Expansive Design
Designing with contradictions

Frederick van Amstel
EXPANSIVE DESIGN

DESIGNING WITH CONTRADICTIONS

Frederick M.C. van Amstel
Promotion Committee:

Dean and secretary  
University of Twente, chairman

Prof. dr. Geert P.M.R. Dewulf  
University of Twente, promotor

Prof. dr. ir. Mascha van der Voort  
University of Twente, promotor

Dr. Timo Hartmann  
University of Twente, supervisor

Prof. dr. Pelle Ehn  
Malmö University

Prof. dr. Chris Harty  
University of Reading

Prof. dr. ir. Fred J.A.M. van Houten  
University of Twente

Prof. dr. Peter-Paul Verbeek  
University of Twente
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Frederick Marinus Constant van Amstel
born on the 26th of January 1983
in Rio de Janeiro, Brazil
This dissertation has been approved by:

Prof. dr. Geert P.M.R. Dewulf  University of Twente, promotor
Prof. dr. ir. Mascha van der Voort  University of Twente, promotor
Dr. Timo Hartmann  University of Twente, supervisor

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Summary

This thesis looks at the practice of design as it emerges in architectural design and service design. The lens adopted considers design both as an activity as well as a space full of contradictions, which are accumulated tensions. Design activity is a professional occupation that interacts with other activities, whereas design space is a range of possibilities considered for a project. The contradictions in both sides are separately identified and then rejoined to follow the transitions from one side to another. In this dialectic, design is the reproduction of contradictions of activity into contradictions of space, and vice-versa.

When pursuing this dialectic, this research has found two ways in which design reproduces contradictions in society. The first, reductive design, aims to reduce contradictions by partitioning the design space into small manageable parts. The second, expansive design, aims to expand contradictions by increasing awareness for the possibilities in the design space. The former ignores, hides, or removes contradictions from the design space and the later uncovers, highlights, or takes advantage of contradictions in the design space. The combination of reductive design and expansive design leads to uneven development. This means that some activities and some spaces are reduced by design in favour of others.

This understanding of design comes from three short-term empirical studies of architectural design and service design projects: 1) the participation of nurses and staff in the redesign of procedures and technology for a hospital rebuild; 2) the participation of researchers, doctors, nurses and staff in the design of a medical imaging centre; and 3) the participation of volunteers in planning activities and evaluating an architectural design for a community centre. These observations of design practice were complemented with two experiments undertaken with design students. The first experiment asked students to redesign the medical imaging centre using representations of activity and space together. The second experiment asked students to play a board game about conflicts of interest in the
development of a hospital. Both investigated how design students learnt to deal with contradictions between activity and space.

The critical analysis of these experiments points to the bias for reduction or expansion of certain representation instruments adopted. In the first experiment, a parametric design tool that represented user activity led design students to redesign space for reduced walking without sufficiently considering other aspects of user activity. In contrast, the board game helped students to realize the intricate web of social relationships that constitute a multidisciplinary project. Students could not avoid or solve contradictions in any case.

The main contribution of this thesis, therefore, is the consideration of design as a product and process of dealing with contradictions. By investigating how design emerges from — and, at the same time, transforms — the contradictions between and across activity and space, the concept of expansive design becomes relevant to architectural design, service design and other design practices. Playing games was found to be a practical way to let expansive design emerge; however, this also depends on the willingness of participants to deal with contradictions in an inclusive way. With that in mind, this thesis provides an initial set of conditions derived from the empirical studies to support design practitioners and researchers in dealing with contradictions in an inclusive way.
Publication list

This thesis is based on original papers presented at academic conferences and submitted to scientific journals. The following papers that have been published so far:


Besides the thesis work, the author has been involved with the other publications during the research project. The following publications are not directly related to the thesis topic, but contributed to strengthen the scientific collaboration around the research project:


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Preface

Design is commonly associated with the shape of things and spaces; in particular, shapes that fit into recognizable styles. Yet, among people involved or acquainted with the origin of these shapes, design refers to the work behind the shapes. Practitioners and critics profit from this ambiguity when they move across the continuum between activities and shapes to make a point; however, this ambiguity is sometimes considered imprecise for academic research. Hence academic researchers, when conducting empirical studies, reduce design to the activity of the designers, or to the product of that activity. Depending on the research standpoint, this entails further reduction, for example, design as a professional activity — such as architecture, industrial design, interaction design, service design, and others — or design as a characteristic of the product — form, function, structure, and so forth. This reduction is also evident in disputes for professional roles.

What is lost through the reduction of design to one of its sides? The creation of new possibilities. Design becomes either a product or a process that avails existing possibilities — requirements, constraints, market demands, problems, solutions, materials, conditions and so on — without questioning these same possibilities. The tendency is to accommodate work to the product or the product to the work, in iterative fashion. No matter how much iteration is held, design is expected to stay within the given possibilities. The creation of new possibilities means redefining work and product simultaneously, fundamentally changing the relations of production. This is very different from iteration and accommodation.

This research project started from this ambition to counter the reduction of design and find new relations of production based on the concept of expansion, yet this was not clear from the beginning. The project leaned sometimes to one side of design, sometimes to another side of design, never settling in any. When people asked me for definitions at an early stage, I could only provide them with a discussion on definitions. “If you define something, it is because you already know what it is and hence no need for research”. By saying that, I skipped defining what I was
researching and legitimated an exploratory approach for research. In line with that approach, I refrained from stating hypothesis, research questions, goals, and measurement variables, to the despair of my research peers. Hardly anybody I spoke to agreed with my definitions of definitions (sic!).

My peers were in the Faculty of Engineering Technology of the University of Twente, collaborating with me through a partnership between the Construction Management & Engineering and the Design, Production & Management departments. The research project that resulted in this thesis was an initiative to strengthen the collaboration ties between the departments and their researchers. With courage, they chose to hire someone to conduct the research with no engineering background. The intention was to look at the participation of users in the design of medical facilities from both social and technical perspectives, in line with the University’s slogan: “high tech, human touch”.

In the Design, Production & Management departments, Mascha van der Voort and Julia Garde had already developed a handful of participatory design projects in hospitals, which served as a continuous source of inspiration. As for the Construction Management & Engineering department, there was a rising research program around the use of technical visualizations for the purpose of collaboration, led by Timo Hartmann and Geert Dewulf. Timo was experimenting with making games out of technical visualizations, as a framework for multi-stakeholder collaboration and research. His idea guided the intervention in design projects herein included. Two of these interventions were conducted in cooperation with Vedran Zerjav, a post-doc researcher with whom I had great conversations.

Developing this research project with the collaboration of so many people was a big challenge for all, since everybody had their own experience and point of view. More often than not we had strong disagreements over basic things. However, this condition turned out to be an advantage for the research project, providing plenty of contradictions similar to the ones found in the studies. Geert Dewulf was the one responsible for mediating the conflicts and keeping the disagreement at a healthy level. I’m very grateful to these marvellous people who had the patience and willingness to
debate and work together with me. The written thesis is just the tip of the iceberg, if it could ever represent those debates.

I also would like to thank people who were not directly involved with my research project, but who provided parallel feedback and insightful conversations: Fabio James Petani, Rodrigo Gonzatto, Dan Lockton, Agnieszka Mlicka, Gulnaz Aksenova, Tim Johansson, and Andreas Hartmann. A special thanks goes to Jonas Löwgren and Vanessa Evers, who encouraged me in the face of an identity crisis. The courses I followed with Pelle Ehn and Yrjö Engeström helped to consolidate my new identity (among others) as a transdisciplinary adventurer seeking mind-boggling controversies.

Finally, I want to keep in my best regards the friends I made at the University of Twente. Hendrik Cramer, Frank Bijleveld, and Alexandr Vasenev (the late one) were always eager to play the meaning of life and other games. Julieta Matos Castaño, Carissa Champlin, and Marc van den Berg were good play partners too, but beyond that, they were collaborative game design partners. I enjoyed playing and making games with these great friends!

If I can say I learnt something from all these different people, it is that new possibilities do not come from accommodation, but from contradiction. In fact, the toughest contradiction I personally faced in my PhD studies was being distant from my son whom I wanted to stay close, for four long years. At last, we are close again and eager to explore the new possibilities of being together now available.

Frederick van Amstel, Curitiba, November 2015.
Introduction

This thesis positions design in between the development of activity and space in human history. Design is understood to be a product and a process of both historical developments. The premise is that, even when activities and spaces develop in parallel, they still maintain a design relationship with each other. The origins and deeds of this relationship are related to the human effort to overcome contradictions in the conditions for living, i.e. to transform activities and spaces such that they provide life sustenance. Contradictions accumulate within activities and spaces due to unfair, unbalanced, and awkward relationships in life sustenance. Design is the attempt to establish new relationships from the existing relationships. Through design, what is a contradiction in activity may become a contradiction of space, whilst what is a contradiction in space may become a contradiction of activity. Therefore, design reproduces contradictions as much as it changes them.

Design is both a verb — to design something — and a noun — the design of something. This ambivalence makes the design word suitable to connote the unstable effort of dealing with contradictions and also to denote the production of tangible products. Architectural design, for example, aims to produce space for certain activities (Lefebvre, 1983; Lerup, 1977; McGuire & Schiffer, 1983; Till, 2009). Service design, in contrast, aims to produce activities that cut across multiple spaces (Holmlid, 2007; Meroni & Sangiorgi, 2011; Stickdorn, Schneider, & Andrews, 2011). Both face contradictions of activity, as well as contradictions of space and, therefore, must create possibilities to overcome the contradictions.

Figure 1 – Design emerges from the development of activity and space in human history. As such, design has also an activity and a space of its own: design activity and design space.
Design overcomes and, at the same time, reproduces contradictions because it is, at the same time, a space and an activity. Design is a specialized activity that develops innovative projects — what is referred here as design activity — but also the range of possibilities considered for each project — the design space. The activity includes not only the professionally organized design activities, but also the less professional efforts of people involved in other activities. If people are changing space to accommodate activity or changing activity to accommodate a certain space, there is design.

This understanding of design is directly related to the professionalized practice of architectural design, as well as to the emerging practice of service design. Together, these are the targets of the empirical studies contained in this thesis. Despite being grounded in these specific design practices, this thesis may be applicable to other design practices that deal with activity and space. The point of departure of this thesis is its broad definition of design based on the notions of (social) activity and (social) space:

What happens in space lends a miraculous quality to thought, which becomes incarnated by means of a design (in both senses of the word). The design serves as a mediator itself of great fidelity — between mental activity (invention) and social activity (realization); and it is deployed in space. (Lefebvre, 1991, p. 27)

This definition points to the potential discontinuity between mental activity and social activity — and all sorts of design problems that can arise from that (mental model mismatches, communication breakdown, and anachronisms). The discontinuity comes from a deeper contradiction between mental space and social space, which is very tense in modern society (Lefebvre, 1991). Contradiction is a central concept for this thesis when used to grasp the process of becoming, i.e. the incessant transformation of reality (Engeström, 2015; Lefebvre, 2009). Any contradiction exists in reality, even if no one is aware of it. However, when brought to consciousness and shared with society, the impact of contradiction becomes tenser. Hence, it is not possible to say that contradiction is an entirely objective or subjective phenomenon; it is both.
For that matter, contradiction is both cause and effect of a social situation. It is described in formal terms as a dynamic unity of opposites. It is dynamic because the opposites are constantly struggling for predominance; at one moment, one is predominant; and at another moment, the other is predominant (Lefebvre, 2009). Their interaction may give birth to a third element, which overcomes the struggle and transforms one contradiction into another contradiction.

The main contradiction dealt by this research lies between the development of activity and space. Previous scholars have seen configuration (Hillier & Hanson, 1984), formalization (Lou, Simoff, & Mitchell, 2006), or organization (Dale & Burrell, 2008; Kornberger, 2004) emerging from the contradictions between activity and space. This thesis considers design to emerge from activity and space, as a process and a by-product of dealing with contradictions. This description of design as an emergent practice is possibly the main scientific contribution of this research project. As for architectural design, service design, and other design practices that deal with the relationship between expansive activity and space, the contribution is the concept of expansive design, which includes contradictions in design activity/space in a productive way, e.g. by playing design games.

The trajectory that brought this contribution to the fore is a transdisciplinary one, passing through two theories that do not fit within one single discipline: the production of space theory (Lefebvre, 1991) and the cultural historical activity theory (Engeström, 2015). Both suggest that contradictions can be grasped by looking at the history of a particular situation, applying abstract measures, such as scales and models and, subsequently, reconstructing the whole phenomenon as over-determined or, in other words, determined by too many causes (Engeström, 2015; Lefebvre, 1975; Stanek, 2011).

Nevertheless, reaching such levels of understanding is not easy in cultural historical activity theory (Engeström, 2015; Foot & Groleau, 2011). Contradictions are situated in historically circumscribed activities and it is neither possible to isolate, nor to reproduce contradictions for experimentation. The production of space theory has a different perspective over contradictions. This suggests that, once contradictions become embedded into space,
they can interfere with multiple activities (Lefebvre, 1991). From that it can be assumed that contradictions dealt by the design activity may become embedded in the design space as a source of problems, solutions and constraints. Also, it can be assumed that the contradictions embedded in the design space may be reproduced by the use of that space as a source of trouble, disturbance and breakdown. This theoretical articulation was set to study how design reproduces contradictions in society.

How design reproduces contradictions in society

The role of design in the reproduction of contradictions has not been investigated in depth yet. One of the few resources available in this regard is the concept of expansive design (Engeström, 2006), derived from cultural historical activity theory. Yrjö Engeström proposed this concept to expand the burgeoning field of interaction design, which was, at that time, very much concerned with designing information technology to achieve certain emergent qualities in use (Löwgren & Stolterman, 2004). Interaction design expressed a concern for the user activities in information technology, yet in a detached fashion. The user activities were considered mostly at the level of operations, on how a generic user would act and react on buttons and windows in a computer screen. There were some authors talking about considering the actions done with language — speech acts (Denning & Dargan, 1996) — and the full performance of the human body (Dourish, 2004). However, Engeström wanted to consider the relationship between design and other activities. This formulation anticipated later developments in interaction design that led to the birth of a sibling practice: service design, which is about aligning the activities that provide a service according to the activities of their customers (Maffei & Sangiorgi, 2006; Meroni & Sangiorgi, 2011).

The concept of expansive design defines design as a social activity concerned with the development of other activities. Instead of producing just instruments (Kuutti, 1995, 2010), expansive design interferes with the purpose of using those instruments, i.e. the
object of user activities. For that matter, expansive design is supposed to consider a range of new issues in interaction design: social relationships, work processes, services, organizations and future visions (Engeström, 2006). To grasp these issues in a historical perspective, expansive design relies on the notion of contradiction. This is defined as a tension that accumulates in the elements of an activity, between different elements of the same activity, between old and new activities and between different activities (Engeström, 2006, 2015; Foot & Groleau, 2011).

Unfortunately, expansive design was introduced solely on the basis of cultural historical activity theory, without relating it to the existing literature in interaction design, architectural design and design studies in general. This prevented the concept from being appropriated by design research and correlate fields. To the best of our knowledge, the concept was never developed further in scientific publications until the present thesis.

The first step made by this thesis to develop the concept of expansive design was to find its opposite: reductive design. In a nutshell, reductive design consists of excluding contradictions from design, whereas expansive design consists of including contradictions in design. They have been theorized separately, to the point of underscoring completely different epistemologies of design. However, they occur together in practice and that is why they are also considered together here.

Reductive design is the common ground among practices such as scientific management (Taylor, 1919), business process modelling (Scheer, 2000; S. Williams, 1967), rational problem solving (Simon, 1973, 1996), cognitive engineering (Norman, 1986), machine design (Friedman & Lang, 1975; Negroponte, 1973), lean production (Womack, Jones, & Roos, 1990), systematic engineering design (Pahl, Beitz, Wallace, & Council, 1984), functional analysis (Voordt & Wegen, 2005), spatial syntax (Hillier & Hanson, 1984; Hillier, 2007), and others that design based on the scientific technique of reduction.

The reduction technique consists of breaking down the phenomenon of interest into independent parts, finding explanations for the behaviour of each part and, finally, aggregating the explanations into an explanation of the whole
Designing based on this technique means, in an abstract way, defining problems before solutions, breaking down problems into sub-problems, finding solutions for each sub-problem and creating an overall solution that contains all other solutions (Pahl et al., 1984). In a concrete way, it means dividing the labour into tasks, attributing them to different design specialists and putting all the results back together under the (super)vision of the boss in charge. The procedure is, for the most, analytical (Vassão, 2008). The last step, the synthesis, is considered very difficult to achieve due to the incompatibility of the parts and disputes between the specialists.

By reducing reality and enforcing this reduction back onto reality by means of design, reductive design increases the tension between activities. At some point, this tension lead to a crisis and expansive design arises from it. Expansive design means creating something new, while learning about it: i.e. realizing the specific collective characteristic of activity, reviewing its underlying motives and uncovering the contradictions in development (Engeström, 2006).

Expansive design is not based on an inverse technique that rejoins parts to form wholes. The expansion technique is based on following the dialectic of parts and wholes that constitutes a historical process of becoming (Lefebvre, 1975, 2009). The first understanding of the whole is abstract, impartial and isolated. As the dialectic unfolds, the whole becomes related to its inner parts.
and to outer parts from other wholes (Ackoff, 1973). The interactions among parts and between parts and wholes become the focus of attention. Since these interactions are changing all the time, it is necessary to keep adding elements to the whole in order to keep the historical perspective. The foundational element that gives structure to this apparently chaotic whole is the historical accumulating contradiction.

![Figure 3](image)

*Figure 3 - The expansion technique relates parts to wholes and small wholes to larger wholes.*

According to the above, there are two ways that design reproduces contradictions: one that tries to reduce contradictions — reductive design — and another that tries to expand contradictions — expansive design. In current design research, reductive design can be considered the dominant side, whereas expansive design represents the alternative path. This thesis aims to draw attention to expansive design, but it will also consider reductive design along the way. The next session includes the contradictions found by previous studies in the various practices of design.

**Contradictions found by previous studies**

Various authors have written about contradictions in design. Robert Venturi is, perhaps, the first to include contradictions in
design as something to be appreciated rather than ignored or excluded:

*I like complexity and contradiction in architecture. [...] Today the wants of program, structure, mechanical equipment, and expression, even in single buildings in simple contexts, are diverse and conflicting in ways previously unimaginable. The increasing dimension and scale of architecture in urban and regional planning add to the difficulties. I welcome the problems and exploit the uncertainties. By embracing contradiction as well as complexity, I aim for vitality as well as validity. [...] But an architecture of complexity and contradiction has a special obligation toward the whole: its truth must be in its totality or its implications of totality. It must embody the difficult unity of inclusion rather than the easy unity of exclusion. More is not less.* (Venturi, 1977, p. 16)

As eclectic as it seems, the post-modern architectural style of Venturi was heavily criticized by Robert Goodman who reframed contradictions as social struggle in urban planning, instead of visual effect:

*I searched the entire book for any description of how people use architecture; there was hardly a word about it—instead the same aesthetic jargon. A series of building plans, elevations and photos show how certain architectural qualities make a building seem more complex and contradictory. There is almost no analysis of whether the buildings used as examples really accommodate the complexity and contradiction of human activities they were intended to serve.* (Goodman, 1971, p. 166)

Goodman drawn attention to the contradictions users faced while using space, which the designers apparently ignored. Henri Lefebvre, who identified more profound contradictions hidden in space, echoed this criticism:

*I have been suggesting, the notions of 'design', of reading/writing as practice, [...] are all directed, whether consciously or not, towards the dissolving of conflicts into a general transparency, into a one-dimensional present — and onto a [design] as it were 'pure' surface.* (Lefebvre, 1991, p. 145)
The criticism was targeted at the allegedly transparency design claims to produce when fulfilling user needs. Moving away from such philosophical debates, the empirical studies of architectural practice have identified contradictions in work relationships. Judith Blau conducted a pioneer study of 150 architecture offices in New York and found a contradiction in the way architects deal with risk and opportunity:

Architecture in all of these respects is governed by structures of risk that accompany opposing conditions of various sorts. Risk is always conceived to be a situation fraught with hazards, but I use the concept of the structure of risk in a more specific way as well. The premise is that particular conditions contain an implicit contradiction that sets into motion process that unfold to reveal the full implications of the initial contradiction while at the same time they create a resolution that in turn poses a new set of opposing conditions. (Blau, 1984, p. 1)

Following the footsteps of Blau, Danna Cuff identified another four contradictions in architectural practice:

First, through its emphasis on the traditional role of the creative individual, the profession masks the growing significance of collective action. Second, design is believed to sprout from a series of independently made decisions rather than from the emergent sense made of a dynamic situation. Third, design and art have been separated from business and management concerns, in spite of the fact that the two domains are inextricably bound in everyday practice. And fourth, the image of the architect as a generalist — a Renaissance man — is countered by the challenges facing practicing architects who specialize in their market for services. (Cuff, 1992, p. 298)

Beyond the studies of architecture practice, there are other studies of design practice that also point to contradictions. Pelle Ehn identified a contradiction in the design of computer technology between the forces of tradition and of transcendence:

On the one hand it is necessary to break down the everyday understanding and use within a specific tradition to create new knowledge and new designs. On the other hand designs that are not based on the understanding and use within a tradition
— the users’ practical skills — are likely to fail. Breakdown of understanding of a well-known situation is at the same time the opening to new knowledge and eventually an understanding of something new. The ability to deal with this contradiction between understanding of the ready-to-hand and detached reflection of the present-at-hand is fundamental to design. I shall later refer to this as the dialectics of tradition and transcendence in design. (Ehn, 1990, p. 66)

The descriptive approach of the previous studies contrasts well with a prescriptive theory of design based on contradictions, the theory of inventive problem solving (TRIZ). This theory was formulated after the analysis of a large sum of patents awarded by the former Soviet Union (Al’tshuller, 1984). The analysis identified contradiction as a characteristic of the administrative, technical, or physical world that imposed trade-offs on the designer. The designer wants to improve something, but cannot avoid making something else worse by the same action. Derived from this notion of contradiction, an algorithm for problem solving has been developed:

[...] an algorithmic methodology considers the process of solving inventive problems as a sequential action to define more accurately — and solve — technical contradictions. The thinking process is directed toward an ideal method, or an ideal device. The systematic approach is used in all stages of the solution process. This algorithm also includes specific steps for removing psychological barriers. In addition, it has also developed an informational system consisting of the typical principles used to remove technical contradictions. (Altshuller, 1999, p. 67)

A common point among these previous studies is the role of contradictions in driving design activity. Design activity has to respond to contradictions of design space — for example, the inconsistent combination of styles and shapes of post-modern architecture — and to contradictions in design activity itself — for example, the individual authorship of collective design efforts. Every design action aims at overcoming these contradictions, but they rarely succeed. Design actions may reduce the accumulated tension, but overcoming the contradictions requires a spatial-temporal breakthrough, or a simultaneous change in design activity and in design space (Lefebvre, 1991, p. 54).
### Table 1 - Contradictions identified by previous studies of design practice.

<table>
<thead>
<tr>
<th>Contradictions of design activity</th>
<th>Contradictions of design space</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>Inconsistent combination of styles and shapes (Venturi, 1977).</td>
</tr>
<tr>
<td>Architects must take risks to find opportunities for creative action. (Blau, 1984)</td>
<td>-</td>
</tr>
<tr>
<td>A new artefact must support current practice as much as contribute to changing that practice. (Ehn, 1990)</td>
<td>-</td>
</tr>
<tr>
<td>The emphasis on the creative individual masks the growing significance of collective action. (Cuff, 1992)</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>Design is believed to sprout from a series of decisions rather than from the emergent sense made of a dynamic situation. (Cuff, 1992)</td>
</tr>
<tr>
<td>-</td>
<td>Design and art have been separated from business in spite of the fact that the two domains are inextricably bound in everyday practice (Cuff, 1992).</td>
</tr>
<tr>
<td>The image of the architect as a generalist is countered by the demand for specialization (Cuff, 1992).</td>
<td>-</td>
</tr>
<tr>
<td>Something has be done but the course of action is unknown (Al’tshuller, 1984).</td>
<td>The material reacts treatment in a counter-productive way (Al’tshuller, 1984).</td>
</tr>
</tbody>
</table>

With the exception of the contradictions identified by Genrich Al’tshuller, the contradictions found by previous studies are identified in one of the sides — design activity or design space.
They either consider design as an activity — e.g. architectural practice, or as a design space — e.g. architectural styles, but not as both design activity and design space. Furthermore, they do not track contradictions after they are overcome — as if contradictions were completely eliminated or as if they would never be able to be overcome. The possibility of transforming contradictions of activity into contradictions of space (and vice-versa) is largely missing. Since this thesis considers design both as activity and as space (see Figure 1) and it looks at contradictions in both sides, the contradictions found by previous studies are not taken as material for further investigation. Instead, this research looks at the specific contradictions of space and contradictions of activity that arise in the particular situations where the empirical studies are conducted. The concluding chapter gives a full historical account of the contradictions found in these studies.

**Research method**

The goal of this thesis is to investigate how design emerges from — and at the same time transforms — the contradiction between and across activity and space. To grasp these contradictions as historically situated phenomena, the empirical studies focus on design practice, as manifested in contemporary professional and educational projects. Architectural design and service design practices are selected for the study due to their focus on dealing simultaneously with issues of activity and issues of space. The intention here is to understand how contradictions emerge in specific historical situations. There is no ambition to generalize an abstract design process from that.

The research method is crafted from the notion of formative intervention, a mixture of observation and experimentation of organizational practices (Engeström, 2011). This method has some resemblance to action research (Lewin, 1946) yet it is based on a different branch of psychology — socio-historical psychology (Vygotsky, 1978). This branch departs from the assumption that external stimulus is mediated by a second stimulus generated by the individual and by the society. Behaviour, therefore, is not a direct response to stimulus, but a mediation of different stimuli. The first stimulus is the specific condition of the individual in
society, characterized by a contradiction — not knowing to read when in need to read, for example. The second stimulus is a tool or a sign acquired through societal culture that mediates the interpretation of the first stimulus and the formulation of an action. This action is sometimes called refraction to contrast with the word reflex and response used in single stimulation studies (Figure 4). Since refraction is expected to develop from inside out, the psychological experiments in this branch are much less controlled than conditioned behaviour experiments based on single stimulation (Virkkunen & Ristimäki, 2012; Vygotsky, 1978).

![Single and double stimulation experiment methods compared](image)

**Figure 4 - The single and the double stimulation experiment methods compared.**

The double stimulation experiments are often conducted as part of a formative intervention in collective organizations (Engeström, 2011). After learning the organizational practices through ethnography-inspired observations and identifying contradictions through historical analysis, these contradictions are reintroduced to the practitioners, together with tools they can use to include or exclude them. These tools are developed or are custom-tailored to the specific situation, but can be used in many different ways. They are evocative and, at the same time, ambiguous to leave enough room for unexpected refractions. The participants may learn how to deal with the contradiction with them, in their own way. Hence, mediation is a proxy to learning.
The double stimulation experiments in this research were conducted in two different settings: as part of formative interventions in professional projects, and as part of educational projects for design education. The double stimulation experiments took the form of collaborative design workshops in the professional projects where custom-tailored visualization tools and design games were developed to deal with contradictions. Some of these tools were developed and tested in further the educational projects, where the double stimulation experiments took the shape of hands-on sessions. Two research instruments were employed to measure refraction during and after the double stimulation experiments: follow-up interviews and learning reports written by the participants (Figure 5).

![Diagram](image)

*Figure 5 - The research method adopted by this thesis consists of consecutive cycles of ethnographic observations, double stimulation experiments and follow-up interview or learning report.*

The data collected through the projects were stored in an Issue-Based Information System (IBIS) as individual notes. These were classified and graphically interlinked (Kunz & Rittel, 1970; Selvin et al., 2001). The data is primarily qualitative, stored in formats such as documents, photos, audio and video recordings. Each step of an intervention — online communication, interview, meeting, or workshop — is represented as a graphical map with interlinked nodes in the IBIS. The criterion for connecting notes is quite loose; it just defines that there is a relationship between the notes without stating the nature of this relationship. A large part of
notes were added later based on the rehearsing of audio and video recordings of the interventions.

