case study 2, where the project studio to some extent had been altered for new purposes at the time of the study.

### 3.1.6 Case studies 4, 5 and 6.

The built spaces studied in Case study companies 4, 5, and 6 were all continuous improvement areas. The empirical data was collected through interviews and observation.

The interviews were conducted in either Spanish or Swedish, and the responses were then translated into English. The interviews were carried out to gain insight into the use of and communication in the improvement places. The questions to management were alike in all companies, starting with the informants’ professional position and how much experience the manager had in the company. The interviews were semi-structured and focused on the following issues: how the place were used, what it was called, which information was presented, what was the purpose of the place; if it was a part of their production system and, who has made the planning and design of the improvement area. Those interviews were recorded and then transcribed (except for case study 6, where the interviews were made through e-mail).

Direct observation was made in meetings, during factory work, and in the improvement places on site in case study companies 4 and 5. The architectural analysis (presented below in section 3.1.7) was combined with observation.
points concerning recorded information (such as printouts and the board) and communication. The areas were:

- Number of people in the communication situation, how did they look for information and what did they do?
- A short description of the information artifact (for example a whiteboard, a robot interface).
- Level of difficulty accessing the information.
- Disturbances in the communication.
- Additional observations.

The most profound study was done in case study 4 on two days, March 4-5, 2009. The informants in case study 4 were six operators called Informants 4:1-4:5 and 4:7 and one production engineer, Informant 4:6. There were also two team leaders (Informants 4:8 and 4:9) and one production manager (Informant 4:10). The group of ten informants in case study 4 worked in a set of four robot cells. The operators, the technician, the team leaders, and the production leader have their workplace on the shop floor. There, the interviews were performed among the operators/technicians, and the interviews followed up the observations. The questions had an open-ended structure and were asked after the observation (when in the observation there was an action: communication with people, machine interfaces, or robot cell interfaces, and after the meetings in the improvement places). The questions encouraged the informants to tell what they were doing at the moment, what made them go there, was it for example some kind of a signal, or if they were scheduled, how they access the needed information and, what they did learn. Loose dialog regarding improvements was also indicated. More structured questions were also asked at the end: Do you write on the whiteboard? Why?; or, why not? At appropriate occasions, questions were posed about the experience of the difference between working with robots and with machines, especially connected to the information/communication aspect. The questionnaire for the inquiry and the form for observation were tested in a pilot version on the first day of the observation, evaluated, and then adjusted, in case study 4.

In case study 5, the respondent was the production manager (Informant 5:11), and no blue-collar workers were interviewed. The interview took place on January 20, 2009 at the factory. In case study 6, the informants were an inventory operator (Informant 6:12) and the logistics manager (Informant 6:13), and the interview was made through e-mail correspondence on March 19, 2009. Case study notes from observation and interviews were handwritten on site and then typed into digital documents. Digital photographs were used for documentation in all cases.
3.1.7 Analysis methods

To analyze the empirical data from and in the case studies and to answering the research questions, two analysis methods were chosen: architectural analysis and semiotic analysis. Additionally, the approach was to pattern-match case study 1 to previous research. The theory, is in the thesis used in the development of an analyze model, in a strive to find adequate vocabulary to treat built space and communication.

Having trouble finding suitable methods for analyzing visual materials is not an isolated phenomenon, which has been discussed by Eriksson (2004, 2009). In *Visual methodologies – An introduction to the interpretation of Visual materials*, Rose (2007) observed that there remain few guides to possible methods for interpreting visual materials, even though much academic work is currently being published on things visual. Rose recommends the anthropological approach to visual objects, because it “pays careful attention to the specifics of images; indeed, in its interest in their materiality it might be argued to pay more attention to the full range of possibilities possessed by visual objects than do several other methods” (Rose, 2007; 234). In the cited passage, Rose (2007) discusses images. Communication space is not an image, although it may include images. Are the methods suggested still applicable to communication space? According to Rose (2007), there is nothing that prevents the methods discussed for images being applied to other sorts of visual objects, such as buildings, built landscapes, and sculpture. This supported the choice to combine the anthropological approach used in case study methodology with architectural, semiotic analysis, and information theory, thus providing the possibility to pay attention to a range of possibilities possessed by the communication spaces.

To be able to analyze the effects of a built space in a lean production, the built space has first to be described and itself analyzed. Unwin’s architectural analyze (1997) was used in all the case study companies as a frame, to sort the impressions and to analyze the environment in a similar way when structuring what to describe. In Case study 1 an architectural analysis was done during four days at the development workshop. Unwin’s framework for analyzing the architecture was used as a method to analyze the interior and exterior architecture (Unwin, 1997). Spending time in the workshop among the informants and asking questions about certain areas enriched the analysis. The basic architectural elements considered in the development workshop were walls, platforms, markers, boundaries, roofs, aisles, openings, and cells. The graphical material, objects in the spaces, and colors were also a part of the analysis. In addition, the changing elements (such as lights, temperature, and sound) were brought into the analysis.
Multiple issues of the internal magazine Volvo BM were studied to describe the background to the development workshop. Telephone interviews, searching for more background information such as illustrations, sketches, and plans, were conducted. The two people interviewed were Eriksson, K., CEO, working at Akos-architects in Gothenburg, Sweden, and Eriksson, Y. working at Faktorimuseet in Eskilstuna, Sweden. Eriksson, K. was interviewed on March 29, 2008, and Eriksson, Y. was interviewed on February 26, 2008. Research concentrated on industrial buildings can involve great difficulty in finding material. For example, archives can be in bad order or lost. It is another situation when searching archives for buildings more taken care of, like churches or town halls (Brunnström, 1990:15). This was also the experience when searching for archives in case study 1. At first, in the company organization, it was not known who the architect of the building was. Later, by searching internal magazines, the architect was found to be Ove Svärd, at the time working at AKOS-architects in Gothenburg. Ove Svärd is no longer alive, and documents such as the assignment and the sketches from the time of construction of the development workshop were thrown away in a move of the architect’s office (Eriksson, K, 2008).

In case studies 2 and 3 the architectural analysis was made at the two places, describing where openings, enclosures, the objects, and equipment were placed and their function. The character of the material and whether any graphical material was used were also described.

The material studied in cases 4 and 5 was the interior and the exterior of the improvement places. A plan drawing was also studied in case 4. The basic elements of architecture taken in direct consideration for the analysis of the improvement places in case studies 4, 5 and 6, were the ground, the space with barriers, roofs, markers, supporting posts, paths, openings, walls, cells, and modifying elements. This analysis was made for purposes of describing the design of the places and understanding its function.

In case study company 6, the physical artifact (the improvement place) was analyzed using photographs. One weakness in the study is that we were not able to make an observation at case study 6, due to geographical distance. Despite this, the case remained in the study, since it was from a company that had an alternative way of creation the improvement place. The distance was also an asset since it enlarged the sample, to a non-European country. The observation part in case study 6 was supported by one of the observers’ prior knowledge of the improvement place: he was a company employee during the time the improvement place was created.

The semiotic analysis provides a possibility to interpret the meaning given to the visual objects. Semiotics give tools and vocabulary to describe what we
visually perceive and lays bare “the prejudice beneath the smooth surface of the beautiful” (Rose, 2007; 74). It was used to interpret what the studied improvement areas, obeyas, and the workshop can be said to communicate about the improvement processes, the company, and the users.

Pattern-matching to previous theory was used to support a general approach of analyzing or criticizing the empirical material. If patterns coincide in the findings and previous theory, pattern-matching can help to construct internal validity (Yin, 2009). The results of the Hawthorne studies were compared to the results of case study 1, concentrating on the effect of interior change and the patterns’ coinciding. This part of the analysis can be questioned. The Hawthorne study has in itself been criticized, and the studies were conducted over 70 years ago in another production context. Since the result of one of the Hawthorne studies implies a partly encouraging and partly critical approach to the results of case study 1, it nonetheless gives an interesting discussion about RQ 2: How do built spaces affect improvement processes in a lean production context?

3.2 Reliability and Validity

The analysis methods above are a quality assurance for the multiple case study, using a variety of sources and methods to able the results to be seen from several perspectives. In architectural analysis, semiotic analysis and categorization according to Bates’ Fundamental Forms of Information there is a descriptive effort. In order to describe the existing situation it necessary to find concepts and definitions of what we see and experience. The results of the analysis can be criticized for the fact that there are parts missing. In addition, the description can be described as poor, since a communication space is a complex phenomenon. When we describe the studied objects, we can provide the analytical tools to support a rich description of the items. However, we do not give a full description of them. Kjørup (2009) discusses the full description and stresses that the purpose should guide the description.

The purpose that guides the description of the communication spaces studied in the thesis is to explore the role of built space used for communication in manufacturing industry and in specific how built spaces affect improvement processes in a lean production context. The aim here is to give a rich, adequate, non-misleading, and systematic description of the different communication spaces. This goal is supported by a variety of methods, including interviews with the users, both managers, blue collar workers, and designers. Archive material was studied; observation in situ and the survey was made to support the rich description. Kjørup (2009) argues that the descriptions are not primarily
formulated as true or false but rather, for example, whether one is more or less indicative or misleading, adequate or inadequate, systematic or provisional.

The results of the six case studies were compared to previous research and theory, although some of that research was made in other fields. In order to construct the validity of sources used, informants had access to the draft report. The papers have, for purposes of validating the content, been presented both in the engineering and the design field at a production conference and a design conference. In addition, a paper has been published in a reviewed journal in manufacturing and a reviewed journal in design. In addition to the external review by experts from the academic world, the publications create an opportunity to repeat the studies to verify or disprove the results.

Digital photographs were used for documentation in all cases, and some of them were published in the papers. When using photos, an insight into the effect of recontextualization appears. Something happens when you mediate an interior that somehow partially escaped aestheticization, like, for example, the improvement places. Some of the studied places are created for and have a function as tools for the improvement processes. When they become recontextualized (for example, in academic papers), the context turns the image into a new reading. Interiors and exteriors presented in printed material as, for example, interior design magazines, or for that matter dissertations and books on various architectural phenomena are often highlighted as masterpieces or hors d’oeuvres (see, for example, Cruickshank, 2000; Karlsmo, 2005). The improvement places and development workshops are buildings and rooms constructed for practical use and usability in a lean production context. It seems that the rooms, when they are extracted from their context, non-styled and documented in photos in snapshot style (recontextualized), show their "significance and effect" (Rose, 1997, p. 223). A possible effect obtained by choosing to publish the photos seems to be that some of the cases studied in manufacturing industry have interiors that until recently have escaped what Warren (2002) highlights as the aestheticization of our work places.

The design process includes testing as an important part to confirm functionality and get feedback. It is common for ensuring the quality of design. In case study 1, the interior change was made in full scale and evaluated through a survey. Connected to the preliminary results of case studies 4, 5, and 6, a demo was designed to ensure the quality of the process and to receive relevant feedback from key people in industry. The goal was to test some preliminary ideas of an appropriate design to facilitate the communication in the improvement places. In the improvement place, ten industrial representatives gave a presentation. They gave feedback on the improvement area after the presentation. The result emphasized the strong connection between the enacted information and
the embodied information (the communication space). One example of that connection was a worry that the place was too childish. It seemed that the impression the place was giving to others was more worrying than a bad function. The result also pointed out that design support has to cover the complicated relationship between management, function, design of built space and graphic material, the user experience, and the ideology and culture in the company. The test indicated that a general kind of support has to be constructed.

The model, in this thesis created as a base for a general support, has to be further developed and tested. More studies have to be made within the same context and with a similar sample of informants from industry, but also in variety of places and with different people to develop the model.

3.2.1 The researcher’s role

The nature of the multiple case studies was mainly observational. To be precise, the study did not involve any intervention of the design process by the researcher, with one exception. In case study 1, the nature of the study was different, since the author supervised the design process of two information design students who were working with the interior change. The author did not have contact with the shop floor workers during this period, but it was not unknown that the author supervised the BA-thesis work. The next year after, when this thesis project started, other students continued the redesign supervised by Håkan Wannerberg, an architect and a teacher in Information Design.