The graphical maps served as an intermediate step in the research process and were often consulted and updated, but never fully formalized. They connected the concepts proposed by theories, the concepts adopted by practitioners and the concepts developed during the interventions and provided an ongoing visualization of the investigation. They were mainly used for keeping up with the big picture while analysing data in the multiple interventions (Table 2).
Table 2 - Summary of project interventions and research activities.

<table>
<thead>
<tr>
<th>Project</th>
<th>Project type</th>
<th>Research activities</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Participatory design of nursing procedures and health technology for a hospital rebuild</td>
<td>Professional</td>
<td>Observation</td>
<td>Nov – Feb 2011</td>
</tr>
<tr>
<td>2 - Implementation of a collaborative technology for building modelling in an elderly housing project</td>
<td>Professional</td>
<td>Interviews</td>
<td>Mar – May 2012</td>
</tr>
<tr>
<td>3 - Participation of users in the design of a medical imaging centre</td>
<td>Professional</td>
<td>Interviews, collaborative design workshop organizing, tool development</td>
<td>Jul 2012 – Jan 2013</td>
</tr>
<tr>
<td>4 - Implementation of a collaborative technology for building modelling in a hospital lab project</td>
<td>Professional</td>
<td>Interviews</td>
<td>Feb – Sep 2013</td>
</tr>
<tr>
<td>5 - Participation of users in planning the activities of a nature centre</td>
<td>Professional</td>
<td>Interviews, collaborative design workshop organizing, tool development</td>
<td>Mar 2013 – Jun 2013</td>
</tr>
<tr>
<td>6 - Experiment to redesign the medical imaging centre</td>
<td>Educational</td>
<td>Teaching instruction</td>
<td>Sep 2012 – Sep 2014</td>
</tr>
<tr>
<td>7 - Experiment to play a board game about hospital expansion</td>
<td>Educational</td>
<td>Collaborative design workshop organizing</td>
<td>Oct 2013</td>
</tr>
</tbody>
</table>
Thesis overview

The thesis is organized around the original papers submitted to recognized scientific journals related to design and architecture. Each paper reports on a specific study about the poetic relationships between design, activity and space. Together they form an expansive track that begins with exploratory case studies (Chapter 1 and 2) and end up with experiments in the context of design education (Chapters 3 and 4).

The exploratory case of Chapter 1 set the stage for the thesis, introducing a practical situation: the design of a medical imaging centre that has to expand from the narrow focus on step-by-step operations to a complex bound of social activities. Three different units of analysis are discussed to grasp expansion and its counter-process, contraction (also referred as “reduction” elsewhere in this thesis). The representation of an activity is linked to activity development as a whole. Design is considered an organizational activity, contributing not only to the shaping of space, but also to partnerships, motivation and knowledge sharing. The chapter emphasizes the political struggle for the absence, or the presence, of users in representing user activities. When users were absent, the design activity kept producing representations of space, such as plans, flowcharts and requirements’ lists, that could not address the accumulating contradictions of the project. However, when users were present, the design activity produced spaces of representations where users could represent themselves, build commitment and deal with the inner contradictions of the design activity. This shift is described as an expansion of the object of design activity.

Chapter 2 looks at a specific kind of instrument used to include users in the medical imaging centre project: design games. Two similar projects were added for comparison: a hospital wards expansion and a community centre for environmental leisure and education. The games were designed to deal with the conflicts that arose in design activity in a playful way, helping to identify the current tensions within the design space and realizing the practical actions that can be taken within the project boundaries and outside of it. The three projects offer evidence on how
players harness the transformative potential of play to expand activity and also to redesign space.

The lack of proper instruments to represent activity in the context of designing space inspired the development of a plugin for architectural design software. This plugin is an electronic version of the low-tech prototype developed in the medical imaging project. Chapter 3 reports on a classroom experiment where students had the opportunity to try the software plugin to change the design space reconstructed from the medical imaging centre project. The goal was to test if the contradictions observed in the case study also manifested in the context of design education, suggesting that contradictions are not only present in activity, but also in space — the design space.

The results show preliminary evidence that, even if not embedded in the same social context of the practitioners, the students were reproducing the same contradictions practitioners were also reproducing in their designs. Unexpectedly, the same could be said about the researchers who designed the plugin with a bias to optimize activity by reducing walking paths. Despite making more visible the contradictions of space, the plugin could not help analysing how design students learnt to deal with contradictions. Furthermore, students did not understand exactly why they should take into consideration activity while designing space. Another instrument and experiment was developed for this purpose: a board game about the design of a hospital, which is introduced in Chapter 4. The game introduces artificial boundaries between the players based on the contradiction of exchange value and use value.

The game performance reveals that, if most of the players are trying to cross boundaries just to make the others behave according to own interests, the hospital constructed does not reach a good use value. On the other hand, if players are working solely for common interests, the opportunity for vested interests opens up. The underlying message is that designers need to learn how to deal with this contradiction, instead of using techniques to eliminate conflict, which is deemed impossible.

The conclusions and discussion chapter relate the papers together, enlist the contradictions found by the empirical studies
and characterize expansive design and reductive design as two approaches to deal with contradictions in design. The importance of expansive design is highlighted and some conditions for the emergence of expansive design are given at the end.

Summary of findings

This thesis expects to contribute to design research by developing further the expansive design concept and its underlying practice of including contradictions in design. The papers do not always explicitly mention the contradictions, expansive design or reductive design. These concepts emerged from making sense of the findings summarized below and expanded in the conclusion section.

1. Design is an activity that interacts with other (user) activities by means of representations of space — floor plans, diagrams, scale models, and others. These representations of space can be used as instruments to gather information from other activities (programming) or become a shared object with other activities (participatory design).

2. The representations of space imply a space of possibilities — also called design space — with the following features: problems, solutions, visions, constraints, scenarios, stakes and consequences. This space is disputed by many activities and the design activity has no full control over it. By interacting with this space, the activities reproduce their own historical contradictions, which become embedded into this space. The space of possibilities has, therefore, an abstract existence — problems, solutions, constraints — and a concrete existence — contradictions.

3. The space of possibilities does not contain all the possibilities of space, though. There are many possibilities that are not represented, or even conceptualized, by design activity. Hence, the space of possibilities is smaller than the actual possibilities of space. If space is understood as a set of social relationships, the possibilities of space include the following features: decision; distance; coexistence; encounter; appropriation;
identification; imagination; alienation; friction; marginalization; assembly; demarcation; resistance; and, attachment. These relationships exist among the people involved with this space, but they might not be aware of them. When people become aware of these spatial relationships, they may bring them to the space of possibilities to evaluate, reject and prepare for change.

Considering these findings, expansive design consists of: a) turning the space of possibilities into a shared object between the design activity and other activities; and, b) shaping the space of possibilities in a way that unexpected possibilities of space can be further realized or created. The studies conducted in design education and design practice suggest that playing games can help turn the space of possibilities into a shared object and realize some unexpected possibilities of space. The theoretical implications of these findings are elaborated in depth in the conclusions.
Chapter 1

Expanding the representation of user activities

This chapter introduces the political and methodological challenges of representing user activities for designing space. The representations of user activities (i.e. lists, organograms, or flowcharts) often simplify or structure activities too much. This leaves insufficient room and consideration for future activity development. Nevertheless, design can anticipate activity development if users are able to represent their own activities while participating in the design process.

The case study of a medical imaging centre reveals that, once users have such opportunity, their spatial practices are, not only taken into account, but also expanded. The designers, the users and the researchers created a range of instruments to expand across three units of analysis: operations, actions and activities. As a result, the representations of space proffered by the designers were expanded to a space of representation for the users where new ways of working were realised. Based on this study, an integrated model for the production of space and the development of activity is proposed.

The integrated model traces the expansion of representations of space in design activity towards the representations of user activities (spatial practices) and the formation of a shared object co-constructed with the users (space of representations).

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1 This chapter is originally published as Van Amstel, FMC, Zerjav, V, Hartmann, T, van der Voort, MC & Dewulf, GPMR 2014, “Expanding the representation of user activities.” Building Research & Information, vol. 43, no. 2, pp. 144–159.
1. Introduction

In architectural practice, the design of space is a social activity as much as the activities of people using space. In our current society, these activities mainly interact by negotiating representations that stand for the presence or the absence of users in the design process (Lefebvre, 1983, 1991). The design activity represents user activities during briefing and early design phases, based on information collected from meetings with clients, interviews with users, document-analysis, references from similar projects, or specific literature (Voordt & Wegen, 2005).

Instruments such as lists, organograms, and flowcharts are used to represent user activities in three levels of understanding: the operation level — related to immediate spatial conditions, the action level — related to strategic goals, and the activity level — related to the motives behind doing something together (Leont’ev, 1978).

When representing user activities there is a danger that the process gets stuck due to reliance on an instrument that does not allow for properly shifting the unit of analysis, from one level to another. A list of requirements, for example, might not disclose the underlying goals, as these goals may not be best represented by a list. This is more than just a technical matter of replacing the instrument or adding more information to it. The underlying challenge is to find a unit of analysis that expands the user activities into the future. The difficulty lies in representing activity beyond the current state of development, in order to consider the requirements in relation to actions that have not yet happened and that are quite unpredictable. As designers are accustomed to represent what they already know (Loukissas, 2012), user activities pose a new question to them: how to represent something that is not yet known?

This question requires a distinction between two ways of approaching representation in design. There are theories which consider representation as the mental result of thinking about activity that can eventually be externalized by instruments, corresponding more or less to reality (for example Zhang & Norman, 1994). Other theories consider representation as an integral part of activity itself, based on its communicative role (for example Lorino, Tricard, & Clot, 2011).
Following the first definition, the answer would lead to improving knowledge gathering and instruments to accurately represent user activities in relation to space. Following the second definition, the answer would reveal that design representation is also activity, with its own spatial conditions, strategic goals, and motives that may contradict those of the user activities (Bødker, 1998). The current authors prefer to follow the second definition, as it transforms the lack of knowledge about user activities into an unfolding process of negotiating the presence and the absence of users in design. Following this path, the political and methodological difficulties of representing user activities in design will be highlighted.

These difficulties were faced in practice during an intervention conducted by the researchers in the design of a medical imaging centre in The Netherlands. In this project, the representation of user activities had a fundamental role in guiding the design of space, yet not as straightforward as designers expected. The designers, the users, and the authors created a variety of instruments to represent user activities across the three aforementioned levels: operation, action and activity. This resulted in a new production of space, but also in a next step of development for user activities.

The goal of this study is to describe the intervention in the project and then to theorize the representation of user activities done for the purpose of designing space. The theorization reflect on architectural practices such as briefing (Barrett, Hudson, & Stanley, 1999), programming (Pena & Parshall, 2001), functional analysis (Voordt & Wegen, 2005), simulation (Loukissas, 2012) and participatory design (Sanoff, 2006) in light of cultural-historical activity theory (Engeström, 2011, 2015; Leont’ev, 1978) and the production of space theory (Lefebvre, 1983, 1991).

The paper is structured as follows: the next section explains the theoretical framework. This is followed by the analyzed case data. The last sections present an addition to the framework regarding the role of space in expanding the representation of user activities. This is believed to be an important step toward a user-centred theory of the built environment (Vischer, 2008).
2. Activity representation and expansion

In the architecture literature much has been said about representations of space (Bendixen & Koch, 2007; Ewenstein & Whyte, 2007; Luck, 2007; Whyte, Ewenstein, Hales, & Tidd, 2007), but little about the representations of activity. In the few existing sources, the representation of activity is supposed to begin with a broad unit of analysis which is then divided into progressively smaller units (Kim, Rajagopal, Fischer, & Kam, 2013; Lou et al., 2006; Perin, 1970; Shen, Zhang, Qiping Shen, & Fernando, 2013; Thiel, 1997). This reductionist strategy may offer formal advantages to develop representation systems, but it does not take into account the efforts of practitioners to fill in the gaps between these units when trying to come with a coherent design.

Instead of further examining environmental psychology (Barker, 1968; Gibson, 1986), the referred source for this strategy, another psychological theory is explored: cultural-historical activity theory (Engeström, 2015; Leont’ev, 1978; Vygotsky, 1978). Its strategy to work with progressively larger units of analysis has demonstrated to be useful to study representation practices in architecture (Groleau, Demers, Lalancette, & Barros, 2011).

Cultural-historical activity theory arose as a counterpoint to behaviourism, an experimental program that aimed to explain human behaviour as reflex to immediate conditions (Pavlov, 2003). Activity theorists did not reject the idea that humans respond to conditions, but added the dimension of representation: human action is mediated by instruments that represent the immediate conditions in order to change them in a certain way, defined by an internal goal (Vygotsky, 1978). The subsequent development of the theory led to the implication of actions in society: individuals must coordinate their actions to pursue a joint achievement (Leont’ev, 1978). The fundamental concept was the notion of the object, the thing that motivates the joint achievement and that binds a community, with its own rules and a division of labour (Engeström, 2015). The object is sometimes mistaken for an instrument, especially when an instrument is used to represent the object (Hasu & Engeström, 2000). In that case, the instrument has a shorter life; it may soon be replaced for one that better represents the object.
This expansion from conditioned to social behaviour in cultural-historical psychology is summarized in three levels or three units of analysis: (1) operation — responding to conditions, (2) actions — aimed at goals and (3) activities — oriented to objects and motives (Engeström, 2015; Leont’ev, 1978). This shift is contrasted with other psychological studies that divide activity into progressively smaller pieces (for example Zhang & Norman, 1994), a process that is called contraction (Figure ). Expansion and contraction happens to any activity — not just psychological studies: an action may be expanded to an activity — e.g. the work done by one single individual may be taken over by an institution — and, in the same way, an activity may be contracted to an operation — e.g. due to automation. Representation plays a crucial role in both processes, anticipating the next level of development with instruments crafted to the corresponding unit of analysis.

![Figure 1 - Expansion and contraction of unit of analysis for understanding human activity. Source: Based on Leont'ev (1978).](image)

In a design activity, for example, a list of requirements may be used to identify conditions that should be changed to accommodate new operations. The list may help in realizing that the source of trouble lies not in the immediate conditions, but in unclear goals. In that case, a particular operation must be reconsidered as an action responding to a goal. The list gives rise to a series of steps that fulfill goals, e.g. a flowchart. While making the flowchart, designers identify goalless actions that can be automated as operations. They may optimize the action without carefully considering the consequences in other levels. These consequences only become visible when a user announces an intention to leave such activity due to the lack of motivation for doing a repetitive optimized procedure. In response, designers direct their efforts at the activity level to prevent the disbanding,
using persuasive speech and abandoning the existing analytical instruments.

![Activity System Model](image)

**Figure 2 - The activity system model. Source: Redrawn from Engeström (1987)**

This brief example discusses how instruments alone do not provoke contraction or expansion of user activities. It depends on how they are used, who is involved, and the purpose of representation. These relationships are best captured by the activity system model (Figure 2): a subject of a community transforms an object for an outcome using instruments, regulated by rules and division of labour (Engeström, 2015). In the example above, the subjects are the designers who are working on transforming space (object) with different kinds of documents (instruments), following an optimization mindset (rule) and excluding the participation of users until the very last moment (division of labour). The model is applied to grasp how these relationships change over time — e.g. how the division of labour changed to account for the disbanding. Every change is sought to affect other elements of the model as well, in ripple effect. The small changes accumulate until there is a major breakthrough: object expansion, when the object orienting activity is reconsidered in a totally new way (Engeström & Sannino, 2010; Engeström, 2015).

Object expansion may also occur when different activities try to produce something together, in collaboration. In that case, the initial object is reconsidered as an expanded object in face of the differences and the similarities between the collaborating activities. Later, these expanded objects in each activity may converge into a single shared object (2001), jointly constructed by both activities, provoking changes in both sides (Figure 3).
Depending on those changes, the object can last for a while or for a longer period. The permanence of the shared object can provoke a merge between the activities or give birth to an entirely new activity (Engeström, 2008).

![Diagram showing activities interconnected by a jointly constructed, shared object. Source: Redrawn from Engeström (2001, p. 136)](image)

This model reveals a collaborative challenge when applied to the design realm:

*For designers, as for any practitioners involved in complex organized activity, making sense of their own work as a collective activity system represents an expansive challenge of ‘visibilization’. But this is only the first step. Opening up and making visible the activity systems of key customers or users is the logical second step of expansion. [...] The formation of a partially shared object between the designer and the customer/user is a crucial challenge.* (Engeström, 2006, p. 4)

The object of design is expanded from an instrument to be used by a generic user activity (initial object) to a specific user activity, as represented by design (expanded object). If expansion stops at this point, there is a risk of putting too much structure — rules, instruments, and division of labour — into the user activity (Redström, 2006). Since representations are proffered in order to stand for the user’s presence (Lefebvre, 1983), there is little chance to realize the resistance to the overstructuring that might occur later. In contrast, the expansion to shared objects requires the users to be present, participating in and resisting the transformation of the design object. When users interfere with the course of the design activity, it is possible to say that the design activity becomes an object of the user activity and vice-versa (Bødker & Grønbæk, 1996a). The shared object is, thus, a
jointly constructed representation and material thing that permeates both design and user activities.

Despite the documented evidence of mutual learning between designers and users (Béguin, 2003; Bødker & Grønbæk, 1996a), this process of expanding the representation of user activities is not well covered in design literature. There is still a noticeable lack of knowledge about the formation of shared objects between design and user activities (Luck, 2007). As these objects are emergent, performative, and situated, it is hard to rely on generic descriptions of these two. To grasp the emergence of shared objects in practice, an analysis of a specific design project is presented that the authors observed and supported the representation of user activities in depth. The theoretical framework here introduced underscores the analysis; however, the role of space in representing activity deserves an addition to the framework, which will be presented after the study.

3. Case study

The case study is based on a forthcoming medical imaging centre in The Netherlands which will offer state-of-the-art diagnosing machines such as Magnetic resonance imaging (MRI), Positron emission tomography (PET-MRI), Computed tomography (CT), Single photon emission computed tomography (SPECT), and Electroencephalography (EEG). The project is unique in The Netherlands for its attempt to combine research, technology development, education, and care in the same space. This study covers a small part of the design process: the evaluation and final adjustments of the floor plan, which happened between July 2012 and January 2013.

This case study was selected because it offers a practical challenge to represent user activities in the context of designing space. In healthcare, activities are constantly changing due to regulations, demand fluctuation, and new technologies; they are fragmented and respond to emergencies. Requirements are very specific, often contradictory, and difficult to balance in an overall plan. Designing space that allows user activity expansion is very hard, but an essential effort.
The method employed in the study is formative intervention, a variation of action-research that aims to facilitate activity expansion in organizations (Engeström, 2011). A unique feature of this method is that it unfolds by empowering the analysis of the situation made by participants themselves:

*The unit of analysis is usually a conceptual idea strictly for the researchers. In formative interventions, we turn the unit of analysis into an external auxiliary means, a mediating conceptual tool, for both the participants and the researchers. (Engeström, 2011, p. 608)*

Within the application of the method, the authors developed custom-tailored representation instruments to support the design process instead of using the cultural-historical activity theory models (Figure 2 and Figure 3) — as is usually done in formative interventions, since these models do not offer a clear guidance on representing activity in relation to space. The first two authors followed the meetings of the design activity, analyzed the design documentation, interviewed the project participants’, developed representation instruments, and joined design workshops as participant observers. They worked closely with the two managers of the project, who represented the client organization and led the design activity.

The interviews and workshops were video-recorded and notes were taken. The notes and documents collected were transferred to an Issue-Based Information System (IBIS) where they could be classified and graphically interlinked (Kunz & Rittel, 1970; Selvin et al., 2001). Each encounter the authors had with the designers and the users — online communication, interview, meeting, or workshop — was represented as a graphical map with old and new issues (Figure 4). These maps were composed of five types of nodes: issues (topics that endured long discussions), an issue’s advantages (arguments that try to close the discussion with a possible solution), an issue’s disadvantages (arguments that try to close the discussion with no clear solution), questions (interpretation doubts), observation notes (descriptions), and links to collected digital files. Other authors reviewed the recordings and the discussion among them produced new notes for the IBIS.
Figure 4 - Issue-Based Information System (IBIS) used to graphically analyze the qualitative data collected on the case study. Note: Each node in the map contains an issue (light bubble icon), an issue’s advantages (plus icon), an issue’s disadvantages (minus icon), a doubt (question mark icon), or a note (pen and paper icon).

The graphical maps were used to track how an issue developed throughout the intervention, in an effort to reveal traces of contraction and expansion in the representation of user activities. They were also shown to the project managers to report the partial account the researchers had at different moments of the project for validation, and to help them keeping track of what was being discussed in workshops. The graphical maps served as an intermediate step in the research process, being often consulted and updated, but never fully formalized. They were used mainly for keeping up with the big picture while analyzing data and developing representation instruments. The narrative that follows completes the qualitative data analysis, roughly based on the interaction analysis method (Jordan & Henderson, 1995). The theoretical concepts from cultural-historical activity theory —
operation, action, activity, collective subject, instrument, object, rules, and division of labour — are employed along the narrative to make sense of the historical process (Bødker, 1995).

4. From the business plan to the spatial conditions

The researchers began the intervention when the project was in the early design stages. Briefing had been completed and a floor plan served as the main representation of the object of design activity: the imaging centre space. The floor plan was designed and annotated by architects, machine providers, structural engineers, installation advisors, and the project managers, whom together constituted the collective subject of the design activity, from now on called “the designers”. Among them, the project managers had an active role in aggregating the design community, taking responsibility for briefing the users, elaborating the program, handling information from one designer to another, and also confronting their different perspectives. For these purposes, they organized a biweekly meeting and set up an online document sharing service.

The designers considered the requirements for user activities non-problematic at the beginning of the project and strived to meet the business plan, in particular, the list of diagnosing machines to be acquired and their expected income. They designed the facilities to host the machines according to national regulations and the expertise acquired in similar projects. This initial object of design presented complicated problems such as load bearing, radiation, high-energy consumption, and intense noise that kept the designers busy with the spatial conditions for many months. Designers were very collaborative with each other, but the professionals that are going to work in the centre were not directly involved, although they were considered in the design process.

The professionals included were medical imaging researchers, radiologists, radiographers, technicians, and nurses from the main hospital of two medium-sized cities, hereby called Northwest Hospital and Southeast Hospital (fictional names). The centre was to be located in a retrofitted building between the two cities and could serve as an outreach for both hospitals. The business plan relied on the idea of sharing diagnostic machines to promote
knowledge exchange between research and clinical practice. The professionals that are supposed to move to the centre constitute, in each hospital, a collective subject negotiating with the design activity, hereafter referred as “the users”.

The users were indirectly involved through individual interviews about spatial requirements conducted by the project managers. Based on that, the designers compiled a list of rooms (including information about medical equipment, square meters, adjacent rooms, daylight needs and the name of the user) which was circulated among the users for validation. The project managers realized their lack of understanding when the designers presented a first design full of undefined areas. Since it was not possible to meet all the requirements and their reasoning was not documented, the project managers could not decide what could be contracted in user activities to fit the spatial conditions.

In the meantime, the interviews triggered an informal discussion among the users about the motives for joining the imaging centre. When the project managers came back to them for a follow-up interview, they noticed disagreements. The users from Southeast Hospital were particularly sceptical about whether the centre would offer any advantage to them (as they already had similar machines at their own radiology and nuclear medicine departments). The users from Northwest Hospital were enthusiastic, but worried about the capacity of the centre to deal with patient complications during a scanning procedure. In any case, both manifested a concern about how sharing the machines would work.

To evaluate the current design and to make adjustments, the researchers suggested a workshop with at least one person present for each user activity. To give an example of what could be discussed during the workshop, a sample animation was created based on the floor plan depicting the usage schedule of the building by different activities, their costs, and revenues (Figure 5). The animation had five dimensions: the three dimensions of space plus time and money. This animation was not used in the project, but it reflects the authors’ understanding about the centre’s spatial and economic conditions at that point.
Figure 5 – Stills from the 5D animation about the building’s usage schedule. The rooms light up in colors to represent user activity while the income generated and operating costs are shown at the bottom.

The contraction of user activities represented by the designers and the authors (see Appendix I for a summary) did not help to address the issues raised by the users, as the issues were positioned at different levels of understanding activity. Before going through spatial conditions, the users wanted to discuss the motives and the goals behind each space, particularly the why and the how of sharing the diagnostic machines.

5. From spatial conditions to healthcare operations

Despite the offer from the researchers to organize a workshop with users, the project managers decided to organize one on their own. They sent an invitation letter to radiologists, radiographers, nurses, and technicians from the two hospitals, with the addition of two healthcare logistics experts and the authors. The letter set the explicit goal of planning the centre’s care logistics; however, the implicit goal was to raise commitment. The hospitals had not yet signed the collaboration contract with the centre, so they expected their involvement in design to contribute to that decision. Here, there was already a mismatch between the unit of analysis proposed to the workshop — care logistics, or in other words, operations — and the next level of development — an object that motivates the hospitals to expand their care activities to the centre.

The workshop began with a quick introduction of the business plan, the current project phase, and the importance of having the user evaluation. The project managers fixed a printed floor plan on the wall, stood beside it and explained the design rationale behind the floor plan, pointing to certain areas of interest.

As soon as the discussions became more intensive, all the participants stood up and came closer to the floor plan fixed on the wall (Figure 6). They began to question the proposed spatial
conditions by formulating potential problems with particular operations, based on their previous experience with similar spaces. Participants represented operations using verbal narratives while sliding their fingers over the printed document. The discussion jumped from one operation to the other, without considering the actions or activities they were subordinated to. Every time the conversation came back to an operation mentioned before, the operation had to be represented again, since the floor plan was not being marked in any way. There were actually some markers at the table, but the managers did not explicitly offer them to participants. In fact, they wanted to avoid as much as possible having to change the floor plan, since it would imply revising the complex system of electricity, heating, and air conditioning already set up.

The floor plan was designed with the assumption that activities do not overlap in space; each activity would use different diagnostic machines at different times. When participants noticed that there would be overlaps in space and also in time, the unit of analysis
jumped directly to activity: hospital professionals discussed which kind of patients they would send to the centre (their object), the regulations that would apply (their rules), and how the two hospital would work together (their division of labour). There was a major doubt if the capacity of the shared waiting and dressing rooms would be sufficient to keep machines busy with patients in both hospital areas, a doubt aggravated by the double-function of these rooms as circulation hubs. The bottom line was that the activities intersect in space and the subjects were unaware of how they would interfere with the operations of each other. The workshop concluded with many unresolved issues.

The project managers were quite surprised by the results, but they did not complain about the fact that the workshop drifted away from logistics to space, which had been considered adequately resolved prior to the session. They were happy to learn more about the user activities, but worried about the necessary rework on their design. Their initial focus was on the operation level — improving the logistics, but the conversation expanded and contracted throughout the levels without a clear guide (Appendix I).

6. From healthcare operations to individual actions

The project managers then decided to organize a second workshop with the same participants to pursue the issues that had been raised. In the meantime, they also visited the two hospitals to improve their own understanding of the user activities and their current space. They observed the positions of the machines, the corridor widths, the number of dressing rooms, and experienced the space with their own bodies. Nurses and radiographers helped them to understand the goals supported by this particular spatial design. The project managers then showed their own design plans and asked for suggestions on an individual basis. Later, the project managers came back to the design community and asked them to make changes in the floor plan based on their interpretation of users’ actions and goals, which was compiled in a linear workflow diagram.

The design options were consolidated in one major redesign of the facility. For second workshop, the project managers sought the research team’s assistance. The researchers suggested letting
users represent their own activities and interfere with the object of design: space. Since the project managers were afraid that the discussion could drift from the intended scope, the researchers suggested guiding the discussion with an instrument other than the printed floor plan, as the plan only represented the spatial conditions but not the operations.

Instead of a floor plan, it was suggested to use discrete-event simulation of a typical day in the centre. The simulation had the machines arranged in the same way as the spatial layout which took into account the walking time of nurses and patients in the performance measure. However, the simulation did not take into account possible delays, deviating behaviour and walking detours. The intention was that the doubt concerning the number of dressing rooms could be clarified by simulating the care procedures with the number of patients expected per day by the business plan. The simulation output was an animation video of a typical day in the medical imaging centre (Figure 7), plus the resulting performance in figures such as the percentage of machine and room capacity used.

Figure 7 - Simulation of the scanning procedures of the imaging centre.
Source: Courtesy of FlexSim Software Products, Inc

The simulation was based on the steps that patients and staff are supposed to follow in the scanning procedures of each machine,
as prescribed in the workflow diagram. The diagram did not specify where in space each step happened, so this entailed guessing by the researchers where to route patients and nurses. Here, again, there was a mismatch between the next level of development — actions and goals — and the unit of analysis used for representing — step-by-step operations.

The researchers considered the possibility of using the simulation during the workshop as a collaborative instrument to expand representation through discussion and iteration. The participants would suggest new parameters and the simulation would show the consequences on performance, instigating to consider goals. However, the software user interface proved to be too complicated for quick use in such an interaction. The software was probably not designed for that purpose, but the simulation was shown during the second workshop, without the possibility of changing the parameters, just to support the managers’ argument that the number of dressing rooms was enough for the expected number of patients.

The project managers’ visit to the hospitals can be considered an expansion in understanding user activities; however, the instruments used to document that experience did not cope with the expansion: activities were represented as a series of steps, with little information about space, object, instruments, rules, community, and division of labour (Appendix I).

7. From individual actions to collective activities

After realizing the limitations of the simulation to represent actions, the researchers created a low-tech version of the simulation that looked more like a game. Pushpins were attached to each room of the floor plan, and sewing strings were offered to represent the movement of nurses and patients. This instrument is similar to what Grunden and Hagood (2012, p. 109) used in their lean healthcare design: the subjects are supposed to tie and untie the strings while discussing how to optimize a particular action flow. String colours represented different persons walking around the building. The tool was named “the knitting game”, since the hand movements required to use the tool resemble knitting operations (Figure 8). The goal was to represent and optimize the flow of patients and nurses in the scanning action, avoiding back
and forth movement. The material itself imposed the rules: each step in the flow must depart from and arrive at pushpins otherwise they are loosely represented. Since the project managers wanted to avoid users to propose changes in the floor plan, there was this physical distance between the paper and the strings lifted by the pins. Stretching the strings between the pins actually required more than two hands, what purposefully underlined the collaborative nature of the representation. Though the game did not have a winning objective, there were goals, rules, and roles.

![Figure 8 - Knitting game made by the CT scan group. Note: The blue lines are nurse movements and the green are patients. Room labels are overlaid to the picture for readability.](image)

The game was introduced right after the simulation. Project managers divided the participants into two groups, according to the actions under consideration: CT scan and MRI scan. The CT scan group visualized the central role of the dressing rooms in the process and discovered the back-and-forth movement of the nurse between the technical room and the CT scanner, but they did not question the designed space. On the other hand, the MRI scanner group found so many problems in the space that they actually refused to play the game. One of the main complaints was about the space around doors and corridors, too tight to manoeuvre patients on stretchers.
As the discussion within the MRI group was stuck, the CT scan knitting game was brought to the MRI group table to create a combined version. The game helped the MRI group reflect in a more positive way about the design. At some point, a radiologist from the MRI group asked for a sheet of paper from the architect’s notebook and sketched an alternative concept for the area between the CT and MRI machines while asking other participants for their contributions (Figure 9). The sketch opened up a corridor that connected once separated actions — CT scan and MRI scan.

While making the sketch together, the professionals from the two hospitals considered new issues, such as the division of labour between researchers, radiologists, and radiographers in scan monitoring and producing images. Although they had different rooms for each action in their hospitals, they were in doubt if this was also necessary in this facility. A researcher from the Northwest Hospital suggested a single room integrating both functions, as this would allow researchers to eventually look at image post-processing and talk to the technicians. The radiologist from Southwest Hospital was sceptical whether this collaboration could happen and was worried that researchers could put too much pressure on technicians. The issue was not resolved during the workshop, but the suggestion of an integrated room was incorporated by the designers later.

Rethinking the floor plan was not what the project managers had in mind, but they realized that this was necessary to proceed forward to arrive at a more detailed design. They asked other members of the design community to incorporate the sketch in the drawings, while the hospital professionals took a break to visit the construction site, i.e. the existing building that would be altered. There they experimented with their own bodies the spatial dimensions represented by the floor plan — e.g. how large were the rooms and the corridors. The project managers guided them through the main outside operations: arriving, parking, entering the building, etc. When the healthcare professionals returned, the designers’ sketches were presented and a new round of discussions and adjustments occurred. At the end of the workshop, the project managers could reach the desired agreement with the designers’ sketch done over the floor plan. The users’ sketch expanded user activities to capture the motives
raised, while the designers’ sketch consolidated them in tangible goals (Appendix I).

Figure 9 – Healthcare professionals sketch a new concept (a) and later the design team incorporates it in the drawings (b).

The second workshop was considered successful by both organizers and participants. The organizers had the level of
agreement and information they needed to move the project forward while the healthcare professionals enjoyed sharing knowledge and learning how others conducted the same actions differently in their hospitals of origin. Most important, they felt much more committed to and excited about the project.

8. Intervention outcomes

In a conversation with the authors during the construction site visit, the hospital professionals revealed that they did not understand very well what was occurring in the discrete-event simulation shown at the beginning. The animation played too fast and the underlying assumptions were not clear. The professionals did not question the animation since the value of joining the project was still not clear to them. The simulation shown at the workshop did not represent an object they would like to commit to at that stage.

The workshop became interesting when they had the chance of participating in the design of space. Space became a context for exchanging knowledge between the two hospitals, the machine providers, and architects. One radiologist from the Southwest Hospital mentioned that it took almost one year to achieve the same level of understanding with architects in their own hospital rebuild project, what was achieved in just two workshops in the medical imaging centre project. Such knowledge exchange was seen by both hospitals as the biggest advantage offered by the medical imaging centre, since they all pursued their own radiology and nuclear medicine departments, with more or less the same machines. They were more motivated by learning from each other, from researchers, from operation experts, and from machine providers than by the extra capacity incentive offered by a new outreach facility.

The project managers also realized this fact on their own, and made sure that the contributions would be implemented in the official drawings. The concept of the common corridor between the CT and MRI scans was, thus, expanded to the whole plan, integrating the Northwest Hospital’s PET-MRI and SPECT areas. The comparison between the official drawings before and after the workshops (Figure 10) reveals a dramatic increase of floor area dedicated to circulation and shared facilities.
Figure 10 - The floor plan before (a) and after (b) the workshop. A larger amount of circulation now connects the once separate hospital activities. Source: Drawn by the authors based on video stills of the original documents.
The managers explained that this corridor allows for greater flexibility, since the dressing rooms can be used by both hospitals when necessary. The participants believe that the extra circulation might increase the visibility of actions (entering or going out of a room), and therefore awareness, a very important feature for coordination — at the expense of patient’s privacy. There is also a greater probability of informal encounters and exchanges between the professionals in this corridor. The spatial strategy of visual relations and flexible zoning suggested by a study in a radiology department seems to apply here (Tellioğlu & Wagner, 2001).

9. The role of space in expanding the representation of user activities

Workshop participants acted as if space was the fundamental underpinning to the consumption, production, and distribution of knowledge by the centre; however the researchers did not know exactly how to classify space within the theoretical framework. Is space an object, an outcome, an instrument, a division of labour, or simply a rule? The few studies in cultural-historical activity theory that explicitly deal with space (Engeström, 2003a, 2003b; Gutierrez, 1999; Popov, 2010) are quite vague on how to approach space, with one exception (Leander, 2002).

A criticism that could be posed to this study is that the empirical observation focuses too much on the actions of certain individuals, reducing the collective level — activity — to a matter of switching contexts. The medical imaging centre case study has

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2 This study documents the construction in a high school of a replica of the wooden cabin used by Henry Thoreau to write *Walden, or Life in the Woods*. The traditional schooling object — the text — was expanded to a physical representation of the text — the cabin, which actually became more than just representation when being produced by students and teachers. Their wood shop became an alternative context to the classroom, where students and teachers did not need to follow the conventional schooling script of representing knowledge in the form of speech or text. The physical contact with materials allowed them to explore their own bodies to represent knowledge about the object: the wooden cabin and everything else it represents. Space was, then, considered an object in the study.
shown that the expansion of the unit of analysis from operations to activities, and their corresponding orientation, from conditions to motives, can reveal more about activity as a subject and space as an object. Users have mitigated positioning their activities as collective subjects demanding changes in space to the designers, who responded by sharing the object of design with users. Space was reconsidered from a mere instrument for use to an essential object for social production.

A theory that has been quite influential in architecture to consider space in this way is the production of space, which departs from the notion that space is constantly being produced by collective activities and vice-versa (Lefebvre, 1991). Instead of a framework or a system, this theory offers a conceptual triad between the spatial practices that (re)produce the material conditions of life, the representations of space that impose an order to these practices, and the spaces of representations where people find meaning for the everyday life. The terminological inversion between the last two is deliberate: they are opposites, though deeply interlinked by the spatial practices. Architecture, as a spatial practice, is expected to produce works that represent society and, if successful, those works can be (re)represented in many ways by other spatial practices, thus becoming a space of representations. Notwithstanding, architecture must take into account the diverse representations of society that are already present in society to produce such a multifarious work (Lefebvre, 1983, p. 247).

The theory of the production of space has inspired many architects to become more sensitive to social issues (Stanek, 2011) without offering much design guidance, what limits its relevance to practice (Hillier, 2008). The production of space theory can perhaps help clarify the challenge of representing user activities and designing space observed in the case study if the triad is integrated into the shared object model (Figure 3),

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3 The translation “spaces of representation” is adopted (from the French “espaces de représentation”) as preferred by recent scholars (Schmid, 2008, p. 44; Soja, 1996, p. 30; Stanek, 2011, p. 81) against the “representational space” used by the official English translation (Lefebvre, 1991).
becoming the initial, the expanded, and the shared object between activities (Figure 11).

In the case study, the designers were initially very concerned about developing a buildable and believable representation of space, which includes the floor plan and the construction site visited during the second workshop. On the other side, the users were just reproducing their current spatial practices while evaluating the representations of space. The users found it difficult to think about working in such a different space. The expansion of the design activity towards the users’ spatial practices is synchronized with the expansion of the user activities towards the representations of space, which produced the collaborative sketch of a representation of space that embeds not only designer’s knowledge, but also user’s knowledge.

These encounters all happened in a temporary space, a continuum between the places that held the interviews, the workshops, the document sharing, and the small talk related to the project. In this temporary space, subjects took positions and represented their activities. This space was nothing less, nothing more, than the medical imaging centre itself, not yet a building, but already a set of social relationships, a produced space. The shared object between the design activity and the user activity can be considered a space of representations, where subjects...
found the meaning and invested motives for developing this project together.

The shared object did not automatically emerge from the encounter and can still fade after the intervention. Object expansion is neither linear nor stable (Engeström, 2003a, 2005). However, in this case the researchers think it could last longer if the designers adopt a collaborative approach with the users, i.e. participatory design (Sanoff, 2006). The degree of participation in this project can be considered low since users were involved too late, when most of the decisions were already made. Nonetheless, it made a big impact in the project. If the shared object is preserved until the building is completed and the facilities are used, then it will possibly ground the formation of a new self-standing activity that encompasses the medical imaging centre as a whole community, integrating imaging research, technology development, teaching, and care, as envisioned by the business plan.

10. Discussion

The constant shift of unit of analysis by participants and researchers during workshops generated not only knowledge, but also confusion. New instruments were developed without knowing their full potential for representing activity. On several occasions, the activity was contracted, instead of expanded by the representation. The project timeframe did not allow the participants to learn much about that. In other design projects, the expansion of activity representation may not necessarily go through all the levels mentioned in this paper, and it is unlikely to be in the same order. The intervention performed is very limited to understand how expansion happens in design projects because of its time frame. Formative interventions usually track a project across many years, since expansion may stop and continue later (Engeström, 2011). Future studies on the representation of user activities should examine how expansion triggered by participation in design can be sustained after design implementation.

Architects recognize that representations of space can never fully represent what users will experience (Luck, 2007), but the case study findings suggest that if the design object is expanded
towards spatial practices, then the experience becomes actual: designers and users talk as if the building was already there (Luck & McDonnell, 2006). Instead of reification of an abstract concept, the representations of space are already as material as the spatial practices they imply, since they are produced under very concrete economic, political, and cultural conditions. Following Lefebvre, representations can be understood as concrete abstractions (Lefebvre, 1983, 1991).

Apart from this study, the role of the representations of space in activity development remains unexplored. Leander (2002) observes that space has been considered merely metaphorically in cultural-historical activity theory, expressed in concepts such as expansion (Engeström, 2015), zone of proximal development (Cole, 1985), and third space (Gutierrez, 1999). He suggests that — as we did in this study — these concepts are employed to understand the material production of space, a necessary step to avoid losing the empirical ground of the field to an increasingly complex abstract space of theoretical concepts (Lefebvre, 1991). Cultural-historical activity theory has been described as difficult to support a design practice due to its theoretical complexity (Mwanza, 2000). However, this case study showed it was applicable along a formative intervention. Cultural-historical activity theory could guide the representation of user activities in a context of uncertainty without hinging on reductionism — in this case, the imposition of contracted units of analysis. The intervention participants took over the unit of analysis and represented their activities in a different level than what the researchers proposed, what ultimately led to the expansion of their own activities.

Altogether, formative intervention seems to be an interesting method to further develop a user-centred theory of the built environment (Vischer, 2008). Being grounded in the process of change, formative intervention can show how and when the design of space became user-centred, or even, participatory (Sanoff, 2006). Instead of focusing either on the impact of space or on the impact of activity in each other, formative intervention can approach space and activity in a dialectical relationship, revealing how they mutually constitute in practice. The focus is expanded beyond space’s capacity to support user activities to the
user’s capacity to produce space, or in a word, spatial agency (Awan, Schneider, & Till, 2011).

The recognition of user agency before, during, and after design clarifies why users cannot simply convey their needs to designers: users are the ones who, in the end, are going to fulfil their needs through the production of their own space. In the case study, the user needs were clarified when the object that can fulfil them — the imaging centre — became available to them. The question of user needs is a typical case of expansive learning (Engeström, 2015; Miettinen & Hasu, 2002): the needs are not yet there; they are learnt while being produced.

11. Recommendations

The representation of user activities for the design of space requires dealing with multiple instruments and units of analysis. In a workshop, trying to keep participants focused on one instrument and one unit of analysis might generate confusion and disagreement when participants try to push its boundaries. In some situations, keeping the instrument, but changing the unit of analysis is enough to create a productive discussion. That is what participants did when the floor plan was used to discuss actions’ consequences instead of just optimizing operations. In other situations, the instrument must be replaced to deepen the understanding of the same unit of analysis, such as when researchers switched from the floor plan used to learn about conditions to the healthcare simulator that explored operations. And there are situations when both need to be replaced: e.g. when the participants moved from a discussion on optimizing workflow towards sketching a spatial connection between different activities.

The practical challenge is to perceive the appropriate moment to switch the instrument or shift the unit of analysis. This is not possible to know in advance, as what the instruments are trying to represent — user activities — are developing and changing by being or by not being represented. What is possible to do is to critically evaluate the representation instruments to ascertain if they are tuned to the unit of analysis that follows the next step of development for user activities. Replacing, adjusting, and reframing the instrument should seek to expand user activities.
rather than contracting, although contraction might be necessary before expansion.

Due to this instability, following a top-down representation (i.e. disaggregating activity into nested categories such as actions inside activities and operations inside actions) is not recommended here despite this being suggested by some authors (Kim et al., 2013; Lou et al., 2006; Perin, 1970; Shen et al., 2013; Thiel, 1997). Nor is a bottom-up representation, as it happened in the studied case. The recommendation is to have the users participating in representing, creating instruments and being able to shift the unit of analysis when necessary. As such, representations become the presence, not the absence of users (Lefebvre, 1983).

12. Conclusions

This study adds to the discussion about the role of representations in collaborative design (Bendixen & Koch, 2007; Ewenstein & Whyte, 2007; Whyte et al., 2007) and participatory design (Bødker, 1998; Christiansson et al., 2011; Luck, 2003, 2007, 2012). It described the process of expanding the representation of user activities from the operation level (oriented to spatial conditions) to the action level (oriented to strategic goals) and to the activity level (oriented to motives). At the activity level, it was possible to see a connection between different activities by a jointly constructed, shared object. This object not only connects the user activities to each other, but also the design activity to the user activities, promoting their mutual learning (Béguin, 2003; Bødker & Grønbæk, 1996a).

The unfolding characteristic of expansion replaces the problem of not knowing the future by the problem of finding the objects, the instruments, and the units of analysis that can anticipate activity development. Anticipation here does not mean producing abstract knowledge such as predictions, simulations, and scenarios but actually departing from them to build concrete social relationships such as commitment, learning, and space. In the case described, the representations of space were brought from their abstract origin to a concrete emancipatory purpose, working as springboard to expansion (Engeström, 2015) instead of just restricting behaviour, as it is usually done by design (Lefebvre,
By ascending from the abstract to the concrete through design participation, users can control their own activities from an outside perspective using representation instruments. Henceforth, representations of activity and representations of space do not stand anymore for an absent community because this community is present, anticipating the appropriation of space that typically happens only after design is implemented. Participation in design may lead to the formation of a shared object between the design activity and the user activities which can, ultimately, ground the formation of a new activity, with more advanced spatial practices, representations of space, and spaces of representation.

In the context of design, space has the potential to anticipate activity development and ground the formation of new activities. However; in order to grasp space as lived by users, it is necessary to see the human body as producing, not only occupying space (Lefebvre, 1991, p. 170). The implication for the design of space is that to be consistent with user activities, space must be produced by these same activities. In a methodological sense, this means that activity and space can only be fully grasped in-the-making. By and large, design arises as a privileged practice to study the role of representations of space in activity development and the role of representations of activity in the production of space.
Chapter 2

Games to explore the possibilities of space and the space of possibilities in service design

The first chapter of this thesis described the expansion of the design object towards the space of representations with particular attention being paid to the instruments used to assist the expansion. The analysis has focused on architectural design. Nevertheless, many issues raised are beyond the scope of this discipline. The next chapter looks at the same medical imaging centre project, together with two more projects: the nurse wards from a regional hospital and the community centre for environmental education/leisure in a small city. These projects can be viewed as being related to service design, which is an emerging discipline that, like architectural design, merges concerns for space and concerns for activity.

The aim of service design is to create and improve services from the perspective of its users. This is done through inviting users to collaborate with the designers by means of co-design tools, such as games. These games are employed to help users grasp the materiality of services — often described as intangible goods. This chapter introduces a conceptual triad to understand how games are used in service design to explore new ideas and, also, to transform the activities that produce the service — the backstage activities. The findings from applying this triad to the three aforementioned cases draw attention to the discovery of possibilities of space never conceptualised before playing the design games.

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4 This chapter, co-authored with Julia Garde, has been accepted for publication in the Special Issue “Service Design Games” of Simulation & Gaming journal.
1. Introduction

Services are generally considered intangible because they are not bound to an objective physical reality (Bebko, 2000). However, services are also believed to produce an artificial space that shapes the providers’ and the customers’ actions (Bitner, 1992). This contradiction between the tangibility and the intangibility of services has been a major challenge for designing services. On the one hand it is not possible to design services as fixed spaces, but on the other hand it is also not possible to design services as procedures detached from physical grounding.

To the best of our knowledge, the available literature related to services does not tackle this contradiction. Authors recommend stimulating value co-creation between customers and providers (Prahalad & Ramaswamy, 2004; Ramirez, 1999), changing the logic of doing business from delivering products to offering services (Vargo, Maglio, & Akaka, 2008), and systematically analyzing the constellation of resources that constitutes services as a complex system (Maglio, Vargo, Caswell, & Spohrer, 2009). They do not address the tangible aspects of services. The service design approach is perhaps an exception, taking into account both the tangible and the intangible aspects: people, infrastructure, communication, and artifacts (Mager, 2008; Polaine, Løvlie, & Reason, 2013; Stickdorn et al., 2011).

To identify, plan, and organize these aspects, the service design literature recommends organizing co-design sessions with all the stakeholders involved in the design process (Steen, Manschot, & Koning, 2011). In these sessions, specific tools are used to organize the stakeholder participation in the design, such as customer journey mapping (Nenonen & Rasila, 2008), storytelling (van Hulst, 2012), and bodystorming (Oulasvirta, Kurvinen, & Kankainen, 2003).

This study focuses on one type of tool in particular: the design game. A design game is a playful activity in which the service stakeholders receive design tasks to be collectively developed under pre-defined rules. Design games employ well-known board games techniques such as role-playing, turn-taking, and make-believe “to deliberately trigger participants’ imagination as a source of design ideas” (Vaajakallio, 2012, p. 218). They are
typically less structured than leisure games, but draw elements from them to familiarize stakeholders with the design tasks. The main difference between leisure games and design games is that the latter aim at producing outcomes that may affect the stakeholders beyond the game.

Design games are used in service design to perform in three ways: as a tool, a mindset or a structure (Vaajakallio & Mattelmäki, 2014; Vaajakallio, 2012). For project managers, the design game is a tool to identify stakeholder expectations, whereas for the game designer, the design game is a structure for the co-design session. These two ways are very different from the way the players experience a design game, for them the game is a mindset to imagine or transcend ordinary life. These three ways point to the emergent performance of design games.

So far, research in service design games has mainly drawn attention to the games’ potential to support the exploration of design options (Brandt, Messeter, & Binder, 2008, p. 54), leaving to a secondary place the potential to change the social relationships between the stakeholders. This can be attributed in part due to the intangible way services are represented in these games — logical diagrams, flowcharts, or rules — and in part due to the way the games are played, as uncommitted exercises of creativity with people that may not even have strong stakes in the service.

Such lack of commitment may be symptomatic to the split between play and work promoted by protestant ethics (Kane, 2005) and organizational functionalism (Sorensen & Spoelstra, 2011). In those perspectives, play is considered an activity that steps outside of the ordinary to establish its own stakes (Huizinga, 1955). The world can be imagined and enacted completely different, but if a player brings in an outside stake, the magic circle that sustains play activity is broken and everybody is back to his or her normal activities and roles. Play is meant to represent, not change the everyday life.

In contraposition to these perspectives, this study aims to highlight the transformative potential of games in service design by presenting theoretical and case evidence. The first part proposes a conceptual triad to understand games as a space for
action (Lefebvre, 1991, 2014a) and play as a creative activity (Vygotsky, 1967, 2004). The triad is then applied to analyze three co-design projects wherein games help to design services: medical imaging diagnosis, hospital care, and environmental education/leisure. At the end, a cross-case analysis provides insight on the transformative potential of design games at work.

2. Space and games in service design

In comparison to industrial design and interaction design, service design is considered to have a stronger spatial component (Holmlid, 2007). In spite of that difference, little is known about how to deal with this spatial component in design. A common approach to grasp space in service design is to map the spaces where the service interactions take place (Nenonen & Rasila, 2008), however, these spaces are not necessarily questioned through mapping. Mapping takes space for granted, i.e. as a given that service must be adapted to. The implication is that space is hardly taken seriously as something to be designed together with other aspects that are typically associated with service design: touchpoints, frontstage/backstage, roles, and wayfinding.

One possible explanation for this neglect may be the dominant perspective on how space is understood in modern society: as a ready-made physical form that merely contains furniture and people (Lefebvre, 1991). Within this perspective, it makes sense to leave space outside of the scope of service design, since architects, interior designers, and business developers already have firm grounds on this object. From an alternative perspective, space can be considered a set of social relationships such as distance, demarcation, boundaries, enclosure, centrality, and segregation (Lefebvre, 1991). Architects, interior designers, and business developers often overlook these relationships because they cannot be easily set on stone. In fact, the people who actually enact the service in practice are constantly reshaping these relationships.

This perspective provides an explanation why service design often relies on co-design as a method for designing services. The people who provide or use the service — the stakeholders — are the ones who are going to produce the space of service design. Therefore, it makes a lot of sense to include these people in
designing the means of production for that space. In spite of that, the discussions around space in co-design research are still limited to the space of problems, solutions, options, and alternatives, also known as design space (Botero, 2013). Co-design is believed to expand this space with the ideas and insights generated by stakeholders that have a different perspective than service designers, architects, interior designers, and business developers. This metaphorical design space is, nevertheless, very abstract and can easily become completely detached from the actual possibilities of implementing changes.

Design games are typically introduced in co-design sessions precisely to avoid the detachment between the abstract space of idea-generation and the concrete space of implementation (Vaajakallio, 2012, p. 79). The simple materials these games are based on — board, tokens, cards, and others — do more than representing the space of service design, they actually participate in design with their resistances, affordances, and associated meanings (Eriksen, 2012), working as pivot for stakeholders’ actions. Despite this ideal of concreteness the realistic depiction of space is believed to prevent the discovery of new possibilities due to fixed meanings (Kronqvist, Erving, & Leinonen, 2013). Hence space being represented in a metaphorical way. A case in point is LANDSCAPE (Halse, Brandt, Clark, & Binder, 2010), a game that represents office space as a series of concentric circles.

The design games included in the present study adopt the representations of space generated by architects as game boards. This was decided due to the stakeholder’s need to learn, evaluate, or change the architect’s design. In fact, the stakeholders were expected to take action about the meanings fixed by the architect during or after playing the game. A realistic representation was essential to achieve this, although some less realistic representations were also employed.

3. Game spatiality

From this initial scenario, we assume that playing design games can have consequences beyond the scope of designing services, as part of the ongoing production of space in work. To sustain this assumption in theoretical grounds, we need an intermediate concept between the space of conceptual ideas and the space of
physical experiences. This concept should allow grasping the materiality of design games as much as the interactive process of playing them. The existing concepts of play-ground (Huizinga, 1955), magic circle (Salen & Zimmerman, 2004), and playspaces (Walz, 2010) can already do that, but they focus more on the characteristics of space, rather than on the production of space, which is our focus here. In line with the production of space theory (Lefebvre, 1991), we expand further the concept of game spatiality proposed by Wood (2012).

The concept of game spatiality is derived from the production of space theory, which states a triad between the perceived, the conceived, and the lived spaces (Lefebvre, 1991). The conceived space is a mental arrangement of form, function, and structure that intervenes in the world by means of construction. It interacts with the perceived space — the social conventions to use space, where to go, how to move, ownership, etc. — and the lived space — the actual experienced space by its users, with all the meanings, emotions, and other symbolic relationships that users produces within that space. These spaces are not produced in a linear order, but all at the same time and nonstop.

With the purpose of bringing this theory closer to game studies and service design, we have reduced the scope of the triad: the conceived space corresponds to the *space of possibilities*, the lived space to the *possibilities of space*, and the perceived space to the *game spatiality*. The terminology inversion between space and possibilities is a recourse often used in the production of space theory to grasp the dialectics between two opposing elements that interpenetrate each other (Lefebvre, 1983).

Game spatiality is the sense of being in a social space produced while playing a particular game. It is gradually developed by the bodily actions of players trying to understand the game mechanics, position themselves in the game, and act meaningfully. These actions involve seeing and touching the physical parts of the game — tokens, boards, cards, etc., accelerating or slowing down the rhythm of play, listening and responding to other players’ talk, and eventually gesticulating, standing up, bending, and coming closer to another player.
Whereas the sense of being in physical space is given by the proprioceptive muscular-nerve system — which can be measured by kinesthesia tests (Swink, 2009; Walz, 2010), the sense of being in social space is much more complicated to pinpoint (Oksanen, 2013). This social space cannot be measured entirely by regular scales such as extension and volume, for the distances might be based on a different scale — e.g. a qualitative scale. For instance, when two players develop an antagonistic relationship with one another they do not need to demarcate physical distance to reflect social distance. Yet, the distance might become visible by an outburst triggered by a rule-breaking action.