In the observations of the environments, in interviews, and in designing questionnaires for the various studies, it is not possible to avoid some impact on the results from the person who carries out research. Kjørup (2009) argues that a description will always be specific, contain elements of an evaluative nature, and leave traces of the describing subject (for example, by choosing to point out something and leave out something else). In this thesis, the subject that has made most of the description has had, in this case, a role as a doctoral student/teacher in Information Design. The description and the result of the research in this thesis have been guided by the purposes of the thesis. The purpose provides a visual communication perspective to the lean production context. The author’s experience (mainly from visual communication and not from engineering) has influenced everything from the purpose and the subject studied to the analysis methods and results presented.

The pre-understanding, previous experience, and background are the only way into the context. This marks the author’s hermeneutic approach regarding the impact of the researcher on the studied object. Hermeneutics emphasize the researcher’s pre-understanding. It is very important for the understanding that is then generated in the research process. Without our prejudices and pre-
understanding, our horizon of understanding, we will never enter in the text, in
the context (Allwood & Eriksson, 1999). In the early stages of this research, a
great effort was made to enlarge the author’s horizon of knowledge and the un-
derstanding of the lean production context. To get a better understanding of the
context, the author has taken a postgraduate course called Competitive produc-
tion systems. The goal of taking this course was primarily to gain an under-
standing of the ideology behind lean production and the continuous improve-
ment processes that are the basis for the existence of the objects studied.

Another way to enlarge the knowledge base is to work in teams with differ-
ent competencies. In cases 4, 5, and 6, the research team consisted of a Mas-
ter’s student in engineering and visual management and an information de-
signer who gathered empirical material. Paper C was written together with
Tomas Backström, professor in innovation and the above mentioned Master’s
student in engineering. Paper B was co-written with Monica Bellgran, professor
in production.

Having another pre-understanding than the engineer’s also allows one to
contribute a visual communication perspective to the industrial environment.
This, in turn, helps to broaden the horizon of understanding in the lean produc-
tion context. Discussing how people perceive and experience a phenomenon is
inevitable in visual communication. The visual communication viewpoint im-
pacts on the discussion concerning areas for improvement processes and the
solutions to support communication. A role for humanities, as information de-
sign, is to intensify our attention and provide the basis for a more diverse and
profound experience of the phenomena. Interpretation can also give birth to a
discussion that places them in the current debate (Kjørup, 2009). To analyze
built space and its relation to communication provides a base for discussion
about the workspaces in manufacturing industry from a communication per-
spective.

In the studies of visual objects, reflexivity becomes part of the researcher’s
role. When using visual methods (as architectural analysis, photo documenta-
tion, observations of and in the communication spaces) reflexivity is a prereq-
usite for ethical research. Reflexivity means that the researcher has an aware-
ness of what he or she is doing, why, and with what probable consequences
when it comes to the power relations involving the researcher and the re-
searched (Rose, 2007). But this requires the standpoint that there is a stable
identity that can be reflected over. Rose (2007) problematizes this by highlight-
ing the skepticism in different post-structural schools of thought in which both
the researcher and the researched are influenced by discourses which are out-
side themselves. Therefore, a visual material gives you a possibility to give im-
ages that can reflect more about the researched context than a written text
(Rose, 1997). The photos presented in Chapter 4, are an attempt to add and supplementary representation of the researched context. With this said, the photos have definitely, like a written text, elements of evaluative nature, and leave traces of the describing subject. In this thesis, the communication spaces have been documented by the author or designers, and in case study 6 the users of the improvement place. Naturally, a selection is made in the angle and the image slice of the photos. With the other people documenting the places, other angles and objects have been in focus.
4 RESULTS

The results of the studies done in the manufacturing industry, concerning if and how built space were used for communication and affects improvement processes in a lean production context, are presented below. In case study 1, the workshop is described and the material from the case study is categorized with the help of five of Bates Fundamental Forms of Information. The meeting places of case studies 2 and 3 are described, and the perspectives from the management and the operators focus on the effects of the spatial design and communication. The results of case studies 4, 5, and 6 is a description of the improvement places, focusing on how the places were used at the time for the study and their relation to improvement work.

4.1 CASE STUDY 1

Case study 1 was done at a development workshop. The radical change of its interior was the result of several Kaizen processes. The improvement work had its base in lean production and included both the organization and the interior of the development workshop. The study describes and analyzes how the built spaces and the recorded information were related to the enacted, expressed, and experienced information.

In 2007, the management wanted to make an interior change at the development workshop. There were five main target areas for the overall change in the development workshop. In short, the aim was:

- Improve the working environment.
- Change the outdated interior from 1980, and make a connection to the company’s words of value (quality, environmental care and safety) with the support of spatial design. In addition, a feeling of modern, future, bright, attractive, strength and a workshop in world class should be communicated.
- Increase the status of the workshop, including making the workshop more appealing to the customer and the employees.
- Facilitate the orientation in the workshop.
- Let a change in the interior be a signal for a process of change at the workshop as a whole. The change would include: the organization of the workshop, the experience of the work as positive, reduced absence due to sickness, increased motiva-
tion, increased influence, more improvement proposals from the shop floor workers, and a sense of professionalism.

Thus, the department was under a process of change. The manager of the department used a change of the spatial elements as part of the process, believing that the change in the workshop had a link to the operation development. An extract from the interview between the manager (M) and the author (A) illustrates this:

M: [...] We have tried to stoke the engine of operations development efforts. One idea is that implemented ideas create more ideas. When you see the change, like this project has meant, I also believe that everyone links it to their own workplace and their own effort.

A: Could it be any kind of project that goes through and has this effect?

M: But the spatial change makes it visible. You must never forget that.

(Informant 1:35, 2008, translation into English by the author)

It was important for the manager to make the organizational change visible in the built space. Additionally, he wanted to communicate this change and an idea generating culture with the help of the built spaces. The manager also explained that this was not a common approach in the industry; rather, he had reflected over that fact and he wanted to take the work with 5S (i.e the method of sorting, straightening, systematic cleaning, standardizing and sustaining) to another level.

4.1.1 The case study company and the exterior

The workshop studied was a part of a plant owned by Volvo, a big industrial company developing and producing vehicles worldwide. The architect was Ove Svärd, from AKOS architects in Göteborg, and the building housing the workshop was built in several stages (Eriksson, K, 2008). Previously, the plant was spread out in different locations (in the central nearby city, for instance). Outside the city, there was an opportunity to let the factory take the 70,000 m² that it finally needed (Volvo BM-nytt (In Swedish), Volvo BM's internal magazine, 1982). In the beginning of the 1980s, the company started to build the first step of the plant, including workshops, offices, and testing locations for complete prototypes. The workshop came into use in the summer of 1981 (Volvo BM-nytt, 1988).

In case study 1, the first phase of an interior renewal of the development workshop (including new orientation signs, a new color scheme, new equipment, and a clarification of the company’s value words by visual tools) was studied during and after the first phase of changes. The work performed in the workshop was the assembly of new product models.
Exteriorly, the building housing the development workshop had a flat-roof and a brown brick façade. The workshop was located on the ground floor. The dominant spaces were the assembly hall, an open space, two long corridors, some offices, some meeting places, and a lunchroom. The open space was divided by cupboards and walls. Here, different processes took place, such as welding, storage and electrical work. The meeting places and the electrical workshop were built as smaller rooms in the big hall. The building also housed offices on the second and third floors.

4.1.2 The interior – the entrance and the development workshop

FIGURE 7. The aisle leading to the development workshop.

Entering the building, a vestibule and a sentry box with a guard were passed. A narrow aisle (see Figure 7) led toward what might be called the building’s focus or heart, the development workshop. The corridor in had walls with brown brick on both sides and doors in yellow. The floor in the 23 meters long corridor consisted of partially broken floor tiles in white and cream white. The ceiling height in the corridor was 2.3 meters. The ceiling was lowered. It consisted of steel bars with embedded fluorescent lighting. Showers, change rooms, and toilets for the blue-collar workers were placed at the end of the corridor, on the right, near the exit and entrance.

This corridor served as a gateway between the entrance and development workshop. A pass was required to gain entrance to the corridor (see Figure 8). This entrance in the top of the corridor was used by blue- and white-collar workers, as well as visitors and customers. To enter the offices and the admini-
stration floor, the stairs started on the left hand side just after the first pair of doors, detached from the workshop. The facilities for blue-collar and white-collar workers were separated through this arrangement.

Coming from the corridor into the workshop, enhanced the contrast in ceiling height. The workshop had a ceiling height of 10 meters. The roof arched over the whole development workshop, and concrete pillars supported the roof trusses.

FIGURE 8. Plan sketch of the development workshop. The parts shadowed in gray do not belong to the development workshop. The white area to the far right is a big storage. The letter A marks the entrance to the building, letter B the entrance to the corridor, and letter C the entrance to the development workshop.

The development workshop plan was structured as a cross, with the entrance at the top (see C at plan sketch in Figure 8). The outlines of the main hall had a rectangular shape. Aisles and corridors were straight. There were also lines on the floor that marked the different zones of spaces and walkways. A 86-meter long corridor dominated the space from the entrance door. The various barriers, which divided the space, were both permanent and temporary. The walls of brown- or white-painted brick and corrugated sheet metal formed the large volumes of the spaces. Boxes, temporary metal walls, racks, and enclosures (work or meeting cubes) created rooms in the room. On the left, the corridor was defined by the five large doors and a wall of corrugated sheet metal. They had small embedded windows that provided natural light and the ability to see the outside. At the top of the wall, just below the ceiling, there were also a number of windows. The two small offices and cubes, which served as meeting rooms, were adapted for humans. Figure 8 shows an example of a symmetric placement of the two dominant corridors crossing at the development workshop’s premises. The entrance to the workshop was located where the two arms
of the cross met. After renovation, an illuminated sign was placed in front of where visitors came when entering the workshop. The sign indicated which department was located there (see Figure 9).

![Figure 9](image_url)

**FIGURE 9.** The name of the workshop in metal letters, guiding signs, and a presentation of the staff were positioned as the first things encountered when entering the workshop. The walls seen behind the signs are part of a two-story working space placed at the workshop floor.

Unwin (1997) argues that the experience of a place has much to do with its scale. At the development workshop rooms, doors, and passageways were high and wide, making one feel quite small in relation to them. The vehicles were also enormous compared to human size. The size of the rooms are related to the production needs. At the same time, there are spaces built and adapted to human size. Examples were the entrance corridor and the box-like enclosures containing conference rooms. The enclosures had two floors, and a conference room called “Entresolen” was placed on the second floor. The walls defined a smaller built space in the huge room, with spatial elements more suited to the size of humans, not machines. The workplaces were rationally planned, with defined places for each occupation. The objects were placed to take a minimum of floor space. Their placements were neatly and orderly marked by lines on the floor, and consequence of the use of 5S.

**4.1.3 Colors and signs**

The building exterior showed corrugated sheet metal and brown bricks. The same material choices were found inside. The closeness between the materials
of the exterior and interior environment created a crude “open-air” feeling inside as well. The color scheme was planned in the early 1980s. Since 1980s, no thorough or designer-initiated changes were undertaken in the interior until a thesis work done by design students was carried out in 2007 (Informant 1:35, 2008).

The business and the needs of the workshop had dictated the development of color scheme and signage system in workplaces, offices, and meeting rooms. Over the years, traces of alterations could be seen in the layer upon layer of changes in the color scheme and various editions of signage systems combined with handwritten notes. Unwin (1997) argues that color has to do with more than decoration or creating sites with specific moods. Color also plays a role in recognizing and identifying a location. Camouflage is an example of that, by its ambition to destroy or hide the color differences (Unwin, 1997). The workshop interior had mixed color schemes and different kinds of signs from different decades before the redesign of the interior. In 2008, before the redesign, parallels could be drawn to the reasoning behind the camouflage effect. The colors did not help to facilitate the identification of a specific location. The color “Volvo blue” dominated some of the major ports, and provided a link to the company color. The blue color can be seen in Figure 16. On the walls, brown and orange dominated. Trusses and beams had a bright turquoise color, and the overhead cranes were orange.