Interesting enough, this social distance may be different in the game and outside of play, when the players might be really close friends. Play has this attractive feature of enacting social relationships different from what players are bound or accustomed to in other activities (Huizinga, 1955; Vygotsky, 1967). Distance is not the only relationship that can be modified in play though; the possibilities of space encompass coexistence, encounter, imagination, demarcation, and attachment (Lefebvre, 1991), just to mention a few. Players develop these possibilities as they play, not necessarily in a conscious way, limiting and enabling their actions way beyond what game rules prescribe.

Due to the recursive nature of game rhythm, every action in a game changes the possibilities for the subsequent actions (Wood, 2012). Some possibilities may be discussed among the players, some may be considered in player’s thoughts, but the vast majority will remain unexplored. The possibilities considered by players and game designers constitute the *space of possibilities* and the actual possibilities for action constitute the *possibilities of space* (Figure 1).

On this regard, Salen and Zimmerman (2004, p. 165) state that “playing a game is synonymous with exploring a game’s space of possibility” and that “defining this space is the collaborative work of the game design process”. We developed the counter notion of possibilities of space to highlight that players produce space as much as designers do. The space of possibilities may be pre-defined and structured by the rules, quantifiable outcomes, and necessary choices, but the possibilities of space emerge from the transformations in the collective social history. Players can do
more than use the possibilities of space predefined by the designer; they can create other possibilities. In comparison, the space of possibilities is not just smaller than the possibilities of space, but also of a different quality: abstract, speculative and arbitrary.

Game spatiality lies in between those two poles, mediating their production. The more immersed players are in game spatiality, the more they might bring the possibilities of space to the space of possibilities, where they are anticipated, evaluated, and strategized. Game spatiality has, therefore, the potential to expand the space of possibilities when facing gameplay breakdowns and the potential to expand the possibilities of space by directly changing game conditions, such as purposefully rolling a dice out of the table to destabilize chance.

Figure 1 - Game spatiality is produced by the player’s interaction with the possibilities of space offered by the game and the space of possibilities considered by the designers as well as by the players.

4. Play as creative activity

Design games are useful to realize the space of possibilities because they establish a difference between play and work so
that new relationships can be experimented with. However, design games are also useful to keep participants focused on the work activity as an object to be designed. Through exploratory actions, players bring the work activity into play, reconstructing the activity in the imagination. Because they can leave out their customary roles and power relationships, they can also reach a sense of estrangement and detachment from the activity, enabling them to be more critical and willing to change.

Play is, on the one hand, an opportunity to step outside of the ordinary (Huizinga, 1955), and, on the other hand, an opportunity to change the ordinary. It is not the mere reproduction of an activity; it is the creation of a new activity through imagination (Vygotsky, 1967). This becomes explicit in a modality of play called transformative social play. “Players use the game context to transform social relationships. They actively engage with the rule system of a game, manipulating it in order to shift, extend, or subvert their relations with other players” (Salen & Zimmerman, 2006, p.475). In this modality, player’s actions are targeted at the activity being played, not the play activity itself. For example: players raise commitment for the implementation of agreed upon possibilities (Botero, 2013), or they use the game to amplify their spatial agency — the capacity to alter spatial conditions (Awan et al., 2011) — or even transgress the rules of the activity (Schick, 2008; Zaphiris & Wilson, 2010). These actions might trigger further changes in the activity after playing.

Figure 2 – Through design games, play activity becomes a microcosm of work activity, connected to each other by exploratory and transformative actions.
Table 1 – A conceptual triad to understand the production of game spatiality in design games.

<table>
<thead>
<tr>
<th>Space of possibilities</th>
<th>Game spatiality</th>
<th>Possibilities of space</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of space</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract, mental, related to structure.</td>
<td>Tangible abstraction, physical, related to form.</td>
<td>Subjective, social, concrete, related to function.</td>
</tr>
<tr>
<td><strong>Board game props</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rules, quantifiable outcomes, abstract models.</td>
<td>Tokens, game mechanics, turn.</td>
<td>Plot, characters, chance.</td>
</tr>
<tr>
<td><strong>Exploratory actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mapping ideas, comparing elements and strategizing.</td>
<td>Tracing, marking, and touching game materials.</td>
<td>Role playing and storytelling</td>
</tr>
<tr>
<td><strong>Transformative actions</strong></td>
<td>Commitment to implementation.</td>
<td>Altering spatial conditions.</td>
</tr>
<tr>
<td><strong>Spatial relationships</strong></td>
<td>Problems, solutions, perspectives, scenarios, constraints, visions, insights.</td>
<td>Proximity, centrality, property, movement, synchronicity, segregation, visibility, flow, awareness.</td>
</tr>
</tbody>
</table>

We propose a model for design games in which play becomes a microcosm for experimenting change in work (Figure 2). Work is brought to play by exploratory actions and play is brought to work by transformative actions. Exploratory actions are more concerned with the space of possibilities, whereas transformative actions are more concerned with the possibilities of space; however, they are not fixed to that. Both actions produce certain
spatial relationships. For example, an exploratory action may sort out options to make a decision, while the transformative action that follows it — the decision itself — may increase or decrease the power imbalance between the decision-makers and the other players.

Exploratory and transformative actions constitute play as a creative activity. They may be triggered by game spatiality and be directed to the space of possibilities as well as the possibilities of space. Notwithstanding, these actions may also occur in the absence of a formal game. Co-design sessions, if they succeed in their intent to imagine and change other activities, can be considered play activities even if no design game is employed. For an overview of the conceptual triad and the associated actions, see Table 1.

5. Research method

To evaluate the conceptual triad’s power in explicating design games, we have selected three cases of service design projects in which we had a chance to design such games and observe the play activity. Our involvement began by interviewing project managers and designers, followed by observations of stakeholder meetings. When appropriate, we suggested including more stakeholders through co-design sessions — in particular customers and the people who deliver the services. Doing so, we argued that services could be designed based on the needs, requirements and change processes expressed by the stakeholders (King, Conley, Latimer, & Ferrari, 1989; Sanders & Stappers, 2008; Steen et al., 2011). We designed custom-tailored games to represent premises in a way they could be modified and extended by players, yet the initial game state was based on our own interpretation of the issues raised during the interviews. The sessions were video-recorded and later analyzed from a more detached viewpoint.

The analysis roughly followed the interaction analysis method (Jordan & Henderson, 1995). We selected a few minutes of recording from each project to watch together and discussed what we were seeing. These were specific moments when game spatiality was visibly being produced — mostly at the start of a game. The data interpretation is also based on the collected
project documentation, the written notes taken during interviews and meetings, and still pictures.

The case studies that follow are based on our individual accounts, with some additional layer of interpretation provided by the shared discussion. Along the case descriptions, the conceptual triad will be used to punctuate the process and highlight the production of game spatiality. The specific spatial relationships will be mentioned in the text or highlighted in parenthesis. A comprehensive application of the triad can be found in the subsequent cross-case analysis.

6. Case 1 – Hospital wards

The first case is about the development of nursing procedures for a new hospital building in the Netherlands. The development was triggered by a decision from the board of directors that in the new wards there will be only single patient rooms. This represents a major change in relation to the current situation with two-to-five patients’ rooms. Early in the design phase, architects used drawings to discuss with wards’ representatives; however, by looking at the maps, the representatives could not grasp the possibilities of space for the nurse work. Some staff members had concerns about the design, such as whether there would be enough overview of the patients and whether patients would suffer from solitude, but these concerns were not included in the space of possibilities. The development of nursing procedures came too late to alter the architectural design, but it opened up the possibility for implementing new technologies with the participation of their users.

In order to explore the space of possibilities set by the architects and to realize the possibilities of space for nursing procedures, a series of co-design sessions were organized in the hospital by the second author, in collaboration with a member from the board of directors. A design game has been developed for these sessions: HEAD, the Healthcare Environment & Activity Design Game. The game is a combination of free miniature roleplaying (Urnes, Weltzien, & Zanussi, 2002) and structured task analysis (Lafrenière, 1996; Muller, 2001). The miniature environment corresponds to a physical representation of the people, products, and spaces involved in the nursing work, whereas the task analysis
corresponds to a series of cards with rich information about procedures (Figure 3).

The game aimed to enable stakeholders of various backgrounds — from nurse to IT worker — to bring in his or her knowledge and experience. Therefore, play activity was not organized around competition among players, but on collectively imagining the future of nursing activities. To emphasize collectivity, the players were encouraged to take different roles as the game unfolded.

The game board was a map of a nursing ward in the new building, based on the architect’s drawings. Participants moved tokens on the game board to role-play scenarios. The steps taken were made visible by the cards added to the task overview. On each card, participants could write down the responsible person, the location, the information needs and the duration of one task. Special event cards provided a surprise challenge (a problem in the space of possibilities), for example, “what to do in case of a reanimation emergency?” Players needed to discuss how to deal with the events and if they wanted to change the possibilities of space as a reaction.

At the beginning of the session, participants were encouraged to translate their current workflow by playing the current scenarios in the new building. This led to the discovery of problems such as the sterile disposables being stored very far from where they were supposed to be used (proximity) and opportunities such as the small pantries that could be used for various tasks (simultaneity). The distance between storage and patient rooms led to the solution of a new material trolley for every nurse. Additionally, making the current workflow concrete led to the discovery that each ward had a different perspective on work and that these must coexist.

When considering the use of electronic tablets in care, a number of questions related to space were raised: “Where does the nurse enter patient data into the patient file? When? What kind of tools does he/she use?” The position of the tokens on the board triggered the exploration of the possibilities of space; for example, the emotional attachment difference between entering patient data in a quarantined patient room and entering patient data in the staff room.
The tablet concept generated during the sessions had a lasting impact in the project. The patients were supposed to have smart televisions with special functions such as ordering food, but playing out scenarios demonstrated this to be unpractical.
Positioned at the wall, the televisions would not be at eyesight level for lying patients (visibility) and the remote controls would make the special functions difficult to access (segregation). The participants did not come up with a solution during the session, but some months later they had the idea of handling tablets to patients as well. The suggestion was accepted since patients could watch television, use medical applications, order food and play games — all in the same device.

The animated scenario play helped participants to explore the space of possibilities. In a second step, the possibilities of the new technologies combined with the possibilities of space were used to develop a new nursing work activity. Game spatiality highlighted problems and generated insights for the nursing care in the new building. Participating in the co-design session raised the participants’ commitment to the relocation, engaged them with learning about the new technologies available, and stimulated a critical view towards the current work organization.

7. Case 2 – Medical imaging center

The second case is about a medical imaging service, provided by non-invasive scanning technologies that reveal body activity. One Dutch University partnered with a medical devices manufacturer to build on its own campus a medical imaging center for experimental technology such as the hybrid Positron Emission Tomography and Magnetic Resonance Imaging (PET-MRI). The challenge was to combine research, technology development, education, and care in the same center. To make that happen, the University and the manufacturer needed to sign with additional partners: the regional hospitals (including one mentioned in the previous case), which would provide the care services and take benefit from the research.

After some months of designing with specialists, the managers decided to organize a co-design session with the healthcare professionals from the hospitals. Doing that, they expected to influence the hospitals directors in their decision to join the project. The session unfolded as follows. The project managers fixed a printed floor plan prepared by the architect on a wall, stood up beside it and explained the possibilities of space, pointing to the areas on the floor plan as long as they were
mentioned. When the discussion got more intensive, the hospital professionals stood up and came closer to the floor plan fixed on the wall. They began to question the design by formulating problem scenarios. They were somewhat annoyed that they had not been involved in earlier stages of design, when the space of possibilities was being shaped. Participants represented their activities using verbal narrative while sliding their fingers over the printed document. Every time an activity was brought to the discussion, it had to be represented again, since the floor plan was not being marked in any way. The session ended with many open issues.

The project managers asked help from the first author to organize the next session. The author suggested using a design game to keep participants focused on the relevant aspects of activity and avoid generating too many changes in the floor plan. The game consisted of pushpins and strings representing the patients’ and nurses’ paths when following a certain procedure. The participants were supposed to tie and untie the strings while discussing how to optimize the walking path. Drawing with the strings required more than two hands, what emphasized the representation’s collaborative nature. Another physical rule is that each step in the flow must depart from and arrive at pushpins otherwise it is loosely represented. This tool was named KNITTING GAME, since the resulting image resembles a knitting textile (Figure 4).

Managers divided the participants into two groups, according to the activities under consideration: CT scan and MRI scan. Each group had to look at the space prescribed for each scan activity (demarcation). The CT scan group visualized the centrality of the dressing rooms in the process and realized the problem of nurse’s back-and-forth movement between the technical room and other rooms, but they didn’t question the floor plan. In contrast, the MRI scan group identified so many problems on the floor plan that they refused to play the game (resistance). They said that it would only make sense playing the game after the space design was improved. The CT texture was brought to the MRI group and both groups discussed altogether from that point on. Later on, a MRI group member asked for a sheet of paper from the architect’s notebook and sketched an alternative floor plan for the area between the CT and MRI machines. Rethinking the floor plan was
not what the project manager had in mind (vision), but they realized that this was necessary to reach the consensus. They asked the design team to incorporate the sketch in the drawings so that the participants could agree with the adjusted version (solution).

Figure 4 – The KNITTING GAME: the blue lines are nurse paths and the green lines are patients. Playing the game revealed an unnecessary back-and-forth movement due to poor room connections.

The KNITTING GAME was useful only to consider work activity. The floor plan was made inaccessible by the game because the managers did not want to let participants change the possibilities of space (constraints), only the space of possibilities — the walking paths. Since the MRI group could not do the movements they wanted (alienation), they rejected the game and argued for changing the possibilities of space. They managed to completely change the possibilities of space by sketching an own idea and convincing the manager to incorporate it into the official design (compromise). Game spatiality helped participants to make a point by refusing to play the next move, a common practice in
game playing when players are feeling that the game is not being fair.

The co-design session, however, was not enough to convince the healthcare professionals to sign up for the project. Months after the session, the professionals confronted the possibilities of space in the center with the possibilities of space in the hospitals and came to the conclusion that it would be unsafe to send patients to the center due to the lack of proper emergency facilities. The negotiation with the University and medical device providers led to the center being incorporated into one of the hospitals, where eventual emergencies could be properly handled (synchronicity).

8. Case 3 – Nature center

The third case is about environmental education, nature-related leisure, and food services. Six different volunteer associations for environmental education and leisure joined forces to build a nature center on a public park in the central area of a medium-sized city in The Netherlands. This was done in response to the city hall announcement to close the official nature center, located in the outskirts of the city. The associations would not only take over the activities of this nature center, but also expand the services to become a city-center attraction.

Aiming for self-sustenance, the associations invited a restaurant to open a branch in the center and share the maintenance costs. The deal was that the associations organize activities for the general public and the restaurant serves the customers who want to have a meal in between the activities (synchronicity). Both parties believed that the synergy between the services would provide a more compelling case to receive permission from the city hall to use the public park (property).

An architect was hired to design the center, but the associations were having a hard time to evaluate his proposals. They could not tell if the space designed by the architect was going to fulfill their needs. When approached by the associations, the first author suggested organizing a co-design session with the aim of clarifying the center’s activities and their spatial requirements. So far, the associations did not have the opportunity to discuss how they are going to transfer their activities and, most importantly, how the
activities of one association are supposed to interact with the activities of another (simultaneity).

The co-design session included one or two members from each association and happened at the existing nature center. The game played during the session had three phases. First, listing and ordering association’s activities according to three time scales — daytime, weekday and season — and, second, defining where in relation to the center these activities are supposed to happen (Figure 5). Keeping this broad scope helped the participants to identify the need for a garden sink and easily accessible toilets both for activities that begin or finish at the center — an assembly point for excursions. Overall, the process gradually moved from issues of time to issues of space, grounding the discussion onto the spatial conditions to perform activities, hence, the name of the game: GROUNDING ACTIVITIES.

Once all the activities were listed the participants were ready for phase three: evaluating the architect’s design. The association member who worked closely with the architect introduced the design to the others. Some members did not engage with the discussion because they had difficulties in interpreting the design based on the floor plan. After this brief discussion, the members were invited to stick their activities to a room and place additional board game tokens representing requirements and the appropriation of the space. A water drop represented access to water flow; a brown disc represented eventual dirt; a barrel represented the need for storage; a fox represented an exhibition display; and a people token represented a target-group involved with the activity — the elderly, school children or environmentalists.
Figure 5 – GROUNDING ACTIVITIES, phase two: neighborhood plan for the nature center activities, represented as labels. The innermost circle gathers the activities to be held inside the center’s building, whereas the outer circles gather the activities to be held far away from the center.

The board game tokens were put on the plan all at the same time, in a silent move. After participants were done, the facilitator asked about the reason for each token’s placement. A member from the association that lends educational kits to schools surprised everyone by bringing forward a requirement for storage at the office. The storage facility located at the winter garden would not be practical for his activity, since he needed to handle the kits all the time (proximity). Another member asked how much storage space would be needed at the office, but he could not tell exactly. He could only say that the office would not offer
enough space for working with the educational kits. A heated discussion followed, with some participants positioning against bringing too much stuff to the center, while others defending the educational kits’ relevance (friction). The discussion ended with the member promising to measure all educational kits — around 200 items. Soon after that, the session was over and the requirements were sent to the architect for adjusting the design.

Figure 6 – GROUNDING ACTIVITIES, phase three: participants are encouraged to position their activities in the building and indicate their requirements with board game tokens.

In this co-design session, the board game pieces played an essential role in enabling the perception of space as designed by the architect and represented by the floor plan. Even if participants did not understand the plan very well, their task to physically interact with the plan helped them to understand it a little better. The collaborative nature of the task also gave participants the opportunity to quickly learn from each other by mimicking moves.
Beyond evaluation, game spatiality helped participants to discover new possibilities of space afforded by the building and the park. The space of possibilities became full of new ideas and the possibilities of space expanded to a new level of identification with the center, with more commitment to do volunteer work but with tension for the demarcation of space.

The discovery of functional needs was not the main benefit of the session, though. One of the participants raised a question during the session that was kept in mind long after that: “— We have considered very well all the activities of our individual associations, but which activities are we going to organize together?” This question brought the participants to think about what could be done before the center is built. They started organizing events at the old center and, in turn, the city hall handed over the administration of the center to the associations, until the park unit is built. Game spatiality played a small but important role in strengthening the collaborative capacity of the associations group. Remarkably, the co-design session changed the possibilities of space by incorporating the old center into the space of possibilities.

9. Cross-case analysis

The three cases have employed very different game props in co-design sessions. The HEAD game is the most elaborate and broadest in its aim to discuss roles, tasks, responsibilities, technologies, and walking paths. The KNITTING GAME has a much narrower scope, focusing on walking paths in relation to roles and tasks. As we have seen through the case description, the discussion triggered did not follow the intended focus and ended up targeting the underlying floor plan. In the HEAD game, the floor plan was questioned but not changed, yet the participants changed many other aspects of space: furniture, room function, and people’s locations.
Table 2 – Side-by-side comparison of the production of game spatiality in the service design cases.

<table>
<thead>
<tr>
<th></th>
<th>Case 1 – Hospital wards</th>
<th>Case 2 – Medical imaging center</th>
<th>Case 3 – Nature center</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Board game props used</strong></td>
<td>Floor plan board, people’s token (meeples), trolley tokens, tablet mockup, task cards, event cards.</td>
<td>Floor plan board, pushpins, elastic strings.</td>
<td>Neighborhood diagram, requirement tokens, meeples, activity labels.</td>
</tr>
<tr>
<td><strong>Exploratory actions observed</strong></td>
<td>Communication and coordination possibilities through tablets, comparing the processes of the different existing wards.</td>
<td>Bringing the hospital workflow to the floor plan, discovering the back-and-forth movement of nurses and patients.</td>
<td>Visualizing all the associations’ activities across time and space, realizing the need for proximity between workplace and storage.</td>
</tr>
<tr>
<td><strong>Transformative actions observed</strong></td>
<td>Commitment to be active in the change process, critical stance towards work procedures, creating nurse trolley, replacing televisions for tablets.</td>
<td>Refusing to play the game, sketching an alternative floor plan, opening up a new corridor, and changing the center’s location.</td>
<td>Commitment to do more volunteer work, defining requirements in quantities, organizing cross-association activities, making use of the old nature center.</td>
</tr>
</tbody>
</table>
Produced spatial relationships

Scenarios of normal and emergency workflow, proximity awareness through tablets, distance between storage and patient room, coexistence in pantries, perspectives over work procedures, television visibility, special functions segregation.

Troublesome scenarios, patients/nurses’ movements, area demarcation to scanning machines, dressing rooms centrality, resistance to play the game, project’s vision, participation constraints, alienation from possibilities.

Synchronicity between food and leisure services, land property, associations’ coexistence, the center as an assembly point, appropriation of the architect’s design, distance between storage and office, room demarcation, identification with the nature center.

GROUNDING ACTIVITIES is much simpler than the other two games. It stands as an example that the game props do not need to be very elaborate to trigger the production of game spatiality. The participants reconstructed the space of possibilities and produced new possibilities of space through their actions. The tokens used to indicate requirements were manipulated for a short period, but they stood on the board until the end of the session, eventually being pointed at during the discussion. The game props worked as physical statements within the space of possibilities.

In HEAD, the roleplaying moves were captured in the task overview as a permanent resource. The task overview was supposed to make participants feel they were producing something tangible out of the co-design sessions, beyond the fuzzy social relationships considered. In healthcare, there are external and internal policies to standardize procedures; however, the emergent nature of the work makes them difficult to be followed all the time. A standard procedure throughout the wards.
was indeed produced during the session, but there is no guarantee that it is going to be followed exactly as such.

In contrast, the procedures in the nature center were not standardized at all, and one participant even complained that defining requirements in exact numbers meant too much structure for volunteer work. Creating the game for this session was difficult because it was not possible to generalize rules from the existing work arrangements. The game was simple and open in order to match the spontaneity of volunteer work. The discussion could have been held without the game props, but the level of participant engagement would not have been the same.

In the medical imaging case, two co-design sessions have been observed: one with a design game, another without. Without the game, the discussion was much more fluid, but unfocused. The participants raised many issues that were not picked up by the designers because they could not remember them entirely after the session. The game assisted the managers in tracking the issues and keeping the session more focused; however, it also helped the hospital professionals expressing their discontent with the floor plan in their refusal to play.

In the three cases, the participants have produced different spatial relationships: scenarios, centrality, distance, proximity, visibility, coexistence, and others. The play sessions were very creative and explored, as well as transformed, many aspects of the services to be offered. Table 2 provides an overview of the exploratory and transformative actions as well as the spatial relationships produced by them.

10. Discussion

The cases studies present further evidence that design games help expanding the space of possibilities for a service with new ideas, options, problems, and solutions (Brandt et al., 2008; Brandt & Messeter, 2004; Vaajakallio, 2012). The contribution is finding a material counterpart to the space of possibilities, the actual possibilities of space in practice. With this counterpart, it is possible to distinguish actions that explore possibilities from actions that transform possibilities. These actions are very powerful since they can make the unthinkable thinkable and the
impossible possible, but they should not be taken for granted. Design games can only facilitate — like GROUNDING ACTIVITIES that gradually brings spatial relationships to the fore — or hinder game spatiality — like the KNITTING GAME that keeps players away from changing space. Game spatiality is, ultimately, a players’ achievement and not a game’s feature.

From a technical perspective, the usage of architectural drawings as game boards has worked quite well in grounding the discussion onto the space of possibilities. The work scenarios were developed together with the spatial relationships produced in practice, revealing restrictions and opportunities in both sides. In all the three cases, the dialectical development of activity and space has led to specific adjustments in the architectural drawings.

The commitment of design games with producing concrete outcomes can be overlooked if categorized under labels such as serious games or business simulations (Crookall, 2010). Although design games can also contribute to learning, they are not focused on that. Design games have the aim to create and transform products and services, including the work activities that produce them. They could be classified under the label of operational gaming (Shubik, 2009), with the remark that they are not limited to exploration and testing. As this article has tried to show, design games — in particular game spatiality — can be used as pivot for transforming work activities. This intent is similar to the ORGANIZATIONAL ACTIVITY GAME held in the former Soviet Union (Rotkirch, 1996; Shchedrovitskii & Kotel’nikov, 1988) and the DESKTOP PUBLISHING GAME held in Sweden (Ehn, Mölleryd, & Sjögren, 1990), both played during the 1980’s.

Described as such, design games pose a theoretical challenge for game studies: are they playful games or are they just regular work? There is not enough room for such discussion in this article, however, we would like to point out that dichotomies such as true/false play (Huizinga, 1955) do not contribute to legitimate play in culture, but in fact to isolate play from other activities. If culture is produced by all the activities of a certain society (R. Williams, 2011) — and not just by specialized high-culture activities, then play can better be understood as “part of every human activity” (Lefebvre, 2014a, p. 487). In design games, play is
supposed to produce an alternative version of a certain activity, which can still be considered part of that same activity. The alternative is created just to be incorporated into the activity as soon as possible (Ehn et al., 1990).

There is a big limitation to design games, nevertheless. People who did not join the co-design session may not understand the transformations and turn against them. This can be specially damaging if one these people holds a powerful position in the organization. The design can be completely compromised if the co-design session is not followed up with smart political articulation inside the organization. In the cases presented in this article, the authors did not play that role; however, follow-up interviews revealed that at least one person inside the organizations performed this role, with different degrees of success. In the medical imaging case, the design was completely rejected, while in the hospital ward case, the design is being implemented at the time of this writing.

We have no data on service usage yet, but we can imagine usability problems not anticipated due to the service customers — patients in the first two cases and nature lovers in the last case — being left out of the co-design sessions. We suggested organizing specific sessions with users, but unfortunately we could not convince the involved organizations to think beyond the backstage actions performed by the service providers.

11. Conclusions

Games are employed in service design to expand the space of possibilities with new insights from service stakeholders; however, the actual possibilities of space are sometimes not recognized, experienced or realized through these service design games. The implication is that the service stakeholders may be alienated from the possibilities of space; possibilities that could lead to innovations in service delivery. Space is neglected in service design, in part, due to the lack of a proper vocabulary to address its unfolding characteristics. To address that, we propose a conceptual triad that takes into account not only the space of possibilities — the design options to be implemented in the future — but also the possibilities of space — the current conditions for action.
The triad tries to capture the production of space by the actions of players engaged in a design game. Some actions may explore the space and its possibilities, whereas others may transform them, according to the level of player engagement. If players are engaged enough, they develop a shared sense of being in space — game spatiality — and become aware of the possibilities of space. From that point on, they may cut through the alienation imposed (on purpose or not) by the design game and alter the spatial conditions for the service themselves. Such movement should not be prevented in a co-design session even if the game rules are being transgressed, because this is the moment when the participants are gaining legitimacy in producing space. This can contribute to a more critical and pro-active attitude towards space during the actual service delivery.

The triad of game spatiality strengthens the argument for co-design, since it shares the aim to legitimate the participation of users in the production of space. Furthermore, it highlights the importance of participants’ interaction to enact spatial relationships. Last but not least, it emphasizes grounding change to spaces where transformative actions can take place. Play activity arises then as a microcosm for work activity, where new spatial relationships for work can be tried out in a playful manner. This synergy between play and work has been established here to study design games, but it may also be useful to other kinds of games and playful work interventions.

In service design, game spatiality reframes the contradiction between tangibility and intangibility (often used to justify service design itself) into another contradiction, between what is considered possible and what is actually possible. In this new contradiction, a design concept can be tangible as a wall, in its capacity to restrict or enable social action, and a corridor can be as intangible as a board, in its potential to misguide the sense of direction. The question that matters in this regard is not tangibility, but possibilities for action. Since action is grounded on space, the production of space seems to be much more interesting to justify the existence of service design among other approaches to services such as service-dominant logic (Maglio et al., 2009) and value co-creation (Prahalad & Ramaswamy, 2004; Ramirez, 1999; Vargo et al., 2008). This study offers an initial vocabulary to talk about space in the service design approach.
Design games do not produce game spatiality automatically, though. Players are the ones who produce game spatiality through their actions. In so doing, they can make use of the possibilities of space that were never conceptualized — for being outside of the space of possibilities. In the cases described in this article, even if players were designing services to be offered in the future, they already realized and made use of the possibilities of space in their current services. It is reasonable to say that transformative actions initiated in the co-design sessions went beyond play, provoking fundamental changes in the backstage work activities. From the observation of these outcomes, we can conclude that games in service design can be as much insightful as transformative.
Chapter 3

The social production of design space\(^5\)

The previous chapter described how transformative actions performed by users in design games expanded the possibilities of space in various cases. This goes beyond what was thought by the designers to be the space of possibilities.

This space of possibilities in design studies is called “the design space”; the sum of all possible designs for a given brief. The production of this design space refers to the activity of an individual, or the activity of a group of individuals, designing something under constraints. These constraints are sometimes considered the determinants of the design space for this pragmatic function, but their origins and transformations are rarely investigated.

This chapter questions the notion of constraints as a determinant of the design space and introduces instead the notion of contradiction as a driving force behind the production of design space. The intention is to characterise the social production of the design space as a process of dealing with contradictions. This is accomplished through an in-depth look at the social production of design space in the medical imaging centre project and an experiment with design students about the same project. In comparison to the production of design space in the medical imaging centre project, the students’ activity reproduced some of the contradictions faced by practitioners, but not all of them.

\(^5\) This chapter is submitted to Design Studies journal. An earlier version of this chapter was presented as a conference paper. Van Amstel, FMC, Zerjav, V, Hartmann, T, van der Voort, MC & Dewulf, GPMR 2014, “Contradictions in the design space,” in Y Lim, K Niedderer, J Redström, E Stolterman, & A Valtonen (eds), Proceedings of DRS 2014: Design’s Big Debates., Umeå, Sweden.
1. Introduction

Previously seen as an outcome of design (especially in architectural design), space is being studied increasingly as a locus where design happens. The available studies can be divided into two streams: one that focuses on the interactions of designers, clients and users as it happens in offices and elsewhere (Botero, 2010; Luck, 2014; Sharrock & Anderson, 1994; Westerlund, 2009) and another that studies the cognitive activity of designers exploring and redefining an abstract space of possibilities (Gero & Kumar, 2006; Goldschmidt, 1997; MacLean, Young, Bellotti, & Moran, 1991; Mose Biskjaer & Halskov, 2013). This paper brings the perspective of the first stream — in particular, historical analysis (Engeström, 2015; Lefebvre, 1991) — to study the research object of the second stream — design space. The goal is to look at the social production of design space, the contradictions faced by its multiple producers and the attempts to overcome those contradictions by designing space.

The design space is a term used vaguely in design studies to the many possibilities a project has to produce something. When taken seriously as a research object, the design space has been considered to be a definite (Gero & Kumar, 2006) or indefinite (Goldschmidt, 1997) set of shapes and functions for a particular object or kind of objects. Since these shapes and functions sometimes are considered to solve a problem, the design space is also equated to the problem space and solution space described by problem-solving studies (Biskjaer, Dalsgaard, & Halskov, 2014; Dorst & Cross, 2001; Goel & Pirolli, 1992). This space grows together with the activity of individual designers working with an object or out of collective designers sharing a tradition with the same kind of object.

Therefore, the design space has a dialectic relationship with the design activity. At the same time, the design space is produced by design actions — such as imagining, sketching, visualising, weighting, generating or rejecting, and it restricts design activity to a certain direction. This restriction as been attributed to constraints (Gross, Ervin, Anderson, & Fleisher, 1988; Lawson, 2005; Mose Biskjaer & Halskov, 2013), which are explicit definitions of criteria, requirements, needs and other limitations imposed by the conditions for production. Constraints are
sometimes considered the determinants of the design space for this pragmatic function, but their origins and transformations are rarely investigated. It is necessary to look at constraints from a historical perspective in order to understand the dialectic relationship between design space and design activity.

Constraints arise in the design space because the design activity is a social activity connected to many others in society (Dilnot, 1982). The design activity has to respond to material conditions and relationships with other activities, which, in fact, are their origin. These conditions and relationships are not necessarily coherent and explicit, quite to the contrary; they are often incongruent and implicit. Unfair, unbalanced and awkward relationships harbour contradictions, which are tensions that accumulate along the history of an activity (Engeström, 2015; Foot & Groleau, 2011). Previous research has found contradictions of the design activity (Blau, 1984; Cuff, 1992; Ehn, 1990), but little has been done to find contradictions of the design space.

In fact, design activity reproduces contradictions, but also overcomes them. The production of design space may increase the tension and trigger changes to the conditions for production, but this is not the same as changing the constraints for the contradiction, which may still be preserved. To overcome contradictions it is necessary to address, not only the contradictions of design space, but also the contradictions of design activity, configuring a spatial-historical breakthrough (Lefebvre, 1991, p. 54).

This paper experiments with the notion of contradiction as a driving force behind the social production of the design space. This goes beyond the notion of constraints as determinants of the design space. Constraints, issues, problems, solutions and other cognitive frames approach contradictions from one of their sides. The aim of this paper is to ground these abstract components of the design space to the concrete social process that produces them.

The first part of the paper presents a case study on how the design activity of a specific medical imaging centre reproduced contradictions of the Dutch healthcare system in the design space. Ethnographic data reveals the social construction of its design
space and the attempts to overcome the contradictions. The second part of the paper reports on a teaching experiment where students reconstructed the design space and dealt with its inner contradictions. Even though they had different constraints to deal with, they reproduced some of the contradictions, but not all of them.

2. The design space

The design space is as a mental, individualistic, a priori, abstract space where design ideas are generated and considered. One of the most concrete descriptions of the design space is a network of cognitive states that the designer moves from and to (Figure 1). Every move in the design space arises from the intention of the designer, even if this be random (Goldschmidt, 2006). The moves are restricted by two factors: 1) constraints imposed by project definitions, such as criteria, requirements, needs and goals (Gero & Kumar, 2006; Lawson, 2005; Mose Biskjaer & Halskov, 2013); and, 2) the designer’s cognitive processing capability (Simon, 1991; Woodbury & Burrow, 2006). The designer is supposed to move from the initial state to the goal — a preferred state, but the path to get there is not clear. Some researchers believe that it is possible to determine the states from the imposition of constraints in the design space (Chien & Flemming, 2002; Woodbury & Burrow, 2006), whereas others believe that the design space is indeterminate due to the possibility of creating previously unknown states (Goldschmidt, 1997, 2006).

The design space has been mainly used to analyse how designers think alone, but there are new attempts to use it in collaborative design as well (Binder et al., 2011; Botero, 2013; Luck, 2014). In this case, design moves are, not only bounded by personal intention and cognition, but also — and perhaps even more — by interaction with other people. Design moves are motivated by social activity and cause effects, but not in arbitrary way. It is necessary to look at the design activity as well in order to understand the design space.
Figure 1 – A design problem space composed of a network of states. Redrawn from Goldschmidt (Goldschmidt, 1997, p. 444).

The design activity is as a social phenomenon encompassing the actions of individuals and collectives to design something (Bødker & Grønbæk, 1996b; Brereton, Cannon, Mabogunje, & Leifer, 1996; Dilnot, 1982; Luck, 2010). The activity is bound to cognitive, technical, economic, social and cultural conditions that limit the possibilities of designing (Westerlund, 2005). When people engaged in the design activity realise these conditions, they may or may not translate them into constraints to the design space, depending on their cognitive skills to process these conditions (Simon, 1991). The limitation to perceive and process these conditions is currently being addressed by computational tools that expand the designer’s capability to explore, remember and combine objects (Woodbury & Burrow, 2006). These tools describe the design object in terms of parameters, which can be combined in many possible ways (Monedero, 2000). Constraints are typically used as filters in parametric design to reduce the amount of possibilities to a manageable level.

There is a contradiction here between the space of possibilities and the possibilities of space. The design space is infinite in a collective level, but quite limited when assessed by one individual. If that is the case, then it is just a matter of determining the cognitive capabilities of an individual to determine the design space and all its possibilities. However, design activity, as it happens in practice, is not restricted to cognitive processes and is hardly carried on by a single person (Botero, 2010). Even when working alone, designers are under financial, technical, social and cultural conditions that are not necessarily cognised and explicitly
set as constraints. Many constraints are taken for granted, or perhaps, they are not yet constraints.

3. Contradictions of design activity and of design space

We turn to cultural historical activity theory to investigate what lies behind constraints (Engeström, 2015; Foot & Groleau, 2011; Kuutti, 2011; Leont’ev, 1978), which provides a model to analyse activity - in this study, the design activity. The basic formulation of an activity is a subject that pertains to a community transforming an object by means of instruments, bound to rules and a division of labour (Engeström, 2015; Leont’ev, 1978). We derive from this that the object of design is the thing being designed, which has the potential to fulfil a need and the subject might be one or more persons that invest motives in this object. The transformation of the object is the concern of a community, which develops certain rules and a division of labour to transform the object.

Different activities can interact, for instance, when the outcome of one activity is the object of another, such as performance evaluation or instrument development (Engeström, 2015; Kuutti, 2011). The latter is a common connection to design activities, which conceptualises the connected as “use” or “user activity” (Suchman, 1994). The design activity interacts with the user activity to produce design space using methods, such as briefing (Barrett et al., 1999; Luck & McDonnell, 2006) and parametric design (Monedero, 2000), which aim to set constraints to the design space. These relationships are put together using the activity system model (Figure 2).
Activities change due to contradictions, which are tensions that accumulate in the history of an activity and between multiple activities. These accumulating tensions can be measured at four levels (Engeström, 2015; Foot & Groleau, 2011). At the primary level, the most basic contradiction of society — between the individual actions and the collective activity — appears in each element of an activity (subject, instrument, object, community, rules, and division of labour), for example, an individual who wants to produce something the collective does not grant with an exchange value. This is also described as the contradiction between exchange value and the use value typical of capitalist societies (Marx, 1993). At the secondary level, contradiction appears in the relationships between activity elements, for instance, between instruments and rules that do not match. When the activity has a major development, the contradiction achieves the tertiary level, when the old and the new version of an activity collide. At the quaternary level, the contradiction spread among different activities. Figure 3 depicts the contradiction levels using the activity system model (Engeström, 2015).
A parallel can be made to the contradictions of space discussed in the production of space theory (Lefebvre, 1991). The primary contradiction of space is between the fragmentation of local spaces and the homogenisation of global spaces (Lefebvre, 1991, p. 355). This relates to the individual trying to produce a local identity by combining fragments of globalised symbols, such as consecrated architectural types. When this local affirmation reaches a peak, it gets in the way of the production of things in space because people from other places do not appreciate the extreme localism. This is the secondary contradiction of space between the production of space and the production of things in space (Lefebvre, 1991, p. 354). As for the tertiary level, the order of a new production running against the current experience of production relations generates a contradiction between the concrete live experience of space and the abstract order of a new space (Lefebvre, 1991, p. 52). This comes with a lot of anxiety on how things would be produced in the new order. At last, the quaternary level refers to the uneven distribution of power, knowledge and capital over space (Lefebvre, 1991, p. 333). The conflicts due to the accumulation of resources in a certain point of space can easily be seen in large cities, wherein the scarcity of space is a by-product of this quaternary contradiction (see Table 1 for a summary).
Table 1 - A parallel made between the contradictions of activity pointed by cultural historical activity theory and the contradictions of space pointed by the production of space theory.

<table>
<thead>
<tr>
<th>Level</th>
<th>Contradiction of activity (Engeström, 2015)</th>
<th>Contradiction of space (Lefebvre, 1991)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>Between individual actions and the activity system</td>
<td>Between the fragmentation of local spaces and the homogenisation of global spaces</td>
</tr>
<tr>
<td>Secondary</td>
<td>Between the elements of an activity system (tools, rules, division of labour etc.)</td>
<td>Between the production of space and the production of things in space</td>
</tr>
<tr>
<td>Tertiary</td>
<td>Between the old and the new version of an activity</td>
<td>Between the experience of production relations and the order of a new production relation</td>
</tr>
<tr>
<td>Quaternary</td>
<td>Among different activities</td>
<td>Among the uneven distribution of power, knowledge, and capital over space</td>
</tr>
</tbody>
</table>

The above parallel is made to enable the study of contradictions of the design space in relation to contradictions of the design activity. Since the design space is produced by design activity, the contradictions of the design activity are also reproduced in the design space, becoming then contradictions of the design space. Once contradictions are embedded into space, they last longer and keep bothering activity, even if the contradiction of activity has been alleviated or overcome (Lefebvre, 1991). They may even bother other activities, which did not face the original contradiction in the first place. However, there is always the opportunity for change in reproduction. The contradictions of space may alleviate or help to overcome the contradictions of activity. According to the production of space theory, contradictions can only be completely overcome if they are overcome, both in activity, and in space, configuring a spatial-historical breakthrough (Lefebvre, 1991, p. 54).

For the purpose of studying how contradictions are dealt with by design activity and reproduced in the design space in a particular setting, we define a spatial-historical breakthrough as *overcoming*
the four levels of tension of both contradictions of activity and contradictions of space.

4. Research design

Collecting empirical evidence of contradictions in the design space requires a specific research design for three reasons. First, contradictions are not just objective phenomenon; they are both objective and subjective, since they affect and are affected by the observer. Second, contradictions are both the cause and effect of a social situation and, therefore, constantly changing. Third, contradictions are not immediately observable by abstract measures, such as variables. In both cultural historical activity theory and production of space theory they are grasped by first looking at the historical constitution of the situation, then applying abstract measures and, finally, reconstructing the whole phenomenon as over-determined or, in other words, determined by too many causes (Engeström, 2015; Foot & Groleau, 2011; Lefebvre, 1975).

With this in mind, the research design is setup in two parts: a case study about a medical imaging centre and a teaching experiment in a design course. The case-study is based on a formative intervention (Engeström, 2011) performed by the researchers in the design of a medical imaging centre to combine research, technology development and care. The researchers followed the meetings in the design activity, analysed the available documentation, interviewed the designers, developed computer visualisations to support the participation of users and joined workshops where these visualisations were employed to include users in the design process.

The researchers’ notes were stored in an Issue Based Information System (IBIS) and linked to research questions and theoretical concepts. This formed a map of controversies around the project (Kunz & Rittel, 1970; Selvin et al., 2001; Yaneva, 2012). A specific map was made with the contradictions identified in the data with the activity system model in the four levels of tension (Figure 4). The primary contradictions are lined at the bottom of the map and connected to their aggravation in the second level, and so on. The data fragments are connected to the contradictions as their observable manifestations, which are classified as pros and cons.
in the IBIS notation. This distinction is necessary to avoid framing contradictions as inherently good or bad for the project. The map only contained contradictions of activity and not contradictions of space as these are identified in a different way.

Based on the study of design activity, a hypothetical construct has been formed: if contradictions were intrinsic to the design space, reconstructing the design space in another activity would reproduce the same, or at least, some of the contradictions from the original activity. In other words, if the other activity would display similar contradictions of the original activity, this would serve as an evidence of the existence of intrinsic contradictions of space.

To test this hypothetical construct, an experiment has been organised in the context of a facility design bachelor’s course. The experiment was organised according to the double stimulation method (Engeström, 2011; Vygotsky, 1978): the focus is on reconstructing learning, taking more into account process, rather than outcome. The first stimulus is a contradictory situation and the second stimulus is an ambiguous tool that may be used to overcome contradictions. The experiment looks to how subjects develop concepts to overcome contradictions. The purpose of the tool is to objectify the concepts and what helps, not only the experimenters, but also the learner.

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6 A hypothetic construct is an aggregate of variables that measured together provides an understanding of a systematic phenomenon. In Psychology, “construct validation was introduced in order to specify types of research required in developing tests for which the conventional views on validation are inappropriate” (Cronbach & Meehl, 1955, p. 200). The conventional view is the isolation of intervening variables.
Figure 4 – Fragment of a graphical map with contradictions of design activity (blue nodes), related to their pros (green) and cons (red). The two lines at the bottom represent, from bottom up, the primary, the secondary, the tertiary, and the quaternary tension levels.
The students were tasked with reconstructing the design space and making changes to the design object. If contradictions were intrinsic to the design space, their moves would be driven by the same contradictions that drove practitioners. In order to track the moves, a parametric design tool (Autodesk Revit) with a specific plug-in — a custom-tailored family to represent the walking paths of nurses and patients across the facility — was provided. The parametric design feature generates real-time information about travel distances, waiting times, and room connection. Activity is modelled in the same interface as space, therefore, enabling iterations in design between these two dimensions (Figure 5).

![Figure 5 - Walking paths parametric design family for Autodesk Revit with walkability performance for patients (blue) and nurses (green).](image)

This tool was also used in three ways. First, to reconstruct the floor plans and the walking paths designed by practitioners in order to identify contradictions of space. Second, to trace the production of design space by students and, third, to setup two groups of students: one with initial walking paths, and another with no initial walking paths. This was done to check if having extra constraints in the design space drives the production of the design space towards a different direction. The tool was
ambiguous in many ways: a) it did not calculate the optimal path based on the shortest distance; b) it did not show how to connect and how to layout the rooms according to the workflow logics; and c) it did not represent the path of one particular person in a particular moment, but a path that is followed by many people in different moments — a spatial representation for a historical phenomenon. This ambiguity was important to let students develop their own second stimulus, which corresponded to new moves in the design space.

The images reconstructed from the three datasets were stacked to visualise and compare the production of the design space. The stacked images revealed the parts of the design space that changed the most along the process, which are material traces left by the forces driving the design activity. These changes were interpreted according to the parallel established between the contradictions of activity and the contradictions of space across the four levels of tension. We triangulated the visual evidence of contradictions of space with the ethnographic data of contradictions of activity. Even though the images do not represent all the possibilities created and considered by the design activity, it stands as a material trace of the forces driving the design activity, which were related to constraints or to contradictions.

5. The design space of a medical imaging centre

The case study concerned a forthcoming medical imaging centre in The Netherlands which will offer state-of-the-art diagnosing machines based on techniques, such as Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET-MRI), Computed Tomography (CT) and Electroencephalography (EEG). This case study covered a small part of the design process: the evaluation and final adjustments of the floor plan, which happened between July 2012 and January 2013.

When applying the activity system model to identify contradictions across the four tension levels, many contradictions were found. In short, we concentrated on one contradiction that stemmed from the undergoing changes of the Dutch healthcare system since its last reform in 2006 (Pavolini & Ranci, 2008). The reform diminished the role of the state in providing healthcare
and the consequent need for partnering among care providers. Income is now aligned with the actual care delivery and the providers need to grow on their own (Cramer, Dewulf, & Voordijk, 2014). The medical imaging centre arose in this context with the value proposition of it offering shared facilities and knowledge co-creation for nearby hospitals, educational institutions and technology developers. However, the centre had to be self-sustaining and optimised to diagnose as many patients as possible.

This contradiction manifests at the primary level as the medical imaging space (outcome) that is supposed to be logically organised, favouring the productivity of every procedure, while leaving space for the spontaneous co-creation of knowledge. The procedures were already very much optimised in their origin. However, in the new centre, they should produce knowledge that goes beyond optimisation. When this aggravates to the secondary level, the functions of the rooms (division of labour) are defined, not according to the best logistic principles possible (rules), but by the political compromise of assuring a separate space (outcome) for each care provider (community). At the tertiary level, the care providers who used to compete for attracting patients (old object) now are trying to learn with each other in this venture (new object). Finally, at the quaternary level, the activities involved in the project are not sure how the outcomes of the centre will help...
them fulfil their expectations. Figure 6 traces the contradiction spreading through the activity system model.

These tensions were not visible to the designers at the beginning of the project. Nevertheless, they reproduced them in the design space. The business plan and machines’ technical requirements were taken as the main constraint, guiding the definition of isolated functions and exclusive spaces, despite the cornerstone idea of sharing machines to promote knowledge exchange between research and clinical practice. This idea was not set as an explicit constraint by the design activity. Nevertheless, it appeared in the design space when the machine users were invited to participate in a workshop with the designers. They suggested transforming some of the exclusive spaces into shared spaces by adding doors and corridors to connect them.

The reconstructed image reveals that the dressing rooms were the unstable part of the design space (Figure 7). The designers doubted if there should be so many small dressing rooms — to afford more patients per machine — or less dressing rooms — with more space each. Also, they wondered if there should be a bathroom nearby, or even an allotted waiting room for each scanning machine. The researchers supported the workshop by providing a deterministic simulation of nurses and patients conducting routinised procedure in the facility, which gave some input for their discussion.

After trying many different moves, designers and users realised that the most important thing would be to have a corridor that connects the different areas of the facility that allowed sharing of the dressing rooms and informally sharing knowledge in the breaks. The designers moved away from the paradigm of compartmentalisation of functions to a paradigm of multi-functionality. This raised further questions regarding the marginalisation of the care practice, which would not have an optimal facility to work and, instead, would have to work in what was considered best for knowledge co-creation — a flexible environment. The radiographers were worried that the increased connectivity between the rooms would make it easier for imaging researchers to look over their shoulders all the time, and not let them do their work alone. The practitioners did not overcome the contradiction at the quaternary level, so the tension kept
accumulating until the construction of the building was cancelled. The users who joined the design process considered the place unsuitable to deal with patient emergencies and demanded to transfer the medical imaging centre to their own hospitals. This constraint was brought to the design space only after the underlying contradiction accumulated enough tension to make the building appear unfeasible to the partners.

Figure 7 - The four versions of the floor plan with the respective walking paths stacked in a single picture. The darker lines appear in all four versions, whereas the lighter lines appear in some of them.

The main finding from this case study is that the determinants of the design space were not self-imposed constraints, but imperative economic, political and cultural conditions that
contradicted each other. Designers and users had to deal with these contradictions, even if they had not been set as constraints in the briefing phase. Their moves in the design space were driven by these contradictions, which manifested as unexpected technical problems, controversy, uncertainty and late requirements. This was initial evidence that the design space has intrinsic contradictions.

If that were the case, then reconstructing this design space in another activity would reproduce the same contradictions and guide design activity towards similar moves. A teaching experiment explores this possibility using the walking paths tool to manifest contradictions in the design space as explicit constraints.

6. The design space extended to a teaching experiment

The course Methods and Strategies for Facility Design of the University of Twente’s Bachelor in Civil Engineering had related topics to that which was observed in the case-study. As such, the authors brought the project to the course as a practical learning experiment. The context was introduced as such:

_The business case specifies the diagnosing machines that will be available and the amount of patients to be treated per year in each machine. The managers are wondering how to optimise the facilities to meet these numbers. (Data fragment)._  

This is neither a problem nor a solution, but an issue related to the contradiction between knowledge co-creation and work optimisation. However, its historical background was not given. Instead, the experimenters provided students with the results of a deterministic simulation they made to support practitioners in the original project. Students received a copy of the animation generated by the simulation, with the use activities happening along half a day of operation. The use activities were simulated in a very simplified way focusing on the walking paths of nurses and patients around machines. A spreadsheet with performance figures, such as machine capacity usage, waiting times, and room occupation, was also provided.

The experiment consisted of two sessions. In the brainstorming session, students were organised into teams of four and tasked
with formulating problems and solutions. They had to reconstruct the design space in an explicitly social manner: team work. The design space has been explored in a rather abstract way, in the format of written problems and solutions. In the second session, the design space had to be explored in a more concrete way, as a parametric model. This was important, not only for students to realise the material resistance for implementing their solutions, but also to measure their production of the design space through a standard format that favoured comparison. Students were then introduced to the parametric design tool which they could develop the design further, either alone or in pairs. They did not work in teams as in the previous session due to the software/hardware limitation for real-time collaborative modelling. For most students, this was their first experience with the software and the duration of the experiment was only one hour, so they could not explore too many features.

The experiment was repeated in two editions of the course. In the first edition, students received the initial floor plan reconstructed from case data as a digital file. One sample path was included in the file. In the second edition, the full walking paths for nurses and patients were provided, overlaid on the floor plan. Deriving from that difference, two groups are considered: participants who did not have built-in activity constraints (Group 1, n=31) and participants who had built-in activity constraints in the shape of walking paths (Group 2, n=28). Both groups received the first version of the floor plan captured from the medical imaging centre and a brief statement with additional constraints. After the experiment, the previous session’s teams gathered again and received the educational assignment to write a report with the lessons learnt, which was also taken into account to interpret the results.

The software used in the experiment was configured to save automatic backups every five minutes, generating more than one image per student. This was done to track the production of the design space across time as in the case study, but in a much shorter interval. All images, from all students, were stacked into one, again in the same way as in the case study. The difference here was that the combined images did not reflect the social production of design space by one team, but by many teams.
7. Experiment results

Group 1 had the extra task of drawing the paths from scratch in the same amount of time. This resulted in fewer paths and focused production (Figure 8). This group began by moving the reception closer to the entrance and then delving in the dressing rooms distribution between MRI and CT (right part). The corridor solution observed in the case appeared only in two designs of Group 1 and not at all in Group 2.

Figure 8 - The designs generated by Group 1, with no initial paths, stacked in a single image

As for group 2, most students began by changing the PET area (left part) due to the performance figures provided (Figure 9). They
framed the longest paths from the entrance as the best opportunity for improvement. After that, they began to poke with the dressing rooms allocated for PET.

Figure 9 - The designs generated by group 2, with the initial paths already given, stacked in a single image

In both groups, the dressing rooms were the unstable part of the design, pretty much as was the case in the original project. Some students proposed to change them into allotted waiting rooms to avoid patients and nurses having to go back and forth during the intermediate waiting steps of the scanning procedure. One student proposed a coffee-room in the middle of the facility to increase the level of comfort for both staff and patients. Many
doors were opened in both groups to minimise space fragmentation.

Instead of restricting production, the extra constraint in Group 2 let students consider different ways of rerouting patients and nurses. The production of the design space was much more diverse and less focused. Some steps in the walking paths were decoupled or aggregated and the undefined upper part of the layout was occupied, which did not happen in Group 1. It seems that the given constraints were not taken for granted by students, being changed or ignored by design moves. One student report included the following:

*During the assignment some of the routes seemed very odd, that it seemed as if some detours were functional. [...] Unless it was made clear by certain keywords, which were used in the model that the detour had some reasons, these detours were eliminated. (Data fragment).*

The students were aware of the walking paths’ constraint, but they chose to ignore them. Even more, some students of Group 2 occupied the undefined area at the top part of the plan, which is another constraint. The rooms created in this ambiguous area reproduced the same contradictions found elsewhere in the design space: they were single-purpose spaces connected by the workflow logics with extra waiting rooms around them. The students tackled some of the contradictions of the original project, but many contradictions were not addressed and kept accumulating in the design space. A comparison between practitioners and the groups shows the same moves for the primary contradiction and similar moves for the secondary contradiction (Table 2). As for the quaternary level, the students had little information about the interactions of multiple user activities and, hence, did not overcome the contradiction.