In the redesign, 2008, the brown brick walls were painted in a white color. Indicative texts were posted on the conference room surfaces and toilet doors. The workshop doors that used to be blue were transformed with the placement of large photos (see Figure 11). The pictures were close-ups (in some cases, ex-
treme close-ups) of Volvo's new wheel loader models. The photos were combined with texts, citing values used in the marketing of Volvo products; "Ease", "Experience," "Endurance" "Trust," and "Strength" in a typeface called Volvo Broad (Volvo AB, 1998). The photos were approximately 2.7 meters x 2.7 meters in size (see Figure 11) and had a warm yellow hue mixed with black and white. The working stations were painted gray. Some toilet doors that were yellow before were painted gray.

4.1.4 Enacted information - convictions and hopes

The enacted information takes form when people act out their behavior and values, individually and with others. The company's internal magazine described the workshop in 1982 as a physical place that was going to gather different sides of product development, leading to secure and strengthen the company's position. Words like advanced, modern, fierce international competition, strength, and future were mentioned in the articles (Volvo BM-nytt, 1982 and 1988). The workers and interior were mentioned in the 1988 article. That article focused on the fact that the development workshop was not only a center for the most modern technical equipment, but also, at the same time, a center for human beings (Volvo BM-nytt, 1982 and 1988). The interior colors on the walls were brown and orange. The newest computers and testing equipment were placed in the workstations. During the 1980s, the interior was considered attractive, according to the articles. The hope of creating a prominent technical center concentrated not only on the technical equipment but also on a "comfortable environment that put man in focus" (Volvo BM-nytt, 1988). This mirrors the social-technical approach to manufacturing (Sandberg, 1994; Ellegård et al. 1992). The color scheme in the workshop reflected ideas about color and style ideals in the society at that time. A pleasant environment in the early 1980s could have orange- and brown-colored walls, with accent colors such as turquoise and bright yellow. This was reflected in the parts of the workshop interior preserved from the early 1980s and in the articles written about the workshop (see also Fredlund; 2006; Jørnaes, 1977; Triberg & Kallhed, 2007 for examples of colors in fashion and for interiors in the late 1970s and early 1980s).

In the empirical material it was found that the goals for the 2007 renewal of the workshop were associated with values such as modern, strong, environmental, trustworthy, bright, and attractive. Those values were represented by, for example, grey and white colors. The workshop should be world-class, be in the forefront, and show the future. There is coherence between the values expressed in 2008 and those we meet in the in-house magazine “BM-nytt” from the 1980s, like modern, strength, competitive, and future. Strong and modern were still values the company wanted to communicate. The use of the language
has changed since the 1980s. In 1982, the situation was analyzed and described as one of fierce international competition. In 2008, a vocabulary is created that mirrors the wish to compete with harder international competition by using the words “workshop in world-class”. The values acted out in the development workshop (in the embedded and recorded information) is seen as the management’s opinion and their actions. The effect of enacted information has a close relationship to architecture seen as an identification of a place; a view put forward by Unwin (1997).

4.1.5 Embedded information

Embedded information is related to the workshop interior as a whole, as well as furniture and technical equipment. The building is also considered to be embedded information. The exterior consists of brown brick walls with additional parts in corrugated sheet metal. According to the articles in the 1980s internal magazine, the building and its interior gave the impression of a modern and competitive plant (Volvo BM-nytt, 1982 and 1988). This is an example of interaction between enacted and embedded information. During the years, the interior has degraded. The situation before the renewal is described as the maintenance of the interiors has not been a prioritized area. Since the 1980 limited maintenance efforts has been made. In this study, the change of the color scheme on the walls from orange and brown to grey and white, new furniture, new telephones, transport vehicles, jackets, and the reparation of electrical equipments were considered changed embedded information as a result of the changed enacted information. The change in the embedded information has an impact on the target group.

On one hand, the result of the inquiry showed that 20 of 34 informants agreed with the statement that the interior of the development workshop (after the renewal) reflected the concept of the future. On the other hand, the interviews showed opinions about the color on the walls and the orientation. Concerning color an interview gray show to be a boring color (Informant 1:2). The colors had a effect on the orientation. Before the renewal, it was possible to use small buildings in the workshop as landmarks when describing the way (for example, to say "Go to the orange cube.") "That is impossible when everything is gray." (interview, Informant 1:3, English translation by the author). The color choice had an effect on orientation in the workshop. The orientation was improved with the help of a new kind of signage system. The fact that the colors of objects and walls in the built spaces also supported orientation was not taken into consideration, in the new color scheme.
4.1.6 Recorded information

A significant change was made in the development workshop with help of photos and texts. Considered as recorded information are the three photos (size 2.7 meters x 2.7 meters) with close-up pictures of the vehicles on doors and a photo-wall in the lunchroom. Words in plastic material mounted on the photos express the values of the company (see Figure 11). A relationship is established by the proximity of the photo of the big vehicle and the text in order to communicate the value of strength. The vehicle shown on the photo is new and clean. It is being driven, showing its power in a dirty field. In addition, the size of the photo was unusually large compared to the other visualizations in the factory. The doors of 2007 and 2008 can be said to communicate different convictions and hopes.

FIGURE 11. The result of the enacted information in form of embedded/recorded information. An entrance door to the mounting workshop before the renewal (2007) to the left and after the renewal (2008) to the right.

This is an example of how the values of the company (enacted information) became visible in the recorded information. Texts with the same material and typeface as the word "strength" described different locations in the plant. This was a part of the new signage system. The texts were mounted on doors and walls close to the actual locations described. A new metal sign in the entrance showed the name of the workshop (“DEVELOPMENT WORKSHOP”) in upper case letters. The result of the inquiry showed, not surprisingly, that the signage system in the form of words on the buildings were important to facilitate orientation, both for visitors and workers. More surprising was that half of the target group agreed with the expression that the words increased the status and the reflection of the concept of future in the development workshop. The value words had the biggest impact in two areas, the reflection of the concepts of future and attractive workplace. Seventeen of 34 informants agreed with the expression that the value words made the development workshop an attractive
workplace. Twenty-one informants of 34 agreed with the sentence that the value words reflected the concept of future. The majority felt the change in the interior increased the status of the workshop compared to other departments in the company.

The photographs and a photograph wall in the lunch room played a more important role in relation to the increased status of the workshop than the other forms of recorded information. A large majority thought the photos increased the status of the development workshop and the good ambience in the workshop. In addition, the photos reflected the concept of future, according to 22 of the 34 informants. Finally, seventeen of the 34 informants in the target group agreed with the expression that the photos made the development workshop an attractive workplace. The recorded information played an important role in relation to experienced status, ambience, future and attractive workplace.

4.1.7 Expressed information

The expressed information relates to communication by spoken language. In the study, about half of the group of informants had heard comments from other departments and guests. Those comments were written down in the free text line in the survey. Some of the examples expressed about the change were: “Why do you get this and we don’t”, “Wow, here things are happening”, “What a difference”, “Nice doors”, “It was a nice result”, “It looks good”, “Does it have to be gray?”, “Finally the orange color is gone” and “You have a nice environment here. At our department, nothing is happening” (Informants 1:2, 1:6, 1:10, 1:12, 1:16 and 1:31, English translations by the author). In the interviews, the informants expressed that the comments made them more proud of working at the development workshop. The effect of the expressed information also led to effects on the embedded information at other departments. The blue-collar workers at other departments wanted changes in their workshops, and new renewal projects started (interviews, Informants 1:2, 1:3, and 1:19).

4.1.8 Experienced information

Experienced information in the study is associated to the effect of the enacted information in relation to the recorded and embodied, expressed and enacted forms of information. Twenty-seven of 33 informants 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. Sixteen informants of 33 considered that the change in the interior had increased their motivation to go to work and expressed the view that the change
of the interior had an impact on the fact that it made them feel important to the company. Twenty-nine of 34 informants considered that there was a strong connection between the impression of professionalism in their products and work and the design of the interior. Twenty-eight informants of 34 agreed with the expression that the change in the interior increased the status of their department in comparison with other departments. A majority considered the actual change in the interior as a good way to show a change in the organizational structure and agreed with the statement that the actual change in the interior led to more satisfied workers. Finally, seventeen of 33 agreed with the assertion that the actual change in the interior led to satisfaction with their work.

4.2 CASE STUDY 2

Case study 2, the project studio, was created in 2006 in an international manufacturing company. It was developed as a place where effective project work could be feasible. The project studio was originally created in order to support cross functional work. The aim was to improve the integration between R&D and production in order to develop better and more production-friendly products. However, when a huge factory project was initiated, it was decided that it could take over the project studio, since a big room was needed for the purpose. The new project was important for the company, and the time and resources spent were extensive. Different competencies should work together. In 2007-2008, the studio hosted this development project, with over 50 participants, of which 20-25 worked fulltime in the project, according to the informants. The room was especially designed as a cross-functional workspace, with features very similar to those of an Obeya (presented in chapter 1).

The importance of the interior has not been so much considered in industry, a view put forward the interviews in case study 2. It has to be something like a visionary project member focusing on the interior and involvement of an architect in order to put focus on the built space. A view expressed in the interviews is that the usual reasoning in the manufacturing industry is, that if you need space, you find an empty room, put a table there, and then you can start to work. The final step of designing the space in order to achieve support for the work was not so common, but it does not mean that it is not important, according to the informants.

The project studio could be described as an office area placed close to the production on the first floor. In order to go to the room, the employees had to pass through 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 Figure 12). The project studio consisted of tem-
porary office workplaces and a library, which was a silent workspace for reading and writing reports. The whole place also included six smaller conference rooms, a meeting place for a relaxing cup of coffee, and two toilets. Each room had Japanese names, which could be a reminder of correlation between lean production philosophy and its Japanese provenance.

FIGURE 12: Project studio sketch provided by the architect, Informant 2:3 (In Swedish).

The place was flexible, with whiteboards on wheels surrounding one side of the project central. The long table in the center consisted of smaller tables on
wheels, also easy to move. The legs of the table could be adjusted to create a table for standing meetings. The project studio (and this table in particular) were supposed to be a place to see layouts, parts from the production, and other documentation. The walls were covered by visualizations of different phases in the project and information about the project. The place for relaxation and coffee was equipped with a sofa, a coffee table, a suspended lamp, and a kitchenette. One of the conference rooms had a table, comfortable red chairs, and red and yellow curtains. The technical equipment consisted of computers with suitable software, telephones, projectors, projector screens, and a printer (interviews, Informants 2.1, 2.2, 2:3 and observation).

4.2.1 Effects of the spatial design

A project participant who worked in the project studio in 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 conditions were different, randomly chosen furniture, very hot when the sun shined in, and no air-conditioning. We were also more isolated. In the project place, on the other hand, the spatial design facilitated close cooperation and discussions.

(Informant, 2:1, 2009)

In case study 2, the embedded and the recorded information (in other words, the design of the built space, the equipment, and visualizations) affected the experienced information of one of the engineers working in the project studio. The user experienced a feeling of wow, novelty, and success. The embedded information can be said to communicate a “wow”-feeling.

The project studio’s had a crucial importance from a project management perspective. The project studio gave the project a “home,” which made it easier for project participants recruited from the line organizations to prioritize the project. From a project management perspective, in this way, the project was 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 organization. The advantage of the project place was that it was easy to communicate and share information there. All information was located at one place. It was smooth and time-effective to gather around a drawing or a document if something had to be discussed. To stand beside the visualizations on the wall looking, discussing, and showing the different parts of the project made it easy to illustrate the project. The project studio was also where guests
were briefly introduced to the project. In short, the project studio supported the following:

- Effective communication, cross-functional work, and decision-making processes.
- Reinforcing the project identity.
- Facilitating the project manager job.
- A time-saving way to present and discuss the project through the visualizations for guests and visitors.
- A possibility to live and breathe the project.
- Shortening the lead time for development projects.
- Inspiring the employees to a positive view of the company and the project.