Students did not directly address tertiary and quaternary contradictions. That did not prevent these contradictions from driving design activity towards open spaces, with extra connections and functions — favouring collaboration among partners and, at the same time, towards fragmented, streamlined, and optimised spaces — favouring competition among partners, much in the same way practitioners did.
<table>
<thead>
<tr>
<th>Tension level</th>
<th>Primary</th>
<th>Secondary</th>
<th>Tertiary</th>
<th>Quaternary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contradictions of activity</strong></td>
<td>Co-creation of knowledge</td>
<td>Workflow streamlining</td>
<td>Competition</td>
<td>Outcomes</td>
</tr>
<tr>
<td></td>
<td>X Optimisation of work processes</td>
<td>X Political compromise</td>
<td>X Collaboration</td>
<td>X Expectations</td>
</tr>
<tr>
<td><strong>Contradictions of space</strong></td>
<td>Flexibilisation of workspaces</td>
<td>Exclusive space</td>
<td>Compartmentalisation</td>
<td>Knowledge centralisation</td>
</tr>
<tr>
<td></td>
<td>X Spatialisiation of the workflow</td>
<td>X Shared space</td>
<td>X Multifunctional</td>
<td>x Practice marginalisation</td>
</tr>
<tr>
<td><strong>Practitioners’ moves</strong></td>
<td>Splitting dressing rooms</td>
<td>Flexible dressing room space</td>
<td>Large internal corridor</td>
<td>Circulation area for spontaneous knowledge sharing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group 1 moves</strong></td>
<td>Splitting dressing rooms</td>
<td>Moving rooms closer to the entrance, splitting waiting room into many</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group 2 moves</strong></td>
<td>Splitting dressing rooms</td>
<td>Moving rooms closer to entrance, occupying undefined area</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The parametric design tool seemed to be insufficient to deal with the contradictions of the tertiary and the quaternary levels. The reports written by one of the student teams acknowledged this:

*The situation modelled is an ideal situation, where everything behaves as planned. There is no scenario for emergencies. Users of the building will not behave as the parameterisation. The modelled walking paths are the ideal paths: patients or staff will not always follow them, because of the current situation and their own choices and preferences (Data fragment).*

The student reports were quite critical about the tool. They pointed to its poor usability, automation, efficiency and simulation capabilities. On the other hand, they recognised the experiment as an opportunity to learn about the social construction of the design space:

*The last thing we have learned is that every individual gets to a different practical solution with the software, even though the whole group conceived the theoretical solution. This is due to the different ideas of the best implication of the solutions every individual has (Data fragment).*

The contradiction between the wish to co-create knowledge and the need to optimise work processes was both present and clashing in the teaching experiment, albeit in a lower tension than found in the case study — up to the secondary level. This contradiction might not have manifested in the students’ design activity, as they rarely mentioned concerns for knowledge co-creation in their reports, but they still made similar moves than practitioners. This is attributed to the reproduction of this contradiction in the design space, a contradiction between the flexibilisation of workspaces and the spatialisation of the workflow, which escalated up to the secondary tension level — exclusive spaces versus shared spaces. The contradiction between compartmentalisation and multi-functionality, as well as the contradiction between knowledge centralisation and practice marginalisation, were not addressed by students’ moves or their reports.
8. Discussion

The main advantage — and limitation — of double stimulation and formative intervention methods employed by this research is that they do not isolate cause and effect relationships (Engeström, 2011; Vygotsky, 1978). Instead, they investigate phenomenon as being determined by too many causes, or in a word, over-determined. The present empirical work shows that it is possible to determine a design space, provided that the determination is socially constructed and that contradictions are taken into account. The following relationships were considered to determine the design space: the economic imperative of productivity, the cultural trend of knowledge co-creation, the engineering design tradition, the optimisation bias of the tools used in the experiment, and the formal characteristics of the design space; all being understood as manifestations of contradictions in history (Engeström, 2015) and in space (Lefebvre, 1991). The resulting over-determination could be a better argument against prescription and modelling than indeterminacy (Goldschmidt, 1997).

These multiple determinations were mediated by the design moves of individual and collective students working together to produce the design space. They did not just respond to the conditions, but actually created new possibilities by challenging the existing constraints. For this capability of creating new states and opening new paths in the design space, the design moves cannot be described as exploration of (a given) design space (Goldschmidt, 2006; Maher & Poon, 1996; Woodbury & Burrow, 2006) but, as the production of (an emergent) design space. This space is not produced by a lonely designer — even he or she is working alone — but, by the multiple activities connected to the object being designed — the user activity being just one of them. Looking at this social production of the design space can help design studies going deeper than the paradoxes found in design discourse (Dorst, 2006), which is more concrete than constraints but, still far from contradictions. Contradiction seems to be a key concept to understand the erratic (Dorst & Dijkhuis, 1995), meditational (Bødker, 1998; S. Tan & Melles, 2010), and dialectical (Goldschmidt, 1991) characteristic of design activity, as well as becoming the ontology (Cicmil & Marshall, 2005; Luck, 2014) of the design space.
Nevertheless, contradictions are difficult to study empirically. Contradictions are described as situated phenomena (Foot & Groleau, 2011), which are hard to grasp in an experiment. In retrospect, seeing traces of contradictions was much easier while the researchers were engaged in the project, rather than when conducting the experiment with design students. The deterministic bias of the tool was not fully realised until students criticised it in their reports. Researchers could not stay above contradictions and look at them with distance. They were already reproducing the contradiction by interacting with it. In fact, the research activity was already facing this contradiction in the increasing emphasis of publications indicators in Dutch universities (Groot & Garcia-Valderrama, 2006). In comparison to the design activity of the medical imaging centre, academic research is doing this the other way around: emphasising work optimisation at the expense of knowledge co-creation. The convergence of healthcare and research in the medical imaging centre is not a coincidence, but a cause and effect of the contradictions present in their underlying systems.

9. Conclusions

The design space produced by a design activity is not determined by constraints. Instead, the design space is determined by multiple conditions that contradict each other: economic, cultural, stylistic, cognitive and others. These conditions are neither internal, nor external, to the design activity, but constitute the material base where the design activity emerges. This means the design activity is not an individual cognitive activity, but a social pragmatic activity aimed at changing these material conditions. The design space consists of the possibilities considered, but also created by the design activity to change these conditions. Each move in the design space contributes to reduce or expand the design space. In fact, they produce design space. However, design moves reproduce contradictions of the design activity onto the design space, as contradictions of the design space. These contradictions of space can even bother other activities beyond the activity that produced it in the first place.

The evidence of the existence of contradictions in the design space has been found in a case study of a medical imaging centre. This was verified further by an experiment with design students. A
parametric design tool was developed for this experiment, to visualise in a crude way the forces behind the design moves; arguably the contradictions of activity and the contradictions of space. Using this tool, students ended up stuck and boosted by the same — but not all — the contradictions that practitioners faced in the industry project, despite not working under the same conditions. The results suggest that the contradictions of a project are intrinsic to the design space, even if they are unknown.

Contradictions offer an alternative to constraints in understanding design activity’s limitations and drivers. They are constituted by the systemic tensions that accumulate and drive a certain activity, provoking trouble in many different ways. Contradictions cannot be removed, nor solved; rather they can be aggravated, alleviated, or overcome when reproduced in the design space. In any case, contradictions will not go away. Any alleviated contradiction will keep accumulating tension without notice, until it surfaces again in the design space. Thus, the design activity bounces between contradictions in the design space, but not without changing them. Evidence of this bouncing activity has been found in the collected images of the design space from the case study and the experiment, in particular, in the dressing room instability.

The study results are consistent with the view that the design space is a space of becoming (Luck, 2014). Any design considered in the design space is not just a possible one, but also an actual one coming to life. It already exists and affects the design activity, as does any material in the physical world. Each move in the design space expands or contracts the potential to change the world. Making sense of design in this way can strengthen the emerging approach to design research that pays more attention to artefacts, practices, and history rather than inscrutable cognitive processes (Kuutti, 2011). This could, perhaps, lay the basis for a design approach that is concerned, not only with overcoming contradictions of design space, but also with overcoming contradictions of design activity. In order to reach these spatial-temporal breakthroughs (Lefebvre, 1991), design practitioners, design students and design studies will have to learn crossing boundaries between different social activities and social spaces.
Chapter 4

Expensive or expansive? Learning the value of boundary crossing in design projects

The previous chapter found evidence that contradictions of design activity reproduce into contradictions of design space. A specific setting has been studied where a specific contradiction arose. This chapter looks at a more general contradiction of the capitalist division of labour, between exchange value and use value. This contradiction is analysed in the division of labour among multiple stakeholders in a design project, which gives the context for a theory about boundary emergence. Boundaries are expected to rise when the contradiction between exchange value and use value is nurtured by strong differentiation amongst the stakeholders.

The research setting for this chapter is another experiment with design students; this time based on a board game designed to introduce boundaries between players and where each student takes a stakeholder role in a design project. Before playing, the students were asked to read about boundary crossing strategies and to try to apply them while playing the game. The task turned out to be difficult. Even when students knew they should collaborate, they could not give up their self-interests easily. The results suggest that knowing boundary-crossing strategies and having the necessary instruments do not necessarily lead to collaboration and sustainable expansion. This implies that it is necessary to generate complementary differences, to improvise new tactics and to develop shared objects among activities.

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1. Introduction

Design projects are increasingly complex and fragmented. To cope with complexity, work is divided into separate activities, run by specialized professionals (Blau, 1984; Rau, Neyer, & Möslein, 2012). These activities are connected by a common object of design (Engeström, 2006), which travels from one activity towards another in a production chain, supposedly increasing its value with each contribution. Since every activity aims for a return on its contribution, be that monetary or not, the object’s value is split into two: the exchange value — for what can it be exchanged — and the use value — the practical usefulness. (Engeström, 2000a). In favour of exchange value, design activities eventually ‘throw work over the boundary’, disregarding use value and influencing the next activity to do the same. After going through a chain of activities that prioritize exchange value, the object might be completely devoid of use value — a commodity in the Marxist sense (Engeström, 2000a; Lefebvre, 1991).

In project organization literature, boundaries are considered one of the main factors associated with the commodification of design objects, although not described in such Marxist terms. Boundaries are related to differences between organizational units and knowledge disciplines, which cause problems to communication, coordination and organizational cohesion (Carlile, 2004; Dossick & Neff, 2010; Neff, Fiore-Silfvast, & Dossick, 2010; Pemsel & Widén, 2011). Project organization theories prescribe some strategies to cross organizational boundaries: dissolve boundaries in temporary teams formed by representatives of different units and a neutral leader (Pahl et al., 1984, p. 139); skip boundaries by hiring a single organization to design and build the object (Cheng & Tsai, 2008); anticipate activities that happen later in the value chain by adopting an integrated project delivery method (Lahdenperä, 2012); or implement technology that makes boundaries visible and manageable in the object of design (Eastman, Teicholz, Sacks, & Liston, 2009; Singh, Gu, & Wang, 2011).

These boundary crossing strategies have proven difficult to apply in practice (Gottlieb & Haugbølle, 2013; Hartmann & Bresnen, 2011; Neff et al., 2010; Pemsel & Widén, 2011). The problems associated with boundaries cannot be solved in a simple way because they stem from an inherent feature of the division of
labour: the contradiction between exchange value and use value (Engeström, 2000a; Lefebvre, 1991). Even if organizational units and knowledge disciplines are strategically merged or homogenized, boundaries will still be active to justify the division of labour. Any homogenization strategy will have to face the boundary crossing tactics of difference preservation (Lefebvre, 1972), such as interfering with someone else’s work, making undercover alliances, and sabotage.

Boundary crossing, as a strategy or tactic, may cost more time and money than expected (Cicmil & Marshall, 2005); however, it may also expand the possibilities of generating unique value for the object of design (Miettinen & Paavola, 2014). Whether boundary crossing is expensive or expansive depends on the specific circumstance where it happens, or in other words, it is an emergent phenomenon (Akkerman & Bakker, 2011). Due to the limitation of predictive knowledge to learn about an emergent phenomenon, practitioners have to adopt a learn-by-doing approach to boundary crossing (Engeström, Engeström, & Kärkkäinen, 1995).

If design practitioners learn the value of boundary crossing while crossing them, a difficult question is posed to design education: how can design students learn the value of boundary crossing if, for the most part of their study, they are working together under the same institution, the same discipline, playing almost the same role? The aim of this paper is, therefore: to advance further the understanding of boundary crossing in design projects and to explore how design students may learn boundary crossing from playing a game.

The game is called The Expansive Hospital in reference to the underlying theory: expansive learning (Engeström, 2015). This theory has been previously applied to study boundary crossing in many kinds of organizations, in particular, healthcare organizations (Engeström & Sannino, 2010; Engeström, 2006; Kerosuo, 2004). The Expansive Hospital artificially introduce boundaries among students and let them experiment well-known boundary crossing strategies and to develop their own boundary crossing tactics. In spite of the name, if players do not cross boundaries or cross boundaries only to maximize exchange value, the hospital becomes expensive instead of expansive, leading to
the hospital’s bankruptcy and the consequent premature end of the game.

The game was brought to a bachelor-level facility design course to complement the assigned readings on boundary crossing. Playing the game followed the double stimulation method (Engeström, 2011; Vygotsky, 1978), which introduces an ambiguous situation among participants to observe emergent behaviour. This experimental method typically relies on small samples, diminished control, and qualitative in-depth analysis. Our specific analysis is framed by the concept of boundaries developed by the expansive learning theory (Engeström, 2015) and the complementary concept of differences from the production of space theory (Lefebvre, 1972, 1991, 2014a, 2014b), both of Marxist origin. As a concept design game (Habraken & Gross, 1988), the purpose is to check the applicability of these concepts and, as a double stimulation experiment (Engeström, 2011; Vygotsky, 1978), the purpose is to validate the pedagogical approach of using games to learn boundary crossing.

The theories behind the game are firstly introduced, followed by the design process and the experimental method. The reports written by students who played the game are then used to reflect upon the value of boundary crossing in design projects as well as the possibilities of learning it by playing games.

2. The emergence of boundaries between activities

The expansive learning theory identifies boundaries in the connection between different activities (Akkerman & Bakker, 2011; Engeström et al., 1995). An activity is defined as a subject — individual or collective — transforming an object for a specific outcome, by means of instruments, rules and a division of labour (Engeström, 2015). Organizations are constituted of many activities connected by outcomes; what is produced by one activity becomes an element for another activity. For example, the outcome of design education activity may be — among other things — students (subjects) capable of carrying on design activities in the industry.

Boundaries emerge amidst activities because the outcome is not used by the same activity, instead, by another activity. Each
activity must generate an outcome, on the one hand, for exchange value — eventually measured in monetary terms — and, on the other hand, for use value — measured by the practical use of the outcome (Engeström, 2000a). To generate unique outcomes and at the same time enable negotiation for profit, an activity must differentiate itself from the others, developing a different object, instrument, rule, community, or division of labour. This process of differentiation has the side effect of creating boundaries among activities, perpetuating the contradiction.

To cope with the contradiction, the object of activity must be constantly reshaped according to the expected and the unexpected outcomes. In face of an increasing demand and aiming for a larger profit, one activity might transform the object into a commodity that can be exchanged for almost anything at a low price, resulting in a high exchange value. The setback is that this object loses its unique qualities and usefulness, resulting in a lower use value. Any activity must negotiate the object value because, if it does not produce something unique, it may be taken over by another activity or delegated to automation (Kaptelinin & Uden, 2012) and, if it does not produce exchange value, it may not get the necessary resources, instruments or subjects from other activities.

The contradiction can be overcome, though, by a mutual effort from two or more activities to learn about each other and to prioritize use value. The object becomes coproduced and used by both activities, whose boundaries become a site for collaboration and co-creation of value (Ramirez, 1999; Vargo et al., 2008). The connection between activities expands from an exchanged outcome to a shared object (see Figure 1) (Engeström, 2001).

This expansion from exchanging outcomes to sharing objects is not permanent and does not eliminate boundaries or differences. Activities learn from their differences while working together, but such learning generates further differences that may hamper sharing. While some people might cross boundaries for the sake of learning, others might just want to interfere with a practice that is not beneficial for them. Boundary crossing, therefore, does not require or imply the consensus.
Eventually, specific instruments will be created to maintain the shared object despite the lack of consensus, the so called ‘boundary object’ (Star, 2010). These terms — boundary object and shared object — are not to be confused here, since instruments can merely represent objects but not replace them (Hasu & Engeström, 2000). When the instrument of an activity is confused with the object of that activity, a significant reduction may be taking place: activity being reduced to a function of the instrument. This is often the case when a technology, a contract, or an organizational chart imposes a different set of responsibilities, rules and division of labour to a chain of interconnected activities, in an attempt to strategically reshape boundaries. These instruments may become boundary objects but never shared objects that orient multiple activities; they are just a means for that orientation (see discussion in Akkerman & Bakker 2011, p.147).

The concept of boundary crossing (Engeström et al., 1995; Suchman, 1994) is related to the concept of boundary spanning (Aldrich & Herker, 1977), however, there is a major distinction between them. Boundary crossing assumes that boundaries emerge through collective historical activity and cannot be shaped at will due to the materiality of contradictions, whereas boundary spanning assumes that boundaries are closure mechanisms that can indeed be managed by certain roles in an organization. The failure to acknowledge this distinction has spread confusion in boundary studies (Akkerman & Bakker, 2011; Star, 2010). Such confusion, we believe, stems from a knowledge gap between emergent and managed behaviour.
The production of space theory can fill this gap by linking boundaries to the process of activity differentiation. Boundaries are understood as the mark of an activity in space — disciplinary, organizational or physical space (Lefebvre, 1991, p. 191). Every time an activity is repeated, a difference arises, which can be of two kinds: induced and produced. Induced differences stay within the boundary (e.g. variation and improvement) and produced differences break through the boundary (e.g. antagonism and diversity). For instance, when activities are competing for exchange value, they induce differences that bring them small competitive advantages — such as return-to-scale, while activities collaborating for use value produce differences that can complement each other — such as synergetic partnerships.

The theory also relates differences to strategies and tactics, which are coordination mechanisms among activities. Induced differences are coordinated by strategies, ‘how groups tend to minimize the chances of maximal gain for their partners or adversaries — or conversely how they maximize their own minimal gain’, whereas produced differences are coordinated by tactics that respond to adverse conditions with ‘dissimulation, retreat, denial and misunderstanding’ (Lefebvre, 1972, 2014a). These differences and coordination mechanisms appear simultaneously in opposition to each other, up to a point when there is an inversion: induced differences become produced and vice-versa. The turning point is when the tension generated by the contradiction between exchange value and use value is at the peak (Lefebvre, 1991, p. 372), which corresponds to the moment when boundaries become effective, i.e. emerge.

An instrument that induces differences may not provoke boundary emergence at first; however, the induced differences may become produced if enough tension is raised. By default, produced differences deviate from induced ones, but they can also be forced back into the system. The transition from induced to produced entails the conflict for expanding differences whereas the transition from produced to induced entails the conflict for reducing them.

The theory of expansive learning together with the production of space allows for grasping boundaries as emergent phenomenon, fuelled by contradictions, shaped by differences, and manifested
as conflicts. This formulation can help to take a critical look at boundaries in design projects and to create an opportunity for expansive learning in design education.

3. Dealing with boundaries in design projects

There are many scholarly texts about boundary crossing in design projects (see Akkerman & Bakker, 2011 for a literature review on the topic). Some of these texts emphasize strategies to deal with boundaries — by inducing differences, while others emphasize tactics — by recognizing produced differences. Among the references mentioned in the introduction, we chose to discuss an engineering design textbook that focuses on boundary crossing strategies (Pahl et al., 1984), and a case study on the design of a swimming pool that focuses on boundary crossing tactics (Cicmil & Marshall, 2005). Both references include strategies and tactics, but they devote much more space to one or to the other.

The textbook’s overarching strategy is a systematic approach for design: divide the object of design into independent tasks and subtasks; distribute them among specialized professionals, define interfaces for information transfer across the tasks; and synthetize an overall solution. This approach allows for saving time with simultaneous or concurrent engineering of different parts of the system, but bears the risks of lack of information exchange and unsuitable solutions. To mitigate these risks, the textbook proposes organizing a temporary team freed of the current organizational boundaries and hierarchies, led by a project manager that oversees the big picture. ‘Departmental boundaries are thereby transcended’ (Pahl et al., 1984, p. 139).

Systematic approaches like this are the point of departure for the case study on the swimming pool. The project was organized in nested teams: the client team — composed of client with architecture team — and the contractors’ team — composed of many subcontractors. The architecture team was formed by the architect, the structural engineers and the building service engineers, all from different firms. The architect took the role of project manager and coordinated the different design activities. The two-stage procurement procedure anticipated the contractor’s activity hoping to minimize the emergence of constructability too late in the process. Despite the strategy, ‘the
lack of trust and the persistence, of the old ways of doing things, attitudes and suspicions are perceived by the project participants to have caused tensions and problems’ (Cicmil & Marshall, 2005). The strategies did not prevent the project from running over schedule and added extra complexity for conflict management, which was dealt by improvised tactics. The study concludes that strategies are not enough to deal with boundary crossing in construction projects.

4. The boundary crossing challenge for design education

Boundary crossing is a challenging topic for design education. Reading the literature mentioned above does not seem enough to learn boundary crossing since the associated conflicts needs to be experienced directly. In the expansive learning theory, this is expressed by the transition from object to instrument. When the text is the object of learning, students are evaluated by their capacity to reproduce the text — in an exam for instance (Engeström, 2015, p. 81). However, if students are stimulated to use texts as instruments for their learning activity, the object of learning becomes the same as in the work practice (Engeström, 2015, p. 99). The text is no longer used merely to achieve good grades, but to deal with a practical object, in the case of this challenge, crossing boundaries in a design project.

Design students typically learn how to organize projects through group assignments and design studios (Kuhn, 2001; Ward, 1990). When they are following the same course, chances are that they have similar backgrounds and interests. It is difficult to promote confrontation, especially when they can team up to divide the assignment into separate tasks and get a reasonable group grade out of it. Business simulations and concept design games have been tried in design education to provoke such confrontation (Bogers & Sproedt, 2012; Chanin & Shapiro, 1985; Habraken & Gross, 1988; Sacks, Esquenazi, & Goldin, 2007); however, they are typically based on abstract combinatory systems, with finite sets, which does not stimulate the creation of knowledge beyond the possible combinations, in other words, expansion (Engeström, 2015; Hatchuel, 2001). These games do not induce enough differences to make strong tensions and boundaries emerge.
between players; in fact, players more or less follow the same rules and display similar strategies.

Learning by doing in industry is difficult since complex design projects have too high stakes for students to directly partake. It is also difficult to cross boundaries between faculties to organize projects involving students from different design disciplines (Denton, 1997). The bottom line is that students rarely have the opportunity to experience boundary crossing directly.

Our response to this challenge is a board game designed to experience boundaries in a complex design project. The idea of creating a board game came after conducting three case studies in healthcare. The first case is a medical imaging centre with state-of-the-art diagnosing technique. The second case is a microbiology and pathology laboratory inside a medium-sized hospital. And the third is a combined housing and palliative care unit for the elderly. The main data set consists of partially transcribed semi-structured or open interviews conducted with practitioners involved in the design process during the timeframe of investigation (2-3 months for each case). For the sake of space, a detailed account of these cases is not possible here; however, a summary of the boundary crossing strategies found in these cases can be seen in Table 1, together with requirements to enable them in the game.

The board game was designed to communicate the findings of these case studies to a broader audience and to provide expansive learning opportunities for design students. The game is informed by case data, inspired by theory and developed according to the iterative design approach, which emphasizes playtesting prototypes to feel the gameplay and collect suggestions from players (Salen & Zimmerman, 2004, pp. 11–12).

Before the experiment with Bachelors students, the game was tested three times with Masters students and PhD researchers. Every time it was tested, a map of issues was recorded in an Issue-Based Information System (IBIS) (Kunz & Rittel, 1970; Selvin et al., 2001) with the purpose of assisting reflection on what needs to be done next to improve the game. Adjustments followed. Iterating between designing and testing also contributed to sharpening the theory of boundaries based on activity differentiation, working
similarly to pilot experiments and concept design games (Habraken & Gross, 1988).

Table 1 - Summary of boundary crossing strategies applied in healthcare construction projects and the requirements for the application of these strategies in the game.

<table>
<thead>
<tr>
<th>Boundary crossing strategies</th>
<th>Case 1 – Medical imaging centre</th>
<th>Case 2 – Hospital lab</th>
<th>Case 3 – Elderly housing</th>
<th>Requirements to implement the strategy in the game</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temporary team</strong> (Pahl et al., 1984)</td>
<td>Building team with all the construction partners.</td>
<td>Concurrent engineering sessions.</td>
<td>Building team with all the construction partners.</td>
<td>Players should be able to team up to conduct a task together, but the team formation shall not be fixed.</td>
</tr>
<tr>
<td><strong>Overseeing leader</strong> (Pahl et al., 1984)</td>
<td>Client.</td>
<td>Contractor.</td>
<td>Architect.</td>
<td>There should be one role responsible for giving directions and moderating others.</td>
</tr>
<tr>
<td><strong>Dividing tasks</strong> (Pahl et al., 1984)</td>
<td>A Gantt chart for every partner.</td>
<td>A model for every partner.</td>
<td>Partners subcontracted.</td>
<td>Player tasks should be clearly defined in the construction contracts.</td>
</tr>
<tr>
<td><strong>Collaborative technologies, Building Information Modelling</strong> (Eastman et al., 2009)</td>
<td>Online issue tracking system and document sharing (Project Place).</td>
<td>Parametric modelling (Revit), clash detection (Navisworks), meetings with a big screen, and file sharing (Docstream).</td>
<td>Parametric modelling (Revit), meetings with a big screen, and file sharing (Docstream).</td>
<td>The hospital may be represented by three dimensions blocks or by more abstract representations such as calculations and sketches.</td>
</tr>
</tbody>
</table>
5. The Expansive Hospital Game

The game plot is based on a hospital under constant expansion, in which all the profits are reinvested in real state. Each game session simulates a process that takes between 5 and 25 years of a typical hospital trajectory. Players design the hospital but also treat patients with the built facilities. Each patient successfully treated earns a point of credibility for the hospital. A hospital with no credibility points is closed and the game is over, whereas a hospital with 20 credibility points earns the excellence award and the winning condition is achieved. The game is also over when the hospital does not have money to pay the maintenance costs for the current facilities, a condition called bankruptcy in the game.

The rules are such that information will likely be lost during gameplay. The hospital is built with building blocks, each representing one facility type, with a pipework layer underneath. If players do not know what is already implemented, they cannot decide how to operate or what to build next. There is also a risk of clashing a gas pipe with an existing water pipe when adding extensions, allowing the contractor to charge an extra amount. Players receive squared ‘database’ sheets (see Figure 2) to keep track of information as they like, but that is not mandatory for playing and there is no instruction on how to fill them out. This is done to highlight the consequences of having or not having information readily available in negotiating with other players.

This is in a nutshell what players collaborate for. Conversely, there is a competitive side of the game. Each player choses one of six roles available, with mutually exclusive powers and a different way of earning money: the architect can design the building shape; the engineer can design the pipework; the builder can implement the designs; the hospital director can decide where to invest; the facility manager can maintain the facilities; and the nurse can admit and guide patients across the building. Players negotiate how to use their powers, charging the hospital heavily for their services, or harming others players. If they play too competitively, the hospital quickly goes bankrupt; if they play too collaboratively, one of the players may have an advantage over the others.
The hospital is built in three dimensions with plastic blocks, which represent typical functions, e.g. consulting room, operating theatre, trauma centre and so forth. These functions must be arranged according to their technical requirements — connection to water or heating pipes — and the needs of the patients waiting in the queue. Each block and each patient have different requirements according to function and illness, respectively. The treatment starts as soon as the hospital has the first function needed by the patient, then the rest must be built during the treatment. The hospital earns a fee once the treatment is completed.

The money flows from the insurance company to the hospital account and then to player accounts. The architect, contractor, and engineer earn money in the construction round, while the hospital director, facility manager, and nurse earn their fees in the healthcare round. The hospital design is supposed to be
developed and implemented during the construction round by the construction players; however, the healthcare players may discuss and influence the design in both rounds. Each player has his own turn to make decisions within the round, but since the decisions are immediately visible, they are often questioned and renegotiated.

Due to this game flow, a player’s decisions depend very much on other players, but the dependences are not symmetrical. Each player plays a different game mechanics (Table 2), but they all affect each other in unpredictable ways due to the large number of possible choices for each player. The unpredictability allows each player to have a negotiation margin: players are expected to be too busy with their own mechanics to understand what is going on with other players. The complexity of game mechanics makes this game very open-ended and prone to unexpected behaviours (see supplemental video content presenting the game mechanics).

Differences are induced between players in the hopes that they will experience boundaries while playing. If player roles are considered self-standing activity systems (see Figure), the differences induced are within their object, their instrument, their rules, their community and their division of labour (see Table 1 in Appendix I). These activity systems, however, are not historically constituted and cannot stand as such; the activity system model is meant to understand change from one structure to another in an existing activity and not to impose an empty structure to an activity (Engeström, 2015). Play is indeed an activity, but an activity that enacts another activity through imagination (Vygotsky, 1967). The contradictions inherent to the activity being enacted also manifest in play, though in less tension (Engeström, 2015, p. 106). We believe that if enough tension is raised by play activity, players may fully embody their roles and produce their own differences, characterizing the formation of their own activities. In contrast, if little tension is raised, players will just follow the rules and invest no further motives to their objects. This is, nevertheless, expected at the beginning of the game, when players are still trying to understand the game rules. If they do not manage to go beyond following the rules and embody their roles, no boundaries will be played at all.
Table 2 - Game mechanics identified by boardgamegeek.com that applies to players in the Expansive Hospital game; each player plays a different game mechanics.

<table>
<thead>
<tr>
<th>Role</th>
<th>Game mechanics (boardgamegeek.com)</th>
<th>Application in The Expansive Hospital</th>
<th>Board game consulted and/or played as a reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nurse</td>
<td>Worker placement</td>
<td>Moving patient meeples.</td>
<td>The Pillars of the Earth (Rieneck &amp; Stadler, 2006)</td>
</tr>
<tr>
<td>Facility Manager</td>
<td>Secret Unit Deployment</td>
<td>Knowing the pipework but hiding it from the others to build more than necessary.</td>
<td>Cleopatra and the Society of Architects (Cathala &amp; Maublanc, 2006)</td>
</tr>
<tr>
<td>Director</td>
<td>Commodity Speculation</td>
<td>Investing in facilities and patients that look more profitable.</td>
<td>1830: Railways &amp; Robber Barons (Tresham, 1986)</td>
</tr>
<tr>
<td>Architect</td>
<td>Pattern building</td>
<td>Designing a building that looks good in his opinion.</td>
<td>Ugg-Tect (Obert, 2009)</td>
</tr>
<tr>
<td>Engineer</td>
<td>Tile placement, Pattern building</td>
<td>Resolving the puzzle of pipework tiles.</td>
<td>Tsuru (McMurchie, 2004)</td>
</tr>
<tr>
<td>Contractor</td>
<td>Auction/Bidding</td>
<td>Bidding for a construction contract.</td>
<td>Master Builder (Kramer &amp; Witt, 2008)</td>
</tr>
</tbody>
</table>

The game stimulates players to produce their own differences via the contradiction between exchange value and use value. If rules are followed mechanistically, the hospital goes quickly bankrupt since player’s outcomes are measured by money and not by
usefulness — exchange value, not use value. The usefulness of a player’s outcome can only be realized by relating it to the emergent qualities of the hospital: a) capacity to adapt to fluctuations in patient queue; b) reasonable maintenance costs; c) cooperative crew. Use value becomes clearer through emergent collaboration, whereas exchange value becomes clearer through emergent competition. In other words, players must collaborate for use value while competing for exchange value. Easy compromises are not possible once boundaries are under effect. The game suggests strategies to cross boundaries (Table 1), but the tactics are not given.

The main strategy at the disposal of the hospital director — the overseeing leader — is to change the contract with construction players every round. There are three types of contracts derived from the Dutch regulations (Bruggeman, Chao-Duivis, & Koning, 2010): the traditional contract — when the architect helps defining a design and a budget before asking the contractor’s opinion; the fast-track contract — when the contractor is responsible for everything, including paying the architect and engineer according to standardized fees; and the integrated contract — when the director defines a fixed budget for the construction players whose income can be freely negotiated. These contracts can be used to moderate players, for example, by changing from fast-track to traditional if the contractor is overcharging. However, the moderation can always be countered. In the same example, the contractor may refuse to bid for a traditional contract, halting all the construction work in the game.

To summarize, the game is a caricature of a hospital project and also an open system for the emergence of ambiguity, uncertainty and overwhelming complexity that are so typical of project-based organizations (Askland, Gajendran, & Brewer, 2013; Chinowsky, 2011; Cicmil & Marshall, 2005).

6. Experimental method

The Expansive Hospital was introduced in a facility design course from a Civil Engineering Bachelors program to let students learn boundary crossing beyond what texts say about it. The course consists of an engineering design introduction based on the textbook by Pahl et al (1984), alternating between lectures and
hands-on sessions for group assignments. The first lectures introduce the difficulty of representing knowledge in design instruments such as Building Information Modelling (BIM) (Eastman et al., 2009) and the importance of maintaining a reflective practice (Schön, 1983). After these lectures, the board game was introduced in a hands-on session with the goal of letting students directly face the issues discussed by literature. Before the session, students were individually required to write a report about the study of the swimming pool project (Cicmil & Marshall, 2005). The assignment asked: ‘Is it possible to reduce the risks of concurrent design activities, by using a two stage tender process or other collaborative design methods?’ After playing the game, they were also requested to write another report reflecting on the gaming experience, this time in a group.

Students organized themselves in groups of six, making in total seven groups simultaneously playing the game. The game was introduced without explanations; game mechanics had to be picked up from the rulebook or by asking questions to the teachers at the class. It took an average of one hour to understand all the rules and to achieve a smooth game flow; two hours was the total duration of the session. The learning reports were collected, coded and analysed according to the activity system model (Figure ), looking for evidence of produced differences (Lefebvre, 1972, 1991) within the enacted activities. The produced differences are used as a measure for the emergence of boundaries among players and also of expansive learning, which here means learning beyond the text. For the sake of space, only two groups are discussed in this study: the group who performed the best and the group who performed the worst according to the game’s quantitative outcomes.

The experiment with students has two aims: to sharpen the boundary-related concepts that inspired the game creation and to test the pedagogical approach of learning boundary crossing by

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8 Before this course, a couple of pilot experiments were organized with the authors performing as facilitators, explaining the rules and observing the game, what resulted in a much more strict playing by the rules. It was also experimented with individual learning reports, but the reflections were considered too shallow.
playing a game. The method is a combination of concept design game and double stimulation. “Concept design games are research tools intended to help us better understand designing. They do this by opening to scrutiny the concepts we use as designers, as well as the structures of the complex artifacts we manipulate” (Habraken & Gross, 1988, p. 152). And double stimulation is a psychological method to study learning, taking the process more into account than its outcome (Engeström, 2011; Vygotsky, 1978).

The first stimulus is a contradictory situation and the second stimulus is an ambiguous instrument that may be used to overcome contradictions. The experiment looks at how subjects make the second external stimulus their own internal stimulus, i.e. how they resolve the ambiguity and give a certain meaning to the instrument. The instrument helps to objectify meaning making, what helps not only the experimenter but also the learner.

In the experiment presented here, the interdependence between players is considered to be the situation where the contradiction between exchange value and use value manifests and the database sheet is the purposefully introduced ambiguous instrument. Other game components as well as anything participants bring to the experiment — e.g. a notebook or an electronic calculator — may also be appropriated as a second stimulus. Since the second stimulus is considered to be the underpinning for learning (Vygotsky, 1978), it is expected that it is mentioned in the learning reports delivered by students. A good deal of interpretation based on the aforementioned theories is employed to identify this stimulus among the many others reported.

The task of writing the report can also be considered a contradictory situation in itself, since no clear explanation about what to learn from the game was provided. The instruction given was to relate the learning experience to the texts previously assigned for reading (Cicmil & Marshall, 2005; Eastman et al., 2009; Pahl et al., 1984; Schön, 1983), which can also be considered an ambiguous tool given for the task of writing the learning report. The double stimulation method was in fact a pedagogical premise of the whole course program, which aimed to take into account and support individual and group development. In the present study, the learning reports written
before and after the session are compared to find evidence of this development.

7. Experiment results and analysis

Student reports mention many attempts to influence other players decision’s, to come along and exchange information, to use common visualizations, to help with a task outside of own expertise, and to co-create solutions, actions typically associated with boundary crossing (as described by Akkerman & Bakker, 2011). Despite trying similar strategies and playing the same game, the performances of these two groups were completely different: group A managed to build a working hospital and group B was bankrupt before treating any patient. The sum of earnings in group A is almost five times larger than group B, meaning that its hospital financial capital increased way beyond the initial 2000 (Table 3).

Table 3 - Final earnings for each player role, in game’s money. In group B, the nurse did not earn anything because no patient was treated. Group A manages to treat many patients within the same amount of playing.

<table>
<thead>
<tr>
<th>Group</th>
<th>Role</th>
<th>Accumulated earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Nurse</td>
<td>2400</td>
</tr>
<tr>
<td></td>
<td>Facility Manager</td>
<td>3400</td>
</tr>
<tr>
<td></td>
<td>Director</td>
<td>2225</td>
</tr>
<tr>
<td></td>
<td>Architect</td>
<td>350</td>
</tr>
<tr>
<td></td>
<td>Engineer</td>
<td>1320</td>
</tr>
<tr>
<td></td>
<td>Contractor</td>
<td>210</td>
</tr>
<tr>
<td></td>
<td><strong>Total paid by the hospital</strong></td>
<td><strong>9905</strong></td>
</tr>
<tr>
<td>B</td>
<td>Nurse</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Facility Manager</td>
<td>430</td>
</tr>
<tr>
<td></td>
<td>Director</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Architect</td>
<td>470</td>
</tr>
<tr>
<td></td>
<td>Engineer</td>
<td>680</td>
</tr>
<tr>
<td></td>
<td>Contractor</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td><strong>Total paid by the hospital</strong></td>
<td><strong>1860</strong></td>
</tr>
</tbody>
</table>

The analysis of the reports that follows tries to explain these results through the theory of boundary emergence from activity differentiation.
1.1 Shared objects in group A

Group A used the databases as instruments for storage and design. The hospital director made an income statement; the facility manager represented the position of the blocks already built; the engineer made one sketch; and the nurse had a sophisticated care plan including the facilities needed for the current admitted patients and the number of satisfaction points expected to be spent. The nurse was the only one that used the database to represent future situations instead of just taking notes of what was already built (Figure 3), what could be considered an expansive use of building information modelling (Hannele et al., 2012; Miettinen & Paavola, 2014). The nurse was the only one that used the database to represent future situations instead of just taking notes of what was already built, what could be considered an expansive use of building information modelling (Hannele et al., 2012; Miettinen & Paavola, 2014).

The nurse had a holistic view on patients, considering not just the queue, but also patients inside the hospital and future patients that did not even show up in the queue. His object was shared with the facility manager and the hospital director, who worked together to maximize patient admission and discharge. Oriented to this object, the healthcare team gradually developed a vision of a profitable hospital guided by the rules of operation efficiency. They convinced the construction team to charge less and less for their work, up to the point that they discovered a weakness in the
game’s rule: the integrated contract allowed conducting inspections for free, meaning that the contractor could simply lift a block to see the hidden pipework. That is not a beneficial action for the contractor, but he did not manage to convince the other players to do otherwise.

The result is that the contractor was the last in the group, but the group managed to collect much more money overall. The construction team did not hamper the game in order to avoid the loss of exchange value. They were so involved with the challenge of designing integrated facilities that they did not mind losing the game at the individual level. The differences produced by players in group A (see Table 2 in Appendix II) suggest the existence of two shared objects that reinforce each other: the patients generate profits for the hospital, and those profits are reinvested in the design of integrated facilities, with the aim of treating even more patients (Figure 4).

![Diagram: Interconnected activity systems in group A: the healthcare team collaborates for patients while the construction team collaborates for design. The exchanges between these objects reinforce each other.]

**Figure 4 - Interconnected activity systems in group A: the healthcare team collaborates for patients while the construction team collaborates for design. The exchanges between these objects reinforce each other.**

### 1.2 Exchanged outcomes in group B

The healthcare team from group B did not have a shared object. Players acted in an individualistic basis, with not much regard for the teams they belonged to. The following excerpt from the learning report summarizes the situation:
According to the rules of the game there should be two teams; the construction team and the healthcare team. There was no consultation between the players on the healthcare team, which resulted in building unnecessary facilities, and going over budget. In the construction team there was a bit of collaboration, mostly to figure out the best way to maximize their income and bring the hospital further in debt. This resulted in the hospital going bankrupt in three rounds and the construction team having their pockets filled with cash. It was clear that no one had a long-term vision and was only in it to win personally, instead of reaching the team goal (Group B, excerpt from learning report after playing the game).

Figure 5 - Interconnected activity systems in group B: healthcare players throw their outcomes over the boundary until the object is emptied of use value by the construction players. The value chain ends up in a useless building that cannot serve as an object to generate patient income.

Players from group B followed strictly the rules, but spent an insurmountable amount of time in negotiating outcomes, mainly to protect individual interests. After giving up negotiating, a player would throw his work to the next player just to keep the game
going on, but the quality of that work was already compromised. The collaboration among the architect, engineer, and contractor can be considered a shared object, yet one that produces a completely useless building due to its extreme tendency towards exchange value (Figure 5). This object fails to feed the nurse with more patients and the game was over after three rounds due to the lack of money to build new blocks and to maintain the current ones. The activities organized themselves as a chain, connected mostly by the mandatorily demands and supplies prescribed by the rules. Since using the database sheet was not mandatory, none of the players did it. It is possible to conclude from this analysis that group B produced fewer differences than group A (see also Appendix II).

1.3 Groups compared

The emergent boundaries in group B form the pattern of a value chain: one activity delivering work to another activity, each adding value to a common object of production. The value of this object, however, was increased in terms of exchange, but not in terms of use, resulting in a very expensive and useless building. The emergent boundaries in group A do not form the pattern of a value chain, instead, it resembles the description of a value constellation, characterized by the co-creation of (use) value (Ramirez, 1999; Vargo et al., 2008).

The varied organization morphology within these two groups highlights the importance of not taking boundaries, boundary crossing, shared objects or instruments for granted. The game introduced the same conditions for all the groups, but each group created its own boundaries based on the interpretation of the rules, social relationships within the group, personal experiences and other elements. Some groups used the building blocks, some used the information database, and some used concepts such as ‘the need to collaborate’ as instruments to cross the boundaries.

The players enacted six different activities in both groups, corresponding to player roles as designed. None of the players enacted two or more activities, yet this was observed in a previous testing session, when an architect took over the work of an engineer who was not able to understand his role and negotiate a position. In this specific session, the boundary
between the architect and engineer could be considered reduced or even dissolved. Nevertheless, in the present experiment, all players’ activities deviated from the differences induced by the game rules and, therefore, had their own boundaries (see Table 2 in Appendix II for a full account).

8. Learning as reported by students

The comparison between the learning reports before and after playing the game suggests that students underwent a reality check on boundary crossing strategies such as two-stage tendering, collaborative technologies and integrated delivery. Despite reading about the strategies from Pahl et al (1984) and knowing their pitfalls from Cicmil & Marshall (Cicmil & Marshall, 2005), students could not simply apply the strategies and avoid the pitfalls. Once embodied in their game roles, they realized that it was difficult to give up personal gains in favour of group gains, no matter how rational the argument was. Group B blamed the lack of a common goal among the players for the early bankruptcy. Conversely, group A affirmed having a common goal but also individual goals, which became difficult to distinguish due to the ambiguity of players’ action and talk. Sometimes players would act for the group benefit, sometimes for their own personal benefit, and sometimes for both.

Despite not using the database sheets, group B reports to have experienced some principles behind building information modelling (Eastman et al., 2009), a collaborative technology strategy for boundary crossing:

*While playing this game we noticed that the visualization of the hospital was very helpful. Not only for the communication in the teams but also for the overall game play. While the health care team or the construction team was arguing, the visualization was helpful in order to choose which decisions would be right to make. [...] The visualization of the hospital, the result of working on a BIM (Building Information Modelling) principle, contributed to the learning process of the game. [...] A BIM tool is useful to implement much information within one model (Group B, excerpt from learning report after playing the game).*
Group B used the building blocks as a single model (a boundary object) to plan and design, whereas group A used multiple database sheets to do so. The database sheets allowed group A to look beyond the task at hand, in particular through the database made by the nurse (see Figure 3). Instead of confirming the advantages proclaimed by the text read for a previous lecture (Eastman et al., 2009), group A developed a critical view towards building information modelling:

A very important feature of BIM is that information of various disciplines is shared. This provides insight in the other areas of the facility. This can be used to adapt to each other, but during the game this insight created a problem. The problem was that every player from the various disciplines wanted to get involved with the other disciplines to increase their own gain. The players became selfish (Group A, learning report after playing the game).

This critical view represents a considerable expansion from what students knew before playing the game from reading Pahl et al (1984) and Cicmil & Marshall (2005), as can be seen from these excerpts from the individual reports before playing the game:

In bigger designing projects, which require multiple design teams, there is a need for a clear structure in the designing process (Pahl & Beitz, 2007, p. 138). Also process steps have to be independent, (Pahl & Beitz, 2007). The result is that design teams can carry out their process without interfering with each other. (Student R.H, group A, excerpt from learning report before playing the game)

[BIM] gives a digital representation of the physical and functional characteristics of the project. [...] So that people from the management side and the construction and design side do not only see the processes from their own point of view. BIM gives them more insight, which leads to more understanding of each other. (Student J.R, group A, excerpt from learning report before playing the game)

Group B did not manifest any critical stance towards the literature provided in the course; however, the reflection about the failed experience of building a working hospital reveals a deeper understanding of the underlying contradiction:
When one person decides to only go for his own goal and personal gain this can quickly affect the entire group. The consequence of this is that this person gains a short-term advantage at the cost of everyone’s long term. This stems from the fact that this one person can tax the entire system in such a way that the other roles in the project do not have enough leeway to fulfil their own personal goals. When every person keeps the different goals of the different person in mind they can take this in to account when taking their own decisions and everyone can work together working on solution which brings good long term advantages. (Group B, excerpt from learning report after playing the game)

The comparative analysis suggests that both groups have expanded their understanding of boundary crossing beyond the explanations and prescriptions provided by the selected literature. Expansive learning was not caused by the game, but by the joint effort of students trying to cross boundaries and later reflecting about it in the report. In the learning process, the game can be credited for offering a certain resistance to the application of strategies prescribed by the literature.

The experiment results suggest that avoiding boundary crossing by defining clear boundaries, instruments and deliverables does not seem to be enough to salvage use value. The game setup had all of these conditions, but the players eventually transformed them into opportunities to increase exchange value. Dealing with the contradiction depended more on the motivation behind players’ activities than on the ambiguous instrument provided by the game setup. Hence, the investment of motives into shared objects can be considered the meaning of the second stimulus achieved by players when dealing with the contradiction between exchange value and use value.

9. Discussion

This study suggests that knowing boundary-crossing strategies and having the necessary instruments do not necessarily lead to collaboration in design projects. If it is possible to extend the analogy between project-based organizations and games to the present study, boundary crossing requires more than to understand the spoken and unspoken “rules of the game”
In fact, boundaries are liminal spaces where the institutionalized rules of each activity are suspended and new rules can be created (Räisänen & Löwstedt, 2014). This can be exemplified by the negotiated free of charge inspection in group A, which worked against the contractor’s interest. The rules were not the only differences produced, though; they have been observed in instruments, objects, outcomes and the division of labour (Appendix II). The production of differences in players’ activities provides “insight into how agents — individuals or organizations — attain the ‘feel of the game’ which is required in order to be a practitioner within the project organizational field or a project organization field” (Askland et al., 2013, p. 125).

A major limitation of this study is that the learning reports do not track the development of the second stimulus in sufficient level of detail. In studies of expansive learning, data collection typically rely on direct observation and/or video recording (Engeström, 2011). We have chosen not to record the session due to the possibility of students feeling uneasy and exposed during the execution of a graded assignment. In future works, we expect to experiment the game with students from different backgrounds and with experienced practitioners, as part of a long-term intervention in an existing design project organization. In such context, video recording might seem more appropriate, thus enabling a fine-grained analysis of the second stimulus.

In this experiment, we have observed that even when there is little shared space between production and consumption — in the game’s term the construction and the operation round, consumption make its way through design by own effort. In other words, there is also production in consumption, which is in fact the production of use value (Lefebvre, 1991, 2014b). The game could have been designed to take only the boundaries in production into account, with greater detail on the division of labour and the design instruments, making a much more realistic image of what building information modelling (BIM) can be. However, we preferred to emphasize the interplay between the use value generated mainly at consumption and the exchange value generated mainly during production, which is actually the main source of conflict in the game. Humour, as implied by the caricature depicted by the game enabled the emergence of a
counter-discourse (Gonzatto, Amstel, & Costa, 2010) in group A: the criticism on building information modelling, which can also be found in some other texts in the literature (Dossick & Neff, 2010; Holzer, 2007; Miettinen & Paavola, 2014).

Boundaries have been presented here as the contour of fluid organizations, a marginal effect of the production of space among activities. This perspective is relatively new, since most investigation on boundaries often falls to a determinism of knowledge specialization, resulting in compartmentalization or silos in organizations (Carlile, 2004; Dossick & Neff, 2010). They justify the need for instruments (Carlile, 2002; Forgues, Koskela, & Lejeune, 2009) or professionals (Brown, 2008; Kelley & Van Patter, 2005) that are capable of integrating knowledge at the boundary in a neutral or holistic way, ultimately reducing the differences among the activities. The political difficulty of keeping boundary work neutral or even the fallacy of such discourse pushes to think beyond knowledge consolidation as a strategy to manage work fragmentation. While some researchers think about reducing differences and reassembling totalities, practitioners are already tying the knots, crossing boundaries on a daily basis to get work done (Engeström, 2008). Apparently, they do not seek to integrate knowledge, but to create new knowledge that can fill in the gaps and expand the practice, one difference at a time (Engeström et al., 1995).

10. Conclusions

This study contributes to the expansion of project-based organization research towards social, cultural, and managerial boundaries (Askland et al., 2013; Chinowsky, 2011; Pemsel & Widén, 2011; Räisänen & Löwstedt, 2014), in particular, with a theory of boundaries based on activity differentiation. According to this theory, boundaries emerge between activities when the differences in their structure (subject, object, instrument, rules, community, and division of labour) activate the contradiction between exchange value and use value. These differences can turn into competitive advantages or collaborative partnerships, depending on how the contradiction is resolved.

To test this theory and to provide a learning opportunity for design students, a board game has been designed and tested in a
facility design course. The findings of this experiment are consistent with another study on construction projects which found that organizational boundaries cannot be completely eliminated by integrative strategies (Baiden, Price, & Dainty, 2006). In fact, the group of students who blindly applied integrative strategies failed to produce a design object with use value. In contrast, the group that developed provisional tactics to deal with boundaries, produced differences that enriched both the use value and the exchange value of the design object. The production of these complementary differences can be attributed to the emergence of the second stimulus — the motivation towards shared objects. That stimulus was an internal, not external factor; an act of volition to overcome the contradiction between exchange value and use value.

The recommendation based on these findings is that boundary crossing strategies should better focus on motivation rather than on conditions to collaborate such as contracts, methods, and instruments. Also, they should not prevent the emergence of boundary crossing tactics, even if they appear to challenge these same strategies. Leaving room for improvisation seems to be essential in managing the boundaries between project-based organizations — like construction enterprises — and continuous-process organizations — like hospitals, boundaries that typically emerges while playing The Expansive Hospital game and also in the industry (Chinowsky, 2011, p. 4).

With respect to learning, sticking to boundary crossing strategies without enabling boundary crossing tactics may be expensive learning rather than expansive learning. The case of group B is emblematic to this point: boundary crossing was expensive to this group due to the negotiations based on exchange value; however, they still expanded learning beyond text reading. In an industry project, practitioners may not have the same opportunity for reflection after the failure. In that case, boundary crossing might be expensive only. The game analysis suggests that prioritizing exchange value in design negotiations leads to expensive learning, whereas prioritizing use value leads to expansive learning, yet this claim needs further confirmation from future studies.

Considering the attention given to integrative strategies in both design projects and literature studied, The Expansive Hospital
game can be considered a critical statement on the way boundaries are currently dealt by design practice and theory. Instead of reporting these studies as a traditional case study — what may be done in the future, we have chosen to first design a game that recreates and expand the conflicts and see what students think about them. The goal was not to make the criticism directly, but to let players develop their own criticism about the situation, what Mary Flanagan calls ‘critical play’ (Flanagan, 2009). The usefulness — or playfulness — of critical play in communicating research findings to a broader audience remains to be seen.

Complex, contradictory, and open-ended board games arise as a resource for collective reflection in design education and possibly in other fields, in particular, when dealing with emergent phenomena such as boundary crossing. These games seem to be particularly useful in expanding the object of learning beyond the text, getting closer to the related societal practices. Granted, playing games is safer and quicker than going through conflicts in practice, what could be useful for experienced practitioners too. In a rough comparison, it is possible to say that the contradiction between exchange value and use value was much tenser in the design projects studied than in the play activity, causing and being caused by uneasy business relationships among the firms involved. Future studies may explore the application of games to enable boundary crossing strategies and tactics in design projects with multiple firms and stakeholders.
This last chapter discusses the common threads between the paper-based chapters and then suggests a next step in theory development. A central theme emerges from this discussion: the role of contradictions in design. The specific contradictions covered by the various chapters are worked out more explicitly and in depth as a means to give context to the research within a broader historical setting. Following this, the two approaches to deal with contradictions in design — expansive design and reductive design — are characterised. The potential of expansive design is explained at the end.

My reflections on the outcome of the multiple chapters that follows lays the ground for the thesis’s theoretical propositions. This stands to streamline the ideas and offer an antidote to the fragmentation otherwise implied by the thesis structure built around self-standing papers. The evidence collected is overviewed in this chapter, together with the theoretical concepts used throughout the papers. This is done to describe the transformation in the design projects studied, as well as in the research project itself. These transformations had profound consequences that need mentioning here.

For instance, in the medical imaging centre (chapters 1 and 2), the transformation triggered by the participation of users in design was so radical that the location of the centre had to be changed. Chapter 1 was written before this decision, yet, there was a word of caution about the fragility of the shared object: if participation in design would not sustain, the motivation of the stakeholders to work together would diminish. So it happened. The increased concerns for patient safety, the uncertainty around the financial sustainability and the lack of further stakeholder involvement led to the rejection of the medical imaging centre location in favour of using a free space inside one of the hospitals. This was not a direct outcome of the workshop, but the workshop might have contributed to it.
The expansion of user activities led to an outcome the project managers did not expect or want. However, the prospects for the emergence of a collaborative activity seem to be better now that all the parties have agreed upon working together inside one of the hospitals. This development could have been anticipated before by adopting a more expansive approach in the design. Instead of rushing to build the centre as fast as possible, the managers could have spent more time in involving partners with the reason to build. In other words, defining better what is going to be shared in the centre. By so doing, alternative ways of dealing with the patient safety issues could have been realised. The expansion of the design object did not reach this level, in part due to the representation instruments being contracted to space and workflow issues.

Chapter 2 further advanced the analysis of this project looking at another contradiction: between the space of possibilities and the possibilities of space. In the medical imaging centre project, the socialisation of the design space with stakeholders did not return by exploring more possibilities for design. In fact, as the cross-analysis makes it clear, some possibilities were rejected or ignored by the stakeholders, yet some created and transformed. In any case, the participants’ actions during and after the participatory workshops broke through the space of possibilities and reached the possibilities of space, provoking changes to the work environment. This corresponds to the refusal to play the knitting game and the subsequent change of the medical imaging centre’s location.

These studies have pointed to the gap between the representations of space and the space of representations (chapter 1) and the analogous gap between the space of possibilities and the possibilities of space (chapter 2). The analogy could be extended to the gap between the designer’s mental model and the user’s mental model which is used in cognitive studies of design (Norman, 2002). However, the studies included in this thesis are not cognitive, but historical. Instead of framing the gaps as mismatches caused by the lack of understanding from either the designer’s or the user’s side, the case studies frame the gaps as historically accumulating tensions — contradictions (Engeström, 2015; Lefebvre, 1991).
To look at how contradictions drive design activity and become manifest in the design space, chapter 3 described an experiment with design students. The students were provided with a parametric design tool that could represent and model activity and space together. The pattern of successive layouts created by them follows a similar cycle that the practitioners went through, suggesting that the same contradiction was driving their design activity, yet in a lower level of tension. The conclusion is that the design space has intrinsic social materiality that cannot be moulded by designers at will. The paper advances design theory a step further in understanding what is behind problem-solving in design activity: the social production of design space.