(Summary of interviews, 2009)

The embedded information affected the experience of a project leader and the actions of the project members. The design of the embedded information facilitated the project management work, creating more face-to-face interactions and shortening the lead-time for the project.

The empirical material shows, what was usually acted out in the embedded information in manufacturing industry, was other values behind the actions than the importance of the spatial design. For example, that we take what we have, a table and a chair, start to work and don’t equip the working space with air-conditioning. This reasoning can be connected to what is allowed to be cared about in a culture of rationality. What is allowed to be considered as important to say, see, and design in an industrial lean production context is formed by the culture. Considering the design of the built spaces is not a dominating feature in the industrial culture, according to the informants. Nevertheless, from case studies 1 and 2, the design of the built spaces was experienced as a variable that affected the project management task and the participant experience of the project and the company in a positive direction.

4.3 Case Study 3

In case study 3, a meeting place in a prototype workshop was created in a manufacturing company (see Figure 13). The designers of the meeting place were two students from Information design – Spatial design. The design was made in close cooperation with the operators who were meant to use the place. It was inaugurated in the summer of 2006 and was still in use 2009. The informants explained the start of the project as a consequence of a strive to make prototypes as cheaply or cheaper at home as around the world. They experienced loss of time and the possibility for misunderstandings when communicating with someone for example in Spain in rough English. At the new meeting
place, it became easy to come down and show a plan or discuss and develop an idea and the prototypes could be made at the company. The informants put forward that they usually create a meeting place with a table and some chairs, that never had worked as good as the place they have now.

The challenge for the designers was to create a meeting place on the shop floor where operators could work with some administration that was, at the same time, attractive to bring visitors to. It should also be a place where operators and production engineers could meet to produce prototypes in house instead of placing orders elsewhere, in order to save time and money. Some keywords for the meeting place were modern, order, 5S (and in order to support this, a clear place for each item had to be created), and creative. (For a description of 5S, see section 1.2)

This was a meeting place where the production engineers could go to show their sketches, discuss them, and do testing if the ideas worked. When operators and engineers were brought together, the response was immediate, according to the informants. The meeting place in the prototype workshop was like a small obeya in the sense that different competencies gathered in a well-designated spot to facilitate communication and shorten the time required to develop a solution for a new feature or product.

FIGURE 13: Meeting place in prototype workshop (photograph by Sara Göransson)

The meeting place in the prototype workshop was placed in a corner with a view of the factory floor. One glass door led out to a small garden. Five windows let in light. A table in light-colored wood was placed diagonally in the room, and chairs were placed around the table. The surface of the table was big
enough for drawings and sketches. A small cupboard was placed there to store documents. A projector screen was placed on the wall. A lamp, which could be seen from a long distance, was placed above the table. The roof was lowered and the new wooden floor was slightly elevated from the surrounding floor in order to contrast the zone of space from the surroundings. The company’s graphic profile was used as a foundation for the color scheme. The colors were also chosen in order to distinguish the space from the surrounding area. Machines surrounding the area were painted in light color and there was a lot of light in the room, in combination with the new lighting. As a communicative environment, all these items and design choices could communicate to users and visitors that the place differed from a traditional factory floor environment (see Figure 14 below). The informants consider the meeting place a much nicer workplace. They express that it especially looks more professional.

![FIGURE 14: Meeting place in prototype workshop, view from the factory floor (photograph by Sara Göransson)](image)

4.3.1 Effects of the spatial design

The effects of the spatial design were shorter ways for the information flow, fast and accurate decisions and problems were localized fast. Knowledge was captured and retained within the company by creating the meeting place in the prototype workshop. The meeting place was experienced as brighter, nicer and as a more professional workspace. The project results were not measured exactly but the prototypes developed in the prototype workshop were developed
ahead of time from the outsourced projects, according to the informants. It was a competitive solution.

The way the spatial design of the meeting space affected the work organization was that operators and production technicians in the department came there to socialize, to work with the project, and to obtain technical information. It became a natural meeting place, and the employees wanted to spend time there. A very close connection to the design department was seen in developing prototypes. There was a speed in a project. The informants expressed that they had a face and a name to a person if they wanted to ask a quick question.

According to the informants the place were found to be much nicer than before and the roof and the floor created a room within the room. The opportunity to sit down, created more contact with the production engineers. The production engineers saw the technical equipment and the potential to use in-house resources when making parts. The products did not have to be transported to a conference room.

One of the design students, involved in the design of the meeting place, expressed that it was difficult to tell how much the room changed the work organization, but the new meeting place changed the attitude to work in a positive direction from what she had learned. In the design student’s view, a change in the interior was also a way to attract customers (Interview, Informant 3:6). This function moves an obeya from a position in the early stages of the product cycle to later stages near sales (see Figure 4), and is an example of the different functions a communication space can have. It is a functioning production workplace and an advertisement for the company at the same time.

In short, the meeting place in the prototype workshop did the following:

- Minimized misunderstandings - fast and accurate decisions.
- Facilitated developments of ideas and decisions - where problems were localized immediately.
- Reinforced the impression of professionalism.
- Shortened the paths of 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.
- Included company branding.

In case study 3, the communication space consisted of the embedded information (i.e., the new furniture and the elevated zone of space limited by the wood floor). The effects of the embedded information on the experienced and expressed information in the interviews were that it looked nicer and was more professional. Additionally, the embedded information changed the enacted in-
formation. Instead of searching for solutions over the telephone, the employees sat down in meetings. The speed in the process got higher, and the products did not have to be transported from one place to the other.

Consistent with the results of case study 2, the design of the embedded information is experienced as something important. What is usually acted out in the embedded information in manufacturing industry is not a holistic design approach. In the interviews it was expressed that if the informants had done the design themselves, probably a place like this had been created with table and some chairs. It can be concluded from the interviews in case study 1, 2 and 3, that, in the opinion of the informants, commonly the values of the company are not acted out in embedded information.

4.4 CASE STUDY 4

In a lean production context, the meeting often takes place around a board. This is one of the basic artifacts used to facilitate the daily improvement work. The daily meeting around improvement is an important key in the continuous improvement work as it is applied in this industry. The improvement places in case study companies 4, 5 and 6 were typically not designed by a designer but by different personnel in the company. A general way to design a part of the improvement place, is to use a consultant firm, specialized on designing boards for improvement work, to design the board. This was the case in Case study 4. Case study company 4, develops and produces mechanical products. It is part of a larger corporate group that distributes its products and services globally and has a partly automated production process with computer interfaces surrounding robot cells and machines (Informant 4:10).

4.4.1 Place for improvement

In case study 4, the improvement place was located on the side of a group of robot cells on the shop floor (see Figure 15). Approximately 20 people used it. The place had the same concrete floor as the rest of the factory. No wall or consistent border defined the place. No computer was integrated in the spatial design. It can be seen as an index for the improvement place, as a place for human face-to-face interaction. It can also indicate that the company chose well-tested methods for following up production, had practical problems, or incurred a high cost for finding a satisfying solution to the integration of computers. Whiteboards, lockers, tables, and some machines surrounded the place.
FIGURE 15. The board in the improvement place in case study company 4. The side for daily meeting is shown.

No barrier or enclosure can be an index for easy access, openness, and integration in the production, but also temporary, easy to move, and unimportant. The passage for forklifts was marked with white lines. The equipment formed a somewhat imaginary border to the surrounding activities. A standing table was placed on one side of a whiteboard. The location for the standing table was marked with mark-up-tape on the floor. Everything in this improvement place had its pre-determined place, marked with this tape. The improvement place could be entered from different directions. Two of the passages were wider than the others. The area was also used for passing through.

The whiteboard placed in the center acted as a marker and identified the place “where improvements were followed up.” The whiteboard could connote actual information, creativity, school experiences, or new ideas, depending on the user’s experience. The board could be seen from some distance from certain angles. The personnel did not call this area an improvement place; rather, it was called “The board” (Informants 4:1 and 4:8). The fact that the name of the improvement place was derived from the board indicates that the heart of the improvement place was the whiteboard. In 2007, two years before the study, the board was introduced in its current form and the structure has been kept ever since. A consultant firm conducted the work that resulted in the board. Nonetheless, this improvement place was waiting for a transformation and a major change on the board. Before the board was introduced, communication problems often occurred. When a problem was discovered, contact was made
with a technician to solve it. The next shift came, and information about the problem was sometimes lost (Informant 4:8). The production manager was responsible for creating the improvement place, and followed up the improvement work with the help of the board (Informant 4:10).

Both sides of the whiteboard were used. One side was turned toward the forklift passageway, and was used at the team meetings. In front of the board on the team meeting side, there was a supply of pallets with marked positions. This made it difficult to come close to the board. A team-meeting participant had to choose between standing close to the board and having no overview or standing at a distance, which could make it difficult to see the information and impossible to hear. In this distant, second position, the participants were also in the way of forklifts. On the other side of the board, daily meetings took place. The meetings on both sides of the board were held standing.

The board on the daily meeting side was marked with the intent of having information displayed under special headlines (see Figure 15). There was also letter-size paper attached to the board. The papers had small letters, clustered together. There were lines to fill in problems in the production. The problems were written with green whiteboard markers, and the text written with the pen was hardly visible from a 3 meter distance.

Everyone could go to the board and fill in the lines, according to one team leader (Informant 4:8). The lines on the board indicating problems were empty on March 4, 2009. Some of the operators mentioned that they had never written anything on the board (Informants 4:1, 4:2, and 4:7). Thus, the empty space indicated either that the board was not used or that no problem occurred in production.

The overview of the robot cells from the improvement area was poor. There was a constant noise from the machines in the area; there was no delimitation of the meeting space, and no protection from external disturbances. In the observed meetings, it was possible for the production leader to hear everyone speak, but it was difficult to hear the others in the group.

4.4.2 How was the place used at the time of the study?
Team meetings were 20 minutes long, and took place once a week. According to one team leader in March, 2009, no team meetings have been held since January, 2009. The reason for this was that two workgroups had been merged together, and there was no priority to have these meetings started (Informant 4:8).

The daily meetings were conducted twice, at 8 a.m. and 3 p.m. They were 10 minutes long and were focusing on the daily work. It was included in the daily management of a production line or cell. This meeting is used to drive neces-
sary improvements that have to be made in order to solve the upcoming issues or problems.

Also shift meetings were scheduled at 2 pm every day, and they took place in smaller workgroups close to the robot cells. The observation was made during morning and afternoon meetings. Operators, team leaders, production technicians, and the production leader (morning meeting) attended. The board was not visible for everyone. In addition, some of the personnel stood behind the board.

The observation provided the following points concerning communication in front of the board during the meeting:

- The production leader asked if there were any problems or accidents during the evening shift.
- The people in the meeting answered that no problem occurred.
- The production leader encouraged the operators and technicians to write on the board under the headline “problem”.

Communication at the improvement place after the meeting:

- After the meeting, problems were brought up in conversation with the production leader in an informal dialog.

There was a problem in a turning machine and a problem with a missing program to steer the robot in a cell that stopped production for more than four hours during the observation. These problems had not been written on the board. One conclusion from this relation is that communication over continuous improvements was taking place at different levels, but the problems were not visualized under the headline “problem” on the board.