The chapter particularly analysed the contradiction between knowledge co-creation and work optimisation, and its reproduction in the design space. This analysis did not uncover contradictions in design activity that arise from the division of labour, like the contradiction between exchange values and use value, which affect and are affected by the relationship between the design activity and other activities. Chapter 4 reports on an experiment looking at how this contradiction between exchange value and use value manifests in the way design students play a board game about building a hospital. In this game, every player takes a different professional role and plays according to their interests. Since money gives a measurable and distinguished outcome for each player, players are seduced to strive to earn money, even if this requires impoverishing the hospital build. The conclusion of the paper is that, if designers prioritise exchange value, boundary crossing is very expensive and generates poor designs whereas, if designers put use value as the priority, boundary crossing is expansive and leads to long-term profits for everybody.

Despite the focus of analysis being on different contradictions, it is possible to say that the board game in Chapter 4 allowed reproducing contradictions in a higher tension level than the parametric design tool described in Chapter 3. The players embodied the stakeholders in their roles and played as if there was a real tension between them. The interlocking relationships between the multiple objects and instruments necessary to design and run a hospital contributed to strengthening the materiality of social relationships. The pretext of play explored by the game
gave students the freedom to try strategies, other than optimising facilities, as experienced with the parametric design tool. They could actually do the opposite; to develop a hidden strategy of worsening the facilities to earn more money individually. In any case, they would not be able to realise this strategy fully since other players would mock them in turn. Some students developed strategies to deal with the contradictions of the game and some others just improvised tactics to keep the hospital growing.

In all cases and experiments, the design interventions and student actions could not eliminate the contradictions that rose in the design activity and in the design space, even if they tried. However, these contradictions pushed practitioners and students to generate new concepts that alleviated the tension or that transformed contradictions of activity into contradictions of space.

Due to space constraints, the thesis chapters did not provide a full historical account of the contradictions studied. Some of these contradictions were not even mentioned directly because they were not yet fully conceptualised at the time of their writing. As it is acknowledged in this kind of study, contradictions in thought are always an approximation to the contradictions in society (Lefebvre, 2014a; Stanek, 2011). The next section provides a detailed historical account of the contradictions faced by the researchers, practitioners and students with the aim of approximating them to some of the contradictions in society related to design activity and design space. The aim is not to present a comprehensive list of societal contradictions, rather to indicate the relationship between the contradictions found in this thesis and societal issues.

Contradictions found by the present study

The intention of framing the chapters as studies of contradictions is twofold: to characterise the thesis as a coherent whole —at the same time incoherent and contradictory; and, to provide a broader (historical) context for the studies, which is very much about specific situations where design emerged amidst the
development of activity and space. This collected historical evidence will serve as a first step towards understanding the complex historical situation in which expansive design becomes relevant — a situation in which contradictions must be included in design.

Table 1 – Contradictions pursued by this thesis and the corresponding chapters.

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1. The expansion of the design object versus the contraction of design representations

In the last six centuries, a contradiction has built up at the heart of design activity: the object of design. This was once easy to grasp: materials. Design was all about transforming natural facts into artificial facts — artefacts. The materials reached their apogee at the beginning of the Bauhaus design school. Their first curriculum stressed the need to master the use of building materials through workshops (Figure ). In general, the materials were not employed to represent something else, like a fake material that stands for an expensive one.
The times of material honesty passed when buildings were designed as complex entities; much like products. This is an expansion that began at the 19th century and that extends to our current times. The question of materials becomes secondary in the face of the need to master large amounts of information that comes from many sources: knowledge disciplines, governmental policies, factories, research institutes and users. The designer is supposed to take into account all the information available, problematise and provide an all-encompassing solution (Simon, 1969). A few cities have been designed from scratch in this way, following big master plans.

Figure 1 - The Bauhaus curriculum from 1919 to 1923 which emphasised mastering building materials — stone, wood, metal, textiles, colour and glass (Gropius, 1919).

This expansion towards complex entities appears in the second curriculum of the Bauhaus school (1937), but becomes clearer in the curriculum of HfG Ulm — considered the post-war Bauhaus successor. The aspiring designers had to master design disciplines and take inspiration from well-established knowledge disciplines. Instead of mastering the material crafts alone in workshops, the
students were supposed to master knowledge application in multidisciplinary teams (Lindinger, 1990).

Figure 2 - The first HfG Ulm curriculum organised around design disciplines and knowledge disciplines (Scholl & Aicher, 1951).

In the 21st century, the complex entity is still the dominant object of design, yet there is a new object on the rise: the emergent performance. This is the expansion of the design object towards interactions, services and experiences. The complex entities are slowly becoming secondary and the materials less prominent. The design object now cut across different products, buildings and cities. It is very difficult to grasp this object since it has no physical bound; it can be anywhere, anytime. Hence, design is being increasingly described as a process, rather than as a product (Cross, Dorst, & Christiaans, 1996; Dilnot, 1982; Horgen, Joroff, Porter, & Schon, 1998). In this indefinite state of affairs, designers have found in the figure of the user an anchor to the design process (Redström, 2006, 2008). The design object is supposed to be crafted on user needs, to be similar to the user in thinking and shape and to avoid user frustration. This is synthetised in the term user-centred design (Norman & Draper, 1986).
This brief history informs us of how the object of design expanded from materials to complex entities and, subsequently, from complex entities to emergent performances. This expansion is far from straightforward. Every step faces a contradiction with the representations produced by design activity. Instead of expanding together with the design object, the design representations are becoming tighter and precise. Designers and researchers are developing these design representations in the hopes of corralling the expansive object to a manageable level (Spinuzzi, 2011). However, the contraction of design representations neglects the qualitative new aspects gained by expansion and the designers are left with the need to force expansive concepts into contracted representations, this does not always work well. This misfit may be noticed only after the design is implemented, when the boredom of standardised modules can be perceived in use.

For example, the cathedrals built during the middle ages were designed based on body and speech coordination during the actual construction. As a place to aid contact with the metaphysical, the choice of materials and the craft excellence were the main concerns. The construction site itself represented the design object as it was emerging. Architectural drawings like we know today were rarely made (Turnbull, 1993).

![Figure 3 - The contraction of design representations in the last millennium. From the construction site to the computer aided drawing systems (CAD), the representations become more precise, abstract and systematic.](image_url)

The dissemination of the perspective technique in the Renaissance and the increased availability of cheap paper
followed the practice of sketching the design object. These sketches were meant to represent the building in a rough way, as a quick and progressive attempt to grasp its shape. The sketches evolved into detailed drawings with strict scales, sections, load calculations and other numerical information that supplanted geometry as a drawing guide (Carpo, 2003). The intention of including so much information was to liberate the architect from the construction site (Ferro, 1982; Habraken, 1985). At this point, the design object was expanding to the building as a complex entity.

Computer Aided Design (CAD) emerged in the late 20th century amidst the expansion of the design object towards emergent performances. The architectural drawings could be made inside the computer with the advantages of increased precision, modifiability and portability. The computer models were much cheaper than the scale models. On the other hand, the manipulation of the drawing became extremely slow and inflexible in comparison to paper and pencil (Henderson, 1991). This was a major step in the contraction of design representations.

Despite the significant advances in making computer modelling tools faster and flexible for conceptual design, the design representations are far behind the expansion of the design object towards emergent performances. Architects still prefer paper drawings to computer-generated 3D walkthroughs when communicating to clients (Groleau et al., 2011). The hindrance might come from CAD not taking into account the human body as a reference for representation (Franck & Lepori, 2007). The contradiction between the expansion of the design object and the contraction of design representations is very tense nowadays, with the challenge to represent interaction, services, and experiences at one side and the increased pressure to develop more precise and abstract forms of representations on the other side.

Chapter 1 addressed this contradiction in an exploratory study of the design of a medical imaging centre. The designers were initially concerned with the accuracy of the representations of space — requirements, floor plans, and quantity surveys. But, as soon as they were confronted with the spatial practices of the users and the inability to represent them using the traditional representations of space, they moved on to a more expansive
approach. New visualisations and games were developed to represent the user activities as services and experiences during collaborative workshops with designers and users. As a result of the collaborative efforts of designers and users, the object of design became, for a while, a space of representations — the inverse notion of space that focuses on lived experience (Lefebvre, 1991).

The analysis of the project tracked the constant effort of designers and users trying to expand the representation beyond what the instruments were capable of, with varied degrees of success. The contraction of design representations hindered the expansion of the design object, but the participants did not accept this condition. At a certain moment, they gave up using the new instruments in favour of the traditional paper and pencil sketching.

The chapter draws attention to empowering user to take control of the representations of their own activities, so that they can be producing the design space together with the designers. The contradiction of design activity becomes then a contradiction of design space.

2. The socialisation of the design space versus the alienation from design possibilities

The design space can be understood in three ways: a) as a physical space where designers work (e.g. a studio or an office (Cuff, 1992); b) as a social space where designers meet users and clients (Botero, 2013; Luck, 2014); c) or as a mental set of possible shapes and features considered for a given product (Goldschmidt, 2006; Woodbury & Burrow, 2006). Since these three definitions complement each other, the design space can be considered a network of ideas, social relationships, and scale models.

The socialisation of the design space refers to the fact that a large number of stakeholders are involved in the production of this space. If, in the past, a few experts would design and others less-skilled would draft, nowadays, all the people involved in design are contributing to a certain extent — they are co-designers (Loukissas, 2012). This social change is linked to physical and mental changes.
The physical changes are perhaps the most visible. In the first half of the 20th century, the design offices had big open plans with large desks and walls where people could discuss and work together on scale models, drawings, and sketches. In the 21st century, the open plan remains the default; however, people talk less to each other while seated in front of their computers. They seem not to be working with the same object, but this is far from the truth. Through the computer, people are exchanging emails, sharing files, and collaborating to build interlinked virtual models (Loukissas, 2012). The contraction of design representations imposes restrictions in the way people can express themselves, but they can be circumvented by communications through a more flexible channel (paper, phone, or email).

The involvement of more people with the production of the design space does not necessarily mean that more design options are considered. Instead, the socialisation of the design space may reduce the design space if new people bring in constraints and no options. Every person filters out the possibilities that he or she finds unappealing and, depending on the group dynamics, the participants might be more willing to agree with someone else’s design option than to introduce a new one. The groupthink behaviour (Janis, 1971) might emerge in this situation.

The socialisation of the design space contrasts with the alienation from design possibilities that may simultaneously happen. Alienation in the production of space theory means hiding the possibilities through abstract representations that make people
feel distant from their own bodies and from what they are capable of doing (Lefebvre, 1983, p. 57; Shields, 1999, p. 40). In the present study, alienation means that some of the design possibilities are taken out of the design space and, therefore, are never considered. These possibilities are put aside for being unacceptable, unthinkable or unknown. This phenomenon is also described as design fixation, the practice of sticking to one design option before even considering other options (Jansson & Smith, 1991).

The contraction of design representations offers an advantage here to explore design options. The design can be represented as a set of parameters, which can be used to algorithmically generate hundreds of design options based on the variation of these parameters’ values (Monedero, 2000). However, these algorithms cannot prevent the alienation from qualitatively different design options, since essential design qualities cannot be drawn to numbers. The alienation from design possibilities is not a lack of design instruments or skills; even if persons want to explore more possibilities, he or she may not be able to do so, due to time constraints, power relationships, social taboos and other kinds of inhibitors. Alienation is unavoidable, but designers and users do not always accept this condition and, eventually, fight to overcome it.

Chapter 2 told the story of designers and users trying together to overcome the contradiction between the socialisation of the design space and the alienation from design possibilities. The design games were highlighted for their capability of representing contradictions without resolving them, i.e. leaving them open for the participants to recognise and expand. The first case reported on the design of a new hospital in which staff were alienated from the possibilities brought by the new building. The architects designed the building without involving the nurses and other staff members at the bottom of the hierarchy. The staff were involved only after the design was completed, through drawings fixed on the walls, which are very distant from the concrete experience that staff have from space. This can be considered a very limited socialisation of the design space and a strong preservation of the alienation from design possibilities.
The research intervention introduced the HEAD game to explore the possibilities of the new building in terms of work procedures. Once the participants were told that the spatial layout was fixed and no suggestions were possible, they became very resistant to contribute. They thought the new layout would not work at all for them but, as they progressed in the game, they took a more positive stance towards it. They did not give up their criticism; in fact they grounded their criticism on the awareness for what was not possible to do. However, they also realised the new possibilities were available. The HEAD game helped the healthcare staff to overcome their alienation, to a certain extent, despite the limited socialisation of the design space.

In the second case, the client brought the architect’s drawing to discuss with the users in a workshop. They used board game pieces to check if the requirements for their activities were being met. The socialisation of the design space could not counter much of the alienation from design possibilities. The users could tell what could work well and what would not work well, but they had extreme difficulty in suggesting how the plan could be different. They could not create new possibilities because they did not know what was already possible — the design space. It would have been less alienating for the participants if the architect was present in the meeting and could sketch new options in real time with the users. The architect helped the users to realise the available possibilities and to create new possibilities, i.e. to produce the design space.

The third case had a different outcome of using games in design. Although the managers of the medical imaging centre asked to create a game to prevent changes in the spatial layout and channel the participants to the workflow logistics, the participants were strong enough to demand changes in the spatial layout and overcome their alienation from design possibilities. They did so by refusing to play the game, as if the game was not fair. This struggle gave rise to collaborative sketching with the architects involved; a more intense socialisation of the design space.

As these cases make clear, the alienation from design possibilities is not a technical trade-off, but a condition related to the socialisation of the design space. Alienation may be overcome if people manage to occupy the design space and co-create new
possibilities, as was seen in the third case. Such co-creation of possibilities implies a new way to deal with knowledge and work processes, which brings forth the next contradiction.

3. The co-creation of knowledge versus the optimisation of work processes

Organisations, which in the past tried to foster knowledge production with information systems, are now trying something different: co-creating new knowledge. That means people from different departments, backgrounds and disciplines join efforts to learn something new, something that is not yet there to be learnt, something that has, in fact, to be created while learning (Engeström, 2015). Streamlining and distributing knowledge among the workers cannot achieve this. A contradiction arises since the co-creation of knowledge goes in the opposite direction of the optimisation of work processes.

In the past, the worker and the process were indistinguishable. When the worker was responsible for executing the whole process on his own, it was not possible to detach process from labour. Even if the workers were part of a collective association, there would be no division of labour between them. In fact, the workers would do the same tasks together or in alternation. The industrial revolution brought a different organisation of work. Each worker had to specialise in a handful of tasks to be performed with maximum efficiency. As factories grew in size and complexity, the tasks were broken down and workers had to become more and more specialised. At some point, workers lost their awareness of the entire work process and a new kind of specialised worker arose to take care of it: the manager. The manager created and used knowledge for the optimisation of work processes (Taylor, 1919).

The epitome of this approach is the creation of the assembly line in the 1920s, a streamlined space for mass-production of industrialised products (Ford, 2007). Instead of workers moving around the factory, the product to be assembled was the part that moved. In the 1950s, the assembly line was redesigned with the principle of just-in-time, which means keeping the inventory low and replenishing only when there are requests by the next step in the production chain (Ohno, 1982). This requires the formation of
multi-purpose teams in which members rotate tasks one with another. These teams were empowered by the manager to make improvements to the work process by their own which challenges the split between worker and process. The worker has to create and use knowledge as much as managers did in the past (Nonaka, 2006). The optimisation of work processes clashes with the co-creation of knowledge because knowledge cannot be mass-produced like information. Knowledge requires going through long periods of sense-making and relating, processes that cannot be optimised due to their subjective and inter-subjective nature.

Chapter 3 looked at how the medical imaging centre project dealt with this contradiction. The centre had a strategic objective of promoting the co-creation of knowledge among technology companies, educational institutions and care providers, but also needed the optimisation of work processes to keep the expensive machines busy all the time. Dealing with these opposing demands had proved difficult since each could lead to completely different designs on their own. The contradiction was overcome when the users gained access to redesigning the floor plan together with the architects. This collaboration led to a new corridor for staff circulation where staff could encounter each other casually and discuss the daily happenings; an activity that could perhaps nurture the co-creation of knowledge.

Despite the moderate success of the workshops, the project failed to build commitment with the participants. The contradiction between the co-creation of knowledge and the optimisation of work processes surfaced again in the design space. The healthcare professionals were more concerned about why and how the co-creation of knowledge would take place in the new centre, rather than the optimisation of work processes. Since they already had similar machines in the own hospitals, the motivation to join the centre was completely other than that which the project managers expected. The participants wanted a more flexible space as an alternative to the routinised work at the hospitals; a place to co-create and learn new things, which was not fully provided.
4. The flexibilisation of workspaces versus the spatialisation of workflow

As a matter of fact, the organisations interested in the co-creation of knowledge are recently trying to make workspaces more flexible to enable temporary project-specific adaptations, casual encounters, and unplanned team work. However, the flexibilisation of workspaces is pursued by organisations interested in the optimisation of work processes too, with a different motivation: they want to shrink or grow the employee base at the minimal costs and the maximum productivity (Dale & Burrell, 2008).

The history of the office provides clear examples on how workspaces are becoming more flexible in general (Van Meel, 2011). The first high-rise buildings were based on enclosed cells with two or three desks each, providing quite some privacy and auditory isolation. Under the influence of Taylorist approaches for work optimisation, the open plan design made its way from the factory to the office. The open plan allowed the managers to oversee a large number of specialised workers, but came with the drawback that it diminished workers’ privacy and concentration. In a reaction to the rationalisation at office work introduced by open plans the Quickborner team developed the alternative office landscape in the 1960s where desks are scattered all over the plan without following a grid pattern. The goal was to create some degree of differentiation and privacy for workers by breaking the visibility lines used by management for overseeing (Van Meel, 2011).

The open plan is still common today, but the trend now is to draw curved shaped circulation areas across the plan. The spaces are fit for teams working in temporary projects, including not only collaborative technologies, but also integrated spaces for recreation and relaxation. More recently, organisations have explored even more flexible workspaces where workers and furniture do not have fixed locations. Everything moves at the office in the attempt to follow the co-creation of knowledge. Since workers are able to work from home or from other remote locations, the only reason to go to the office is to make use of such teamwork facilities.
The flexibilisation of workspaces is synchronised with the spatialisation of the workflow, which goes in the opposite direction. Before the assembly line, workspaces were scattered over factory plans in no rational order. They naturally emerged around stationary large products, machines and tool sets. The assembly line attacked this flexibility: the tasks being ascribed to certain spaces and the spaces being positioned according to the chronological order in which they are supposed to happen. These spaces were laid out on the basis of task duration; if a task lasts for a few seconds, the workspace around the line is very narrow, whereas, if the task is lengthy, the space around the line is broader and more intricate.

The assembly line was the result of abstracting the work processes from the workers, analysing them under a rational framework and reintroducing them as physical constraints. The disposition of workers, supplies, and products in the ordered plan provided a quick overview of task accomplishment status to managers. From the outset of assembly lines, the spatialisation of workflow has spread this far beyond industrial organisations. Modernist architects have taken the strategy to schools, hospitals and even homes. Alexander Klein, for instance, proposed that the home should be designed to prevent the flow of inhabitants to cross each other (Figure 5). In the same spirit, Le Corbusier’s stated that “the house is a machine for living” (Corbusier, 1931). Le Corbusier was also one of the first architects to use bubble diagrams to describe functional relationships between different spaces in a new building (Emmons, 2006).

In contemporary architecture, functionalism is challenged by postmodern architecture (Tschumi, 1996; Venturi, 1977). The building programmes are planned to be more fluid, prepared for future changes, yet maintaining a character. The bubble diagram and other techniques for the spatialisation of the workflow are still in use for the lack of good notations to represent the passage of time in architecture (Thiel, 1997; Till, 2009).
Chapter 3 dealt, not only with the contradiction between the co-creation of knowledge and the optimisation of work processes, but also with the contradiction between the flexibilisation of workspaces and the spatialisation of the workflow. This is to highlight the reproduction of contradictions of activity into contradictions of space and vice-versa. In order to capture traces of both types of contradiction, the chapter introduces a parametric design tool that can spatialise the workflow while designing space, similarly to Alexander Klein’s drawings. This tool is used to analyse the evolution of the design of the medical imaging centre. The initial plan had a very strict spatialisation of the workflow. There was almost no choice for patients and nurses when they entered the flow. They had to step into a room, do what they were supposed to do and step into another room. When finished with the scanning procedure, the patient was supposed to retrace the same steps and leave.
The first plan had segregated spaces for separate activities and the last had integrated spaces for overlapping activities. In the fourth plan, the patients and nurses could choose different paths in the corridors. With the creation of the second corridor at the bottom of the layout, the scanning rooms could be connected to the dressing rooms of both sides. Previously, each scanning room had their own dedicated dressing room.

The spatialisation of the workflow diminished to give room to the co-creation of knowledge. This was no simple adjustment and the participatory deliberation raised conflicts. Some people wanted to spacialise the workflow, whereas, others wanted to make it more flexible. The fourth plan still preserves the contradiction, but in a lower level of tension. This is, in part, due to the resolution of conflicts through deliberation.

Nonetheless, implementing those changes means creating more generic spaces, multiple paths from one to another room and points of distraction. These changes undermined the design strategy to make a perfect fit between the workflow and the spatial layout, but strengthened the business strategy of knowledge co-creation. The users approached flexibility in a different way than the designers. The users, instead of seeing it as the expansion of generic spaces, saw it as an expansion of the possibilities for action. The users shifted the design valuation from market exchanges to practical use.

5. The competition for exchange value versus the collaboration for use value

In cultural historic activity theory and in the production of space there are two types of values that clarify this shift from market exchanges to practical use: exchange value — for what the design object can be exchanged for; and, use value — the practical object usefulness (Engeström, 2000a; Lefebvre, 1991). This distinction of values is borrowed from political economy (Marx, 1993) and applied here to understand the contradiction faced by professionals who must compete and collaborate in design projects.
Every time an exchange is consummated, the value changes according to the law of supply and demand. If the demand is higher than the supply people compete to produce the object faster and cheaper. As soon as people start competing the value is lowered and the object becomes widely accessible. The drawback is that the object might not be useful anymore after making production faster and cheaper.

The competition for exchange value does not affect solely the production of goods. Any industry is subject to the commodification of objects. Even art works can be transformed into mass produced products (Benjamin, 2008). In knowledge work, the commodification implies the optimisation of work processes, since human labour is the defining resource. Knowledge work cannot be optimised without compromising the quality of produced objects, though. These objects are useful in as much as they relate to what people already know, but this cannot be properly measured for exchange. People used to rely on abstract measures borrowed from other fields to keep up with the competition for exchange value, which leads to generic applicable, yet less useful objects.

This priority of gaining exchange value is challenged by recent market changes. Products are no longer considered valuable only for sales' performance. They must perform well after being sold and in use (Boztepe, 2011); otherwise, subsequent sales may be compromised. If the user cannot find an application or the product is too difficult to use, the user might communicate that to other potential users by word-of-mouth and product reviews. If no one wants to use the product, only a low price can convince people to buy. With low use value, the product can be easily copied and sold cheaper, which is not desirable. To avoid this,

Figure 6 – Two ways an object is valued in society: through the immediate use — use value — or through the exchange for something else — exchange value.
organisations are increasingly eager to differentiate their products and create unique experiences that cannot be easily matched (Pine & Gilmore, 1999). This is one of the historical changes associated with the expansion of the design object towards emergent performances mentioned before. A common strategy for this is to expand one product into a service with many products, seamlessly integrated. Use value is co-created between the multiple organisations attached to the service, including the user (Ramirez, 1999; Vargo et al., 2008). The major advantage of this strategy is that, even if the product can be replicated, the service cannot.

This integration is hard to achieve when organisations are competing for exchange value, though. The organisations oriented to exchanges are fragmented into silos and the silos do not communicate very well because communication itself cannot be exchanged. Each unit has their own product and they are not willing to dissolve them into a more consistent service. In these organisations, the use value is a distant target that cannot grant direct benefits to business exchanges.

Competition must give room to collaboration if it is to expand into a service with value co-creation. This is because only through collaboration unique use values can be co-created (Ramirez, 1999; Vargo et al., 2008). Instead of working with separate objects that are later exchanged internally and externally, the organisation works with co-created shared objects (Engeström, 2000b). The shared object begins to grow when boundaries become a site for co-creation and find complementary differences (Akkerman & Bakker, 2011). This replaces the typical rivalry and fights that can be found at the boundaries. Use value motivates collaboration better than exchange value because it can be reverted back directly to their producers; people collaborate because they also like to use what they create. The collaboration for use value entails crossing boundaries between design and use in a cyclical fashion (Suchman, 1994). This is very different to the transaction routine (Williamson, 1981) instilled by the competition for exchange value (Figure 7).
Figure 7 - The collaboration for use value and the competition for exchange value at the boundaries between design and use.

Chapter 4 reports on an experiment conducted with design students concerned with the contradiction between the competition for exchange value and the collaboration for use value. Design is often a multi-disciplinary endeavour based on the activities of different experts. The experiment aimed to explore how students faced the competition for exchange value in design and how they overcame it. This was an important question since design activity was expected to deliver useful objects, not just plain commodities.

The result of the experiment showed that, even if students know they must collaborate to succeed as a group, they find very difficult to give up self-interest. The reflection on the results points to the importance of finding complementary differences instead of reducing them through integrative efforts. This is because overstructuring collaboration can easily turn into undercover competition in which the players use the structure to manipulate the others.

The contradiction between exchange value and use value cannot be eliminated. Even when everybody seems to be collaborating, there might be one person with vested interests. This can be healthy if the collaborative structures are fluid and distributed. To secure this, the collaborative work should feed itself, i.e. people should use what they produce. However, this does not help to sustain the chains that connect activity to global markets.
6. The homogenisation of differences versus the emergence of boundaries

The design of spaces, the products and the services must be similar across cultures if they are to be valued in the global market. This is a necessary strategy if these items are to be included in the globalised lifestyles which are replacing the traditional cultural identities (Canclini, 2001). *The homogenisation of differences* come as a side effect, but also as an inducer of *the competition for exchange value*. Thanks to this, one thing may be valued twice as much as another different thing. This greatly expands the possibility for exchange, but severely reduces the possibilities for use.

Multi-national organisations are major players in *the homogenisation of differences*. They are responsible for pushing the items created in one culture to another. Some of them are so large and so wide that they even claim to have their a culture of their own — the corporate culture (Suchman, 2002). This culture is made of the peculiar habits, beliefs, symbols and procedures that are reproduced by the organisation members without explicit mandates. In the hope of eliminating internal conflicts, top managers try to interfere explicitly with the corporate culture by discouraging certain differences and standardising procedures. In the short term, strategic homogenisation is hardly achieved; the response is often an acute reaffirmation of the difference. The multi-national organisations also reproduce *the homogenisation of differences* internally.

*The homogenisation of differences* does not encourage collaboration and co-creation, but fierce competition on a quantitative scale. Nevertheless, this process is counter-acted by *the emergence of boundaries*. Boundaries stems from differences between cultures, organisations, and departments. However, these differences are not immutable. A homogeneous group of people can be quickly fragmented by the spread of a separatist ideology for example. Conversely, a heterogeneous group can be reunited by integrative technologies. In any case, the differences do not go away, but change (Lefebvre, 1972). Boundaries reflect the intensity of these differences at a certain moment, which can take the form of unspoken rules to guarded walls.
The contradiction between the homogenisation of differences and the emergence of boundaries rises when the design object must be exchanged for something else and when, in the opposite direction, the product must have great use value. Boundaries emerge to protect use values from abuse and to negotiate exchange values without disclosing cost information. They make it difficult to exchange, as well as to use the object's values. The differences between the inside and the outside of the boundary are intensified, instead of homogenised.

Figure 8 - As history unfolds, an invisible boundary may become harder and harder to cross, up to the point that physical artefacts are built to reinforce it.

This theory of boundary emergence from