4.4.3 Management perspective - the board should steer the course

The production leader called the morning meeting “daily steering”. In his view, the whiteboard (together with communication in meetings) should steer the course of the entire production. Activities including steering, problem solving, development, resource assignment, and Quality, Delivery and Cost (QDC) were considered. The morning meeting should always be connected to QDC. The management’s visions for the improvement place were that it should be clear and free, placed in the middle, and have a good overview of the cells. Additionally, it should be a safe place with no forklifts driving through it. Chairs have no place here, since you should be standing up to be “on your toes”, even for the longer meetings (Informant 4:10).
The board should have the right structure of what was actually going on in production. At the time for the study, the production leader did not put up the headlines on the board, which were needed to complete the structure. The suitable information was not provided, with one exclusion: the tact time list. Databases had to be searched in order to have adequate information on the board, and that consumed too much time to be an effective approach. The tact time list had figures with different colors (black and red). The production leader expressed "if there are red letters at the tact time list, the part of the board concerning problems should not be empty, as it is now" (Informant 4:10).

Instead of getting information from the board or databases, the production leader was present in the production at 6 a.m. every day. Through conversations with workers, he learned about the resource assignment, the scrap parts, the status of delivery, any stops in production, and accidents or incidents. He also did this in order to learn more about the processes because he was newly hired (Informant 4:10).

4.4.4 Operator’s perspective

Operator involvement in how the process of continuous improvement works was low. They were not involved in how the board should work. They stated that decisions were not in their hands. Operators do not write on the board. “It is not for me” (Informant 4:2). “I don’t write on the board” (Informant 4:1) Some awareness was expressed of what the informants called the Japanese way (Informant 4:1, 4:2, 4:4). Solving the problems occurring in production was seen as a definition of improvement. During our observations, the personnel used the improvement place to pass through, to pick up things in the lockers, to attend the scheduled meetings with the production leader at the standing table, and to pick up pallets. The board was not given attention, except at one of the meetings. It has to be said though, that this was a quite short observation at one improvement place of several in the company.

In case study 4, the communication space affected the enacted information. At the meeting observed, not all the participants could hear the talk or see the board. The board (the embedded information) was not used to write on (enacted information). Instead, the communication regarding improvements was carried out by the expressed information in informal dialogues. The embedded information, the board, the marked zone of space, and the other equipments were important tools to manage the daily production and drive improvement work from the management perspective. Since he did not have easy access to the suitable information (recorded information) at the time for the observation, the place could not fully work.
4.5 Case Study 5

Case study company 5, located in Sweden, is a medium sized Swedish manufacturing company supplying components for the automotive industry. Case study company 5’s vision was to continuously be the leader in innovative design, technology, and quality (Informant 5:11).

4.5.1 Place for improvement

![Kaizen corner, case study company 5.](image)

The improvement place studied, called Kaizen corner at the company, was located on the production floor, close to machining area. The Kaizen corner had a clear, pre-determined place, and a sign on the outside with the name “Kaizen corner”. A group of engineers at the company designed the Kaizen corner. The first placement of the Kaizen corner had been in an area with disturbing sounds. It had been hard to communicate there, and the disturbing sounds created some negative associations to the place. The Kaizen corner was then moved to the current area, were it was placed at the time for the case study in January, 2009.

The Kaizen corner as a whole, exteriorly, acted as a marker for the place of improvement, with its blue contrasting color and a different enclosed appearance in the factory. The floor was made of wooden material and differed from the floor outside. There was no roof at the Kaizen corner.

The room was enclosed with sound reduction walls and defined a clear enclosure, a cell, which worked as an index for improvement work. It also had a
symbolic function, that this was another room, separated but important for production. The cell could be entered through an opening in between the walls, like a hallway. Inside the cell, the visual representations for improvement were the whiteboard and the printed PowerPoint slides mounted on the walls. The slides presented the education, production system, information, and lean tools. There was a table for six people placed diagonally to provide the possibility to hold meetings (see Figure 16). The table’s diagonalization in effect pointed to a whiteboard with important information to follow up production. There was a computer in one corner and a writing board. Boxes for printers were stored in different areas in the Kaizen corner. There were no disturbing sounds, and the entrance corridor excluded the place from visual disturbance from the outside.

4.5.2 How was the place used at the time for the study?

The Kaizen corner was originally planned for education, quick meetings, and daily meetings with managers and group leaders. The intention was to use the Kaizen corner more than it was used in January, 2009, the time for the observation. The reason, according to the production manager, was that, historically, in times of high production, there was limited time to use the Kaizen corner.

Morning meetings with management concerning results from previous days were one use of the Kaizen corner. The results were to be written on the board, and the issues were planning, maintenance, material, and following up problems with the machines. The discussion around the board should be focused on yesterday for a short period of time, and the rest of the time should be forward-looking and solution-oriented (Informant 5:11). At the end of January, 2009, it was noted on the board that the last morning meeting took place in December, 2008. It was a turbulent time for industry with financial crisis, which affected the business and dropped volumes. The Kaizen corner had to a certain extent turned into a storage room for boxed items. The work planned for in the Kaizen corner was meetings, like the team meetings in case study 4, and education. In March 2009, the orders were less frequent, and case study 5 took the opportunity to start a training program in the Kaizen corner. According to a phone interview with the manager in the end of March, 2009, there were daily meetings for training purposes in the Kaizen corner (Informant 5:11).

In case study 5, an active search for the optimal localization for the Kaizen corner was done. It was visible from a distance with the help of the walls and the sign, the embedded and recorded information, and was connected to an enacted value. On one hand, from the exterior of the Kaizen corner, the communication space could be said to communicate that their improvement work was important. On the other hand, at the time of the observation, the board was not updated: there was no sign of activity in the recorded information. An activity
in the embedded information, the boxes moving into the Kaizen corner, potentially enacted another value: that the Kaizen corner constituted for example, a good storage, mirroring a diversity in the understanding the use of the place.

4.6 Case Study 6

Case study company 6 designs, manufactures, and installs elevators for the Colombian and American market. Its headquarters are located in Colombia. The company employs a total of 500 people internationally. The study was made at the logistics department in March, 2009. Information shared in the company was mostly done through a computer system. With the use of handheld devices, the operators were able to access information about inventory from anywhere in the warehouse. At the beginning of 2007, the company experienced a negative performance in terms of quality, delivery, and cost. Consequently, the company’s management charged the department leaders with the task of finding and executing an efficient solution to improve performance within their places of responsibility, in line with the company’s needs.

4.6.1 Place for improvement

![Figure 17: Kaizen corner Case study 6, located at the attic of the warehouse. The table and the board were created from reused material.](image)

In case study 6, the official improvement place was in the attic of the warehouse (see Figure 17). No window was visible. The improvement place was located at a distance from production. A room with brick walls painted white enclosed the
space, located in one part of the attic. There was a round table, white plastic chairs, a board, a fan, and a mailbox. At the personnel’s own initiative, the place was identified as a place that could be used as their meeting place, or as they called it, their Kaizen corner. Obsolete material had originally occupied the place. The employees were allowed to organize, classify, and relocate the obsolete material in order to open up the necessary space.

A table and a whiteboard were needed in the Kaizen corner. One of the materials used by the company consisted of steel cables coiled around wooden drums. After the cable was used up, the remaining drum served as a table for the meetings. For the whiteboard, a leftover white acrylic sheet was hung on the wall in this room. An idea suggestion letterbox was also included in the room so that any employee could write ideas and then deposit them in the box for review. After having arranged their meeting place, the meeting protocols were agreed upon, aimed at improving the process performance. Despite the existence of computer screens and handheld devices on the factory floor, no computer or digital visualization tool was integrated and used in the improvement place.

4.6.2 The manager’s perspective – create a culture, involve people.

The logistics department manager, along with the inventory and distribution process leader, decided to implement a three-stage program aimed at creating a continuous improvement culture within the process. According to the process leaders, the program was based on the belief that employees were key players in the continuous improvement process. The program included the three stages of employee motivation building: continuous improvement and idea generation tools training and employee idea implementation.

Prior to starting the program, the logistics department manager and the inventory and distribution leader carried out an assessment of the current state of the process in terms of the motivation level of the employees and their knowledge and their use of continuous improvement tools. This assessment was performed through individual and group interviews and direct observation at the warehouse. According to the process leaders, this assessment revealed that the motivation level of the employees and their current knowledge of the required tools for continuous improvement were low. The factors influencing the current situation included, among others, a lack of continuity of previous improvement initiatives, a stressful working environment, and a lack of participation by the employees in decisions concerning their process.

The first stage of the program, employee motivation building, was carried out. A movie was shown to the employees, and a subsequent group discussion took place. In the movie, the main character suffered several setbacks in his life
but always kept a certain spirit and a clear objective in mind that helped him overcome his problems. The movie was analyzed by the employees and process leaders through the course of several sessions where open discussions took place. Everyone had the opportunity to express his or her opinions and thoughts. These discussions, according to the process leaders, helped to motivate the employees to become more interested in the improvement process of the department.

As the employees’ interest in the improvement process grew, the second stage was introduced. During this stage, the employees were trained in simple but effective idea generation tools, such as mind mapping, brainstorming and “the six thinking hats” (de Bono, 1999). Additionally, some continuous improvement tools and concepts (such as Kaizen and 5S) were introduced. These training sessions included theoretical material coupled with practical exercises and discussions.

According to the process leaders, as a result of the first two stages, the employees began envisioning what they considered to be the desired state of their process. During the previous stages, several ideas regarding the working environment and improvement processes were agreed upon and, thereafter, the final stage of the program was carried out (Informant 6:3).

The challenge for the employees was to implement their ideas while at the same time complying with very limited budget and time restrictions. The employees identified the need to have a specific place they could call their own, where they could meet and discuss their improvement ideas and plan the future implementation of those ideas. From the logistics manager’s perspective, the place should have elements that stimulated creativity, such as colors, books, and other accessories. Additionally, the place should be isolated from the previously mentioned disturbances in order to have the appropriate environmental conditions for meetings.

According to the interviewed personnel, the continuous improvement meetings have helped, among other ways, in the optimization of storage space and material handling operations (Informants 6:3 and 6:4).

4.6.3 How was the place used at the time of the study?

Despite the initial motivation and participation of the employees, the improvement place had scarcely been used after two years of operation. From both the management and the operator perspective, few meetings took place there because there were disturbances (such as excessive noise, heat, and dust) that hindered the use.

Although their original improvement place had been neglected, the meeting protocols were still in place. The continuous improvement meetings were car-
ried out in one of the offices of the department instead of in the intended place (due to the previously mentioned reasons). According to the interviewed personnel, these meetings took place weekly. During the meetings, the status of earlier improvement ideas was reviewed. In addition, new ideas brought forth by meeting members were discussed and then written down in a standardized template for follow-up. Additionally, employees from other places in the company were invited to the meeting each week in order to be shown how continuous improvement meetings were executed in the inventory and distribution department (Informants 6:3 and 6:4).

In case study 6, the values behind the enacted information are linked to the values of lean production (for example, motivating the employee and making her or him an analyst). This is achieved by different means at the studied company. The employees were encouraged to design their improvement place and the furniture (embedded information). The expressed and recorded information, the film and the dialog, also contributed to work in line with the values of the company. The experienced information in the Kaizen corner was that it was too hot and dusty. That had an effect on the enacted information, and the place was left unused.
The places studied are not experienced in a vacuum: they are experienced in relation to the surrounding industry (for example, disturbing heat, sounds or people passing through with a forklift). When designing a space with the purpose to facilitate communication (for example, designing an improvement place or a project room), different parameters have to be taken into consideration. The relationship between people, values, and what is communicated through speech, graphical material, and built spaces comes into question. The results of the case studies show a relationship between at least five parameters (i.e. experienced-, enacted-, expressed-, embedded-, and recorded information, from Bates, 2006) in the lean production context. This relation is illustrated in Figure 18.

**FIGURE 18:** Five parameters (i.e. experienced-, enacted-, expressed-, embedded-, and recorded information) are found to affect improvement processes in lean production.
Discussed and exemplified in the following chapter are: how the parameters could be organized, how the built space is used for communication in manufacturing industry, what the built spaces can be said to communicate, and, additionally, how the built spaces affect improvement processes. The notion of 'communication space' introduced in the thesis is fully developed below, presenting a model to describe the relation between different factors in the communication space in a lean production context (Figure 19).

One result from the case studies is that the communication space is not used to its full potential in the manufacturing industry and might sometimes even hinder the work it is supposed to support. Another result is that lingering traces from early 1900s architecture are still often visible in the design of the built spaces, and which may affect the use of the built spaces.

**5.1 The Built Space Used for Communication in Manufacturing Industry**

The built space is used for communication on two levels in the lean production context in manufacturing industry. In the case studies it is observed that the built space is used as an environment for verbal communication and interaction between human beings in the improvement places, the obeyas, and the development workshop (level one). The design can affect this interaction. For example, the redesigned meeting place in the prototype workshop gave a closer connection between the toolmakers and the production engineers than before (see Section 4.3.1). The built space can also be used for communication and affect the user experience (level two). To continue with the example above, the redesigned meeting place in the prototype workshop turned out to be a much nicer and more professional workspace than before, in the experience of the informants. In this function, the built space is involved when the user creates meaning.

The empirical findings show that the communication space consists of more than just walls, texts, and photos on the walls. Communication takes place between the different kinds of users and the ones who perform the design of the spaces. That relationship in the process of communication activates the expressed, experienced, and enacted forms of information, in other words, what users say, experience and do in relation to the embedded and recorded information. To describe how the built space is used for communication in manufacturing industry, the human experiences, the values, the verbal expressions, and the reactions have to be included in the description. Additionally, the users of the places carry with them experiences of earlier meetings and what happened.
earlier in the day, which will affect how they experience the built spaces used in and for communication at that specific moment.

Although different models and terms are created to explain the relationship between humans, architecture, and action, they do not describe the field of built space used for communication in manufacturing industry from a visual communication perspective (see, for example, Bitner, 1992/ Mossberg, 2003; Cheong et al, 2004; Salier & Penn, 2010). The model introduced in figure 19, is focusing on that field, based on research results and theory. The use of five Fundamental Forms of Information (presented by Bates (2006) and applied here in the lean production context) is an attempt to structure the complexity of feelings and ideas human beings experience regarding space and place discussed for example by Tuan (2001).

The model presenting the communication space in section 2.1 above, adapted from Lorenc et al. (2007), is here elaborated and includes the forms of information from Bates (2006), and placed in a context to describe how the built space was used for communication in manufacturing industry (see Figure 19).

**FIGURE 19:** Visual Communication meets built space, experienced information, expressed information, and enacted information, and constitutes a communication space in a lean production context. (Model modified from Lorenc et al., 2007, and including the five Fundamental Forms of Information (Bates, 2006).
In the studied manufacturing companies, the embedded information was the built space, the furniture and fixtures and other objects. The recorded information covered the graphical aspects of the visual communication. The enacted information was the managerial actions and the employees’ action-responses to them. The experienced information was the experienced affects of the communication space and the expressed information that was expressed about, in, and by the communication space.

Consequently, the built space consists of a pattern of matter, which in itself constitutes information that helped the user to sort the impressions. The artifacts in the built spaces were themselves also patterns of matter in the case studies. In the communication space in the manufacturing industry, divergent patterns meet and interact. These patterns are forms of information (recorded and embedded), and they are additionally affected by other patterns in the experienced, expressed, enacted information and constitutes a communication space for the user in a lean production context. These Fundamental Forms of Information in a communication space are received as information, but then interpreted and experienced by a user, in the process of semiosis. What is communicated in a communication space, is dependent on the context where it is produced.

Communicating with the help of the communication space and forcing it to give us messages castes light on the built space used for communication. The result can be related to a communication process. In a way, the communication space characterizes built space as a medium for communication. In the studies presented in Papers A, B, and C connected to enacted information, an information provider (for instance, the management of the industry or a designer), an information asset (a workshop interior or an improvement place) related to the recorded and embedded information, and the users (the shop floor workers, guests, and management) connected to expressed and experienced information were found.

The relationship in the communication process stresses the importance of the sender or the user and their effect on the embedded and the recorded information. In the lean context, the communication space should support engagement and take care of improvement ideas, skills, and learning opportunities among the employees with help of visual artifacts. Various tools such as boards, signs, photos, texts, colors and markings were in use in the studied places, and the boards were central in the improvement places. In all the companies studied, there was a clear relationship between expressed information and the values of the lean production context. The connection was, however, less evident to the recorded and embedded forms of information in cases 4, 5, and 6. This result confirms what was said in the interviews in case studies 1, 2
and 3 about the usual (un)importance of spatial design. For example, in case study 5, the Kaizen corner was intended to engage the personnel through training and morning meetings. On one hand, engaging personnel had an important value in the lean production context, as expressed in words at the company. On the other hand, the place that was to serve as support for this work was temporarily abandoned and turned into an unofficial storage at the time for the observation.

The built space used for communication in manufacturing industry had a special feature in the studied companies. A mix between the built space and the graphical material were occasionally used for communication. In case study 1, a product was remediated in a photograph in the building. The recorded information (photos of vehicles) added value to the building. Texts and pictures were used by the company to communicate a vision to affect both visitors and personnel, an internal company branding. In analyzing the industrial architecture from a communication point of view, the graphical material should be included. When doors and walls were interlaced with photographs of new models, texts, and colors and followed the graphical profile of the company, the second level of the communication space was active, and there was a striving to make the workspaces look attractive.

In case study 1, the words "development workshop" in metal letters and guiding signs followed the graphical profile, with the letters and the signs written in the company’s own typeface. The design of the recorded and embedded information is used to communicate the company’s graphical profile. It may seem as a small act, but here it can be comprehended as what Warren (2002) described as the loads of stimuli surrounding us working on an aesthetic level. In a way, the users of the workspaces are affected by the desire to consume, and a message is infiltrated in the embedded and recorded information in the workspaces.

A redesign of the interior in case studies 1, 2, and 3 was not made for maintenance reasons only. What could be found in the expressed information, articulated about the embodied information, was that the workspace was or should become new and fresh, look professional, attractive, mirroring the future and modernity. In case study 2 one of the informants expressed an impression of a creative modern company, when working in the project studio. The intention was that the workshop in case study 1 should communicate world-class. The information acted out in the other forms of information was affected by the values of the company. The choice of the word "strength" was not a coincidence in case study 1. This word was connected to the company’s values presented in the merchandise material. The company wanted to communicate strength on various levels. The words collated on the photographs at the doors are directing
the interpretation of the recorded information. The studies indicate that, on the management level in manufacturing industry, there is a consciousness about company branding. The manufacturing industry has a novel interest for the aestheticization of workspaces, but in industry, it has still to be connected to function.

5.1.1 The use of the built space for communication – interaction example

Figure 20 below is created to illustrate an example case, based on findings from case studies 4, 5, and 6. A meeting in an improvement place is taken as an example of how the different forms of information can relate to each other in an everyday situation in a place designed for communication regarding improvements in manufacturing industry. When the different forms of information are not aligned with each other, the improvement processes can be disturbed and become difficult. This was typically what happened in the cases studied, which is exemplified in Figure 20 and the text below, based on the empirical findings.

FIGURE 20: Communication space. A visualization example of the five Fundamental Forms of Information interacting in the manufacturing industrial context.

In Figure 20, a production leader, operators, and a company board are involved in the communication (the company board is not shown, but anyway present,
since the values of the company board influence the enacted information. The improvement processes are considered important, but the place for improvement (embedded information) is placed in an environment where it is difficult to concentrate on communication over improvement (see the enacted information and the experienced information in Figure 20). The graphical material on the board (recorded information) is a cluster of information considered important (enacted information) by the information provider, for example the manager. However, it is hard to read from the users’ distance (experienced information). In the texts (recorded information), nothing is visually structured in order to be emphasized as more important than anything else. The operators are told (expressed information) to write on the board, but they are do not write on the board; the lines stay empty (enacted information). There are markings on the floor (embedded information) with connection to the lean tool 5S, but the operators have weak connection between the markings on the floor and what 5S means (enacted information). Here, communication space as a whole may be less supportive for its purpose than it could have been.

5.2 The built space interpreted

What can the built space be said to communicate about the improvement processes? The improvement place is a communication space. Here, with the help of a semiotic analysis, the studied communication spaces can be interpreted and help us understand the values behind their design. Obviously, the built spaces in the studies cases cannot speak, but they are forced to give messages by, for example, the users, and the users speak with their help. This is an example of the process of semiosis (Kjørup, 2004).

5.2.1 Improvement processes are central – but are places important?
The existence of pre-determined physical places for improvements in case studies 4, 5, and 6, and their form a whiteboard as a focus, which gathers people around it, was an indication of an underlying intention. The intention was to gather the personnel, to be united around the processes of improvements in the production as a whole, to expose relevant data, and to create an awareness of the production system. In visual management, the immediate awareness is important. The board is a significant element as a visual tool in the improvement places. The three spaces were transformed into places, with the purpose to facilitate improvement work. The meaning of the place was established in the company from the management perspective. The improvement place held a symbolic function, representing the continuous improvement work in the cases. The symbolic function of the improvement places can be interpreted in various
ways. When the improvement places were not used as planned, they became symbols of something else: not of a living improvement work, but of stagnation or less importance.

The placement of the elements in the improvement places, near machines and robots at the production floor in case studies 4 and 5, indicates integration in the production. In case study 4, the mark-up tape showed the limits of the place. This is an example of a surface on the base plane that alone could be used to define a zone of space on the production floor. In case study 4, it was not an evident zone of space, since only the borders were marked. The markings were perceptible, but the floor at the improvement place still had the same color and material as the surrounding floor. This made the place less evident, and did not catch the attention of someone passing by. It could be interpreted as marking that this place was no more important than a table beside the area, for example, with its position also marked by the same mark-up tape.

The temporary turning of a Kaizen corner into a storage area in case study 5, the unclear limits and use of the place in case study 4, and the reused material and lack of supportive conditions in case study 6 can all be indications that the design of the improvement place was not yet an important part of the production system in practice. Despite the fact that the companies had different ways to implement the lean production philosophy and create an improvement place, the results show a common feature in all three of the cases: a low level of use of the improvement places.

A contributing reason for why the improvement places were not working to their full potential in the three studied cases can be found in the convictions that were acted out in the communication space, maybe on a sub-conscious level. The low level of use can be connected to disturbances such as heat, sound, or movement. These conditions did not support communication between the users. In case study 5, despite the intention of creating an improvement culture and process by designing a place visible from a distance, the dedicated Kaizen corner became a storage area rather than a place for meetings and learning. It was considered as a better use of space at the time, space for boxes instead of humans. The economic crisis 2008-2009 may have affected the use of the Kaizen corner in case study 5. It has to be said though, from the perspective of the informant; also in times of high production, there was limited time to use the Kaizen corner.

The ideological heritage of the early 20th century could be one contributing reason why the improvement places do not yet have their full function, or are given a functional form and space. The goal at the beginning of the previous century was to create functional spaces (i.e., enough space for the production, decent lighting, and the heating of the interiors. Very seldom were human
needs taken into account (Brunnström, 1990, p. 44). It seems that the rationality in producing the buildings and the aim of creating efficient factories spawned a factory scene and an ideology that went hand in hand at the beginning of the 1900s. It was still hard in the 1980s to break away from a dominant mode of work organization (see Ellegård et al., 1992). In the studied companies, there was an attempt to create places to meet and improve the production, and the worker was seen as an analyst, as in Liker (2004). To make the places supporting improvement work, a suggestion is to make the values of the company conscious and to analyze how the values dynamically interact with the other forms of information.

5.2.2 The workshop - a symbol for change and rationality?

Another example that can be used to discuss what the built spaces communicate about improvement processes is case study 1. The radical change of the interior of the development workshop in case study 1 serves as a symbol for a change in the organization. The enacted information acted out in the communication space gives the development workshop a new identity and endows it with values. It becomes a part of the internal company branding. The color of the walls in the workshop in case study 1 had different connotations. The choice of colors on the walls can be said to communicate something. For the manager, the color was used to communicate the future, or timelessness. However, for at least one of the informants, it was considered boring. Here is an example of the importance of the cultural context for information processing. The two uses interpreted the colors through the glasses of earlier experiences and the context. They read into the colors of the walls two diverse meanings. This is an example of what Rose points out as visual communication that is not innocent (2007).

The relationship between built space, lean production and rationality is interesting. A program for "the rational factory" in Sweden written 1915 and the exterior and interior of the development workshop built around 1982 is here compared in table 4 below. Many details in the architectonical form still bear witness to the tradition of the rational factory. A comparison shows that, even if the architect and the company in case study 1 wanted to create something different in the early 1980s, they were working in an almost one hundred year old tradition when creating the factory.

The factory building of 1915 was a rational shell for a rational production. The ideal was big open spaces and the rational handling of tools, machines, and material supply. Stairs and elevators should be located outside the production area. It was important at that period to find the accurate architectonical expression of the production that was planned to take place in the factory. (Brunnström, 1990).

<table>
<thead>
<tr>
<th>THE BUILDING</th>
<th>BERGENS PROGRAM 1915/1918</th>
<th>DEVELOPMENT WORKSHOP CREATED IN 1982</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fireproof, armed, monolithic construction</td>
<td>Fireproof, partly armed, extended house body</td>
</tr>
<tr>
<td></td>
<td>Flat roof</td>
<td>Yes, the same found</td>
</tr>
<tr>
<td></td>
<td>Maximal window opening, 70-80% of the façade surface</td>
<td>Small windows</td>
</tr>
<tr>
<td></td>
<td>Rectangular layout of the building, stair and toilets outside the building</td>
<td>Two rectangles as a cross, stairs and toilets outside the building</td>
</tr>
<tr>
<td></td>
<td>One floor most effective</td>
<td>Development workshop on one floor, the offices on several</td>
</tr>
<tr>
<td></td>
<td>The concrete is dressed with bricks, plaster or stone</td>
<td>Brown brick façade and corrugated sheet metal</td>
</tr>
<tr>
<td>LAYOUT</td>
<td>Big, open rectangular layout</td>
<td>Two rectangular shapes as a cross</td>
</tr>
<tr>
<td></td>
<td>Minimized and rationally planned areas</td>
<td>Yes, the same found</td>
</tr>
<tr>
<td></td>
<td>Department separated by function and fire protection</td>
<td>Yes, the same found</td>
</tr>
<tr>
<td></td>
<td>Short, efficient communication</td>
<td>Yes, the same found</td>
</tr>
<tr>
<td></td>
<td>Facilities for the staff located near the exit</td>
<td>Yes, the same found</td>
</tr>
<tr>
<td></td>
<td>Toilets grouped at each department</td>
<td>Yes, the same found</td>
</tr>
<tr>
<td>WORKING ENVIRONMENTS</td>
<td>First class ventilation and heating</td>
<td>Yes, the same found</td>
</tr>
<tr>
<td></td>
<td>Cleanness and order</td>
<td>Yes, the same found</td>
</tr>
<tr>
<td></td>
<td>Good and rational lighting</td>
<td>Yes, the same found</td>
</tr>
<tr>
<td></td>
<td>A separate lunchroom</td>
<td>Yes, the same found</td>
</tr>
<tr>
<td></td>
<td>Recreation on the roof</td>
<td>Recreation in atrium gardens</td>
</tr>
<tr>
<td></td>
<td>Separate staff facilities for blue- and white-collar workers</td>
<td>Yes, the same found</td>
</tr>
</tbody>
</table>
The layout of the workshop in case study 1 testifies that the function need for production was taken into account. Volumes, openings, and boundaries were tailored for big vehicles. The idea of rationality was established in the basic layout of the factory. Here, the architect’s tradition and beliefs came forward. The long corridors were an example of how the monocural and rationalist perspective was the architect’s tool. It should be easy for trucks to drive through the aisles, and the long perspective created an overview. A theoretical framework for the building could be that it was created with the intent to be, and to show, the industry’s most advanced product development center, with the latest technologies available at that time. In the building, this was communicated with the help of elements from a rational and efficient factory.

In the modern workshop of 2008, there was a discrepancy between the values of the company and what was acted out in the embedded information. The layout of the building was still the same as in 1982. What was changed were colors, signs, doors, and other details in the interior. The manager in case study 1 wanted to create a modern workshop, on “world class” level. One can ask if it is possible to do so in the rational shell of the factory. There can be a possibility that the change just stay on a superficial level. In the study is found a tendency that the building has an impact on the improvement work. This has some accordance to findings presented by Brunnström (1990), concerning the rational factory in the 1900-1930’s. There the building was found more important than the management action because of the permanent character of a building.

5.3 THE BUILT SPACES AFFECT IMPROVEMENT PROCESSES

In this section, the second research question - How do the built spaces affect improvement processes in lean production? - will be discussed, first in relation to the development workshop, then to the obeyas and, finally, to the improvement places.

5.3.1 The design of a development workshop affects improvement processes

An important part of the improvement processes in lean production is to motivate the employee. The photographs in case study 1 increased the status and made the development workshop an attractive workplace, according to a majority of the informants. In a broader perspective, the study indicated that the embedded and recorded information could have an impact on the user on issues like motivation and satisfaction with work and future. The consequence of the renovation in a certain part of the workshop was that the parts not renovated looked less maintained. An example of a comment one of the informants heard
from a college in another department was about the nice environment they had at the development workshop. What was expressed was that on the other department, nothing was happening. The comment illuminates the effect of changed embedded and recorded information on experienced and expressed information that a renewal can contribute to. When more than three-quarters of the employees at the development workshop considered the change in the interior a good signal to show organizational change, the comment can be interpreted in this context. Although there was organizational change in other departments as well, this change was not perceived in full. One difference was that the other departments did not have interior renewal that contributed to making changes in other parts of the organization visible.

Case study 1 showed that recorded and embedded forms of information affected the enacted and experienced information in the company. Examples of recorded and embedded information found in case study 1 include photographs, colors, texts, symbols, illustrations, drafts, and the different facilities.

In case study 1, the communication space was used as a signal for change in other parts of the organization. The manager pointed out that it was the spatial part of the change that made the change visible. The foundation for the renewal was established with the deep involvement of the personnel. The changes in the interior were discussed with the personnel, and the design was closely connected to the goals and values of the company. With another conviction and other values as the foundation for the enacted information, the effect of the enacted information surfacing in the other forms of information would have been different.

According to the results of the survey in case study 1, a spatial change was perceived as something positive by the staff. This result could be expected, compared with the results from the Hawthorne studies. In conformity with the pattern of the Hawthorne effect, there was a tendency for the same pattern in case study 1. The pattern showed that an interior change of the development workshop was a factor that created a positive expectation of change in other levels of the organization. In case study 1, parts of the change did not lead to better circumstances. For example, the color scheme deteriorated from an orientation perspective. However, a majority perceived the change as something positive. Productivity was not measured in case study 1, but the survey showed that the sense of joy in work, motivation, sense of professionalism, status, and satisfaction with their work were positively affected by the change.

Although the result from case study 1 is aligned with the results of the Hawthorne studies, the life length of the positive view and the eventual effect on the productivity can be discussed. If, for example, the recorded information is relevant and works well for its purpose, one assumption can be that there is
sustainability in the positive values connected to the change. Support for this reasoning was not found in the survey as it was done very close after the change. Additionally, even though the results of the Hawthorne studies deny the impact of spatial design in manufacturing industry more than as a tool to show the management’s attention, a question is if it is at all possible to do this kind of comparison today. In the lean production context, the work with continuous improvement and production comes with another approach to the worker, as an active analyst and a contributor to change; more parameters than attention affect the behavior.

5.3.2 The design of the obeya affects improvement processes

The empirical findings based on cases 2 and 3 showed that communication spaces (for example, obeyas) equipped with technical equipments and possibilities for visualization supported different types of performance. The obeya were closely integrated with the management of a project in such a way that could reinforce the project identity, facilitate the job for the project manager, give a possibility to live and breathe the project, and shorten the Plan, Do, Check, Action (PCDA) cycles and lead time for development projects. The obeya did also support the following: effective communication flow, cross-functional work, decision-making processes, development processes (by having adequate technical equipment), and idea generation concerning the cutting of costs.

Visualizing information in and by a communication space like an obeya was a time-saving way to present and discuss the project for guests and visitors. By keeping competencies close to production, knowledge was captured and retained within the company. It created shorter ways for the information flow, supported fast and accurate decisions, and problems were localized immediately. This result coheres with distance and communication findings that showed that attractive, useful common spaces may reduce users’ effective distance, thereby resulting in greater face-to-face communication (Zahn and Trexler Proffitt, 2006).

5.3.3 The design of the improvement place affects improvement processes

In Paper C, three improvement places were analyzed. In lean production, improvement places are zones of space indicated by lean methodology as places for continuous improvements. The enclosure of the places varied in the three cases, from markings on the floor in case 4 to a enclosure in case 6.

The improvement areas consisted of different spatial elements intended to support communication regarding improvement and create a place for learning
and meetings. A whiteboard reoccurred in them all, either fixed on a wall or free standing on wheels. They all had a table, either for standing or for sitting. Two of the improvement places were placed on the production floor. Here, the spatial design was an integration mechanism, since it may support (or hinder) communication regarding improvements in manufacturing systems.

At the time of the study, the improvement places were designed for communication in meetings and learning. One place was not used, due to heat, noise, and dust (case 6). The communication regarding improvement took place at different places, not just at the improvement places or in meetings. The activity concerning the improvement work was low in the improvement place studied in case 4. The operators did not write on the board, and information about the production considered important for the operators was found in other places than on the board. From this aspect, at the observed board in case 4, there was a weak connection in the organization of communication between managers, operators, robot interfaces, databases, and the board. In case 5, the design of the improvement place was made to support the improvement work. However, the board indicated that the last meeting took place two months prior to the observation.

In case 6, the creativity of the personnel was used on two levels, both creating a place and by participating in the improvement process. A deeper understanding of and a motivation for improvement work seemed to evolve from different ways of creating an improvement area and implementing the lean production philosophy. For example, in case study 6, the personnel were active in creating the improvement place. The employees themselves identified, as a result of a process, that they needed a place for improvements. In case 4, on the contrary, a consulting firm originally designed the board. The understanding of the information presented and why it was presented in those two cases was potentially different and could have affected how engaged the personnel were in the improvement work. In case 4, three informants said that they never had written on the board. They had observed the blue markings on the floor and described them as “the Japanese way,” but they did not know exactly why it was done. This marks a problem in the visual management expression self-service information. It is said that the same information should be commonly available and understandable at a glance to all who view it (Greif, 1991). Even though the information is presented on a whiteboard, not all who view information understand it at a glance. There are at least two parts of the communication space that affect the understanding. From a design perspective, supporting communication with the help of visual tools is connected to motivation and adequate answers on the visual queries. In aiming for rapid visual communication at a low cognitive cost in the improvement areas as a whole (and in the information
material), color, form, and motion have to be taken into consideration. What the user brings to the viewing also has to be taken into consideration. This is in line with the reasoning in for example Ware (2008) and Rose (2007).

To understand why participation and attachment to the activities in the improvement place were low at the improvement place in case 4, one can discuss the value of an improvement place that is “on display” but without full integration in the improvement work. This is an example of zero point of space developed by Lefebvre (1968/2002). In case 4 less controlled or imposed places is used for communication. The pseudo-presence of communication can in this interpretation be counter-productive, and the goal of the places with active participants was not achieved. To support communication in the improvement places, the surrounding functions in the organization have to be able to make informed decisions and be aware of the connection between the values of the company, the improvement place, and the purpose of the meeting. The symbolic function may hinder communication in meetings and learning (the use of built space on level one), but it could also support communication serving as a symbol (the use of built space on level two) for values in the company.

The empirical findings based on the case studies show the strong relationship between the organization and the use and benefits of visual communication and why it is important to focus on the relationship between the space and the user. This is possibly input for a discussion about space and perception. Built space should not be seen as an object apart from humans for whom it exists and is given meaning. We can present the sentence "I look at a picture." Here, 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 built space, which affects how we view space. By entering a built space, it surrounds us on every side. In the empirical material, interviews from informants in industry mirror the most common industry approach, saying that if there is a chair and a table, this is sufficient enough, not how the space for the meeting is designed. Being concerned with what the places communicate and the experience of the space seem to be of secondary importance.

5.4 RESULTS USED TO SUPPORT DESIGN

During the studies, the discrepancy between the high professionalism in the product launched and the environment that should house the processes was sometimes hard to understand from the author’s viewpoint in information design. What was surprising in the result was the relationship between the values of the management and the ways the management tried to communicate those
values in case studies 4, 5 and 5. One natural explanation can be that the core competence of an engineer is not in information design. There was a difference between management’s words and how they were acted out in the embedded information. Despite the good will expressed and acted out in activities, the three improvement places were only working to a certain extent or not working as intended. The built space represented a culture less focused on workers as analysts. The influence of the culture was strong, and the design of the spaces was not included in the everyday improvement work. The striving to create spaces dedicated for special projects and zones of space for improvement work was done to create an improvement culture in the existing factory buildings.

In the studied companies, the ability to incorporate the design of the built space seems to be a question of maturity. This finding is in concordance with Liker (2004) where most companies are said to be at a level of implementing 5S and other tools in the process of eliminating waste (Liker, 2004). In this process, one does not naturally integrate thinking about the design of the spaces when making them orderly through the process of 5S. It is also a question of competence. In case studies 1, 2, and 3, the change was made through special projects with design students or an architect and special, interested people, people who had some awareness of the second function of the communication space. An explanation for this is that spatial design not a core competence for a technician, they often lack such qualifications.

From the studied cases, it is shown that the design of built space is connected to the values of the company, and the use of the built space is also dependent on the organization. The awareness of the design of the built spaces was said to be low, by the informants in the case studies. There is no direct connection between a certain set of elements in the communication space and a promised outcome. A limited to-do list, like the one presented in Paper B based on empirical findings (see below), may not always help to make the built space more supportive for improvement process and facilitate communication.

When creating an improvement place in manufacturing industry, consider the following points in order to support communication:

- Design the board and the place to meet the principles of human information processing.
- Reduce disturbing motion, heat, and sound, while, at the same time, locate the improvement area close to production.
- Integrate the design, implementation, and existence of the improvement places in the organization of work.
- Choose spatial elements that connote a symbolic value you want the company to communicate.
- Integrate the board with computer/data network, if it is possible to do this without neglecting the need for readability, overview, and easy access.
A more general approach is needed to create awareness in manufacturing industry about how the built spaces can be used for communication. To make the places support improvement work and to create awareness in manufacturing industry about how the built spaces could be used for communication, one suggestion is to make the values of the company conscious and analyze how they dynamically interact with the other forms of information. A suggested support for this is to translate the five Fundamental Forms of Information into questions (see Figure 21). Being more aware of these factors can help the companies to create places optimized for their purpose. This is a proposal based on the empirical findings in the case studies. However, it is valuable if these findings are verified. To function as a design support, the set of question has to be elaborated, used, tested, evaluated, and redesigned.

FIGURE 21: How to use the result to support the design of the built spaces in the manufacturing industry. Five central factors (i.e. experienced information, enacted information, expressed information, embedded information, and recorded information) translated into questions. The questions are focusing on the relation between the factors in the communication space in order to facilitate communication over improvement processes in a lean production context.
What is done here is a set of example questions to create awareness in the manufacturing industry, an awareness that the built space exists as a variable that affects improvement work and communication (Figure 21 and Table 5). In case 4, the non-existing writing on the board illustrated a difficulty in communication between the factors active in the communication process. This result can be caused by the fact that the production leader was new in his role, that the participants did not understand their role in the improvement work, or that they did not feel comfortable writing on a board. The improvement place was not designed in order to support the users’ way of communicating, and did not answer the visual queries in an efficient way. The question under enacted information connected to this problem is: What are the values acted out in the other forms of information? This is primarily a question to create awareness. Once asked, it can start reflection concerning the functions needed in the spaces and the relationship to the other forms of information, rather than going directly to a solution or artifact (a board, for example). If the answer is that we want to support dialog regarding improvement, the embedded and recorded information should support this in relation to the users’ way of communicating.

Table 5. A preliminary set of questions to support the design of the communication space and facilitate communication.

<table>
<thead>
<tr>
<th>Form of information</th>
<th>Questions (examples)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enacted information</td>
<td>What are the values and hopes that you want to communicate? What activities should be supported? What do the users want to know?</td>
</tr>
<tr>
<td>Recorded information</td>
<td>How are the graphical artifacts designed? Easy to read from the distance? Relevant? What is their connection to the values?</td>
</tr>
<tr>
<td>Expressed information</td>
<td>Are the information presented and the dialog relevant for the group? What is expressed about the current place?</td>
</tr>
<tr>
<td>Embedded information</td>
<td>How are the objects in the spaces designed? Where is the place located? Does it support communication? What is the relationship to the values of the company?</td>
</tr>
<tr>
<td>Experienced information</td>
<td>Are there disturbances in sounds, temperature, or movement? Are the functions experienced accessible for the user?</td>
</tr>
</tbody>
</table>

One suggestion is that those questions can function as way to structure the thoughts and discussion concerning communication space. The questions can be a beginning to create awareness of the built space and to support communication in a lean production context in the work with visual management.
6 CONCLUSIONS

The objective of this thesis was to analyze if and how the built space is used for communication in manufacturing industry. What the built spaces can be said to communicate about the improvement processes was analyzed and also how built space affects improvement processes in a lean production context. An additional objective was to suggest how built spaces used for improvement processes in manufacturing industry could be designed to facilitate communication.

Since we are in interaction with visual objects in the working sphere, visual communication and built space are parts of a field in industry, which has been defined as a communication space in this thesis. The studies show that, on one level, built spaces are used as environment for verbal communication and interaction between human beings in the lean production context. On the other level, the built spaces in the studied industries were also used for communication and affected the user experience. In the communication space, the enacted form of information (based on values) is acted out in both the embedded form of information (built spaces and objects), the recorded form of information (texts, images, and graphic design) and the expressed form of information (spoken words). Basically, the communication space is used on two levels, but to diverse degrees, for communication in manufacturing industry. These two levels are:

1) Communication and interaction between human beings in the communication space, and
2) Communication between information providers and receivers (for example, between management and operators or operators and customers and reverse) with the help of the communication space.

In the manufacturing industry, a potential is at hand for improvements on both levels. On level 1, the spaces studied are not optimally used to support communication, but attempts are made to improve the design of the built spaces. On level 2, there is a not yet a full awareness, but an interest, in the manufacturing industry in using the communication space to communicate the explicit and implicit values of the company.
The forms of information in a communication space are received as information, but then interpreted and experienced by a user. The result can be related to a communication process. The communication space is socially constructed, dependent on the context where it is produced, and affects how the user act in the space and communicate the values in the context.

The semiotic analyses revealed several dimensions in what the built spaces can be said to communicate about the improvement processes in a lean production context. In cases 4, 5, and 6, the built places for improvements, their forms with a whiteboard as a focus, which should gather people around it, could be considered an index for an underlying intention. At the same time, as they were workplaces, they became physical signs with a symbolic function of representing the continuous improvement work in these industries. In cases 4, 5, and 6, there was an attempt to use the improvement places to communicate the process of improvement, using the spaces created for improvement work, but two of them were left unused for this purpose. The improvement places can be said to communicate that the improvement places were not totally integrated into the improvement work. Communication regarding improvement was done in other places, outside of the improvement place (beside the robot cells, in the corridors, or in an office, for example). The improvement places were to some extent “on display” in case 4, 5 and 6.

In cases 1, 2, and 3, the built space was used as support to manage the improvement processes, to motivate the employees, and to create conditions for radical change. They can be said to communicate a culture of change. The function on level 2, in the development workshop, was aligned with an internal company branding. In a preferred reading, in case study 1, the built spaces should communicate modernity, future, and strength.

The studies indicate that remnants of older traditions and values stay in the embedded information, values that do not represent the values related in an improvement culture. The built spaces affect improvement processes in a lean production context and it is suggested in the study that the tradition of the rational factory physically constrains attempts to create another culture and way of organizing the places for improvement work. The spaces studied mirror how people organize their places in relation to their hopes and their values. When the informants acted out their values with actions, words, built spaces, and graphical material, they became the institution. Depending on how the communication space is designed, the studies indicate that the communication space affects diverse areas, such as the identity of a team and a company, project leading, efficiency in presenting projects, decision-making, idea generation, status, and motivation. The communication space can also inspire employees to a positive view of the company and the projects, retaining knowledge in the
company, localizing problems faster, increasing the status for the project or for
the department, reinforcing motivation, bolstering the sense of “joy in work”,
invigorating the sense of feeling valuable to the company, and reinforcing the
impression of professionalism in work and products.

The results of the thesis can be utilized to support the design of the spaces
used for improvement processes in manufacturing industry in order to facilitate
communication. The initial suggestion of how the research results of the thesis
can be used is to create awareness. One way is to use the set of questions pro-
posed in Chapter 5, developed from Bates’ Fundamental Forms of Information
(2006). The questions could be used as guidance in industry, when wanting to
create, for example, places for improvement work. It is here suggested that the
production strategy could include the spaces in industry in the improvement
work, in order to follow up and improve the places in order to reflect the chang-
ing needs, convictions, and hopes of the company.

The model presented in Figure 19 enables a discussion of the relationship
between built space, communication, and users in the communication space.
The model makes more noticeable the characteristics of the communication
space and the fact that the design of the communication space is not fixed. A
design is not in a static state, since the forms of information continuously affect
each other. By observing and analyzing the embedded and recorded inform-
ation, it is possible to have information about how the communication space is
functioning in relation to the continuous improvement work in the company,
for example.

6.2 Contribution

The research aims to contribute knowledge within the areas of Information De-
sign, the doctoral program in Innovation and Design and visual management in
lean production. The research presented in this thesis contributes to an ongo-
ing discussion about the built space and its relation to communication. The de-
scription of the use of built space for communication (Figure 19 and 20) as a
communication space is an argument in this discussion. The clarification of the
two levels describing how the built space are used for and in communication,
provides a deeper understanding of built space in manufacturing industry from
a visual communication perspective. The research presented develops the un-
derstanding of the spatial design, and shows that the spatial design is not fully
used in the lean production context.

In the lean production context, industry strives to improve its processes, but
the potential of the spatial design is not fully used. The contribution in this the-
sis is to point out that the different designs of the communication space have an
effect on the improvement work. The initial questions asked under Section 5.4 are an attempt to enhance the awareness of built space and its relation to communication and to improve the design of those places.

6.3 Future Work

In future work, the research can take several directions. Many questions were found to be interesting to investigate further. Two possible areas are presented below.

The obeya is one of the built spaces created with the intention to support a radical change in the production industry. What are the characteristics of an obeya, inside and outside the lean production context? Where are the places to support the creation of radical ideas in the manufacturing industry from a user’s perspective? How does the user describe those places in words and photographs? In addition, how to combine and support the continuous improvement work towards a lean production with radical change and creativity working with TPS or similar systems is a relevant question and worth researching.

Another interesting research area is to further develop the model and the adherent questions and to test them more, to serve as support for communication and improvement processes in the lean production context in manufacturing industry.
REFERENCES


UNPRINTED SOURCES

Interviews


Observations
Notes including observations and photos in the author’s possession from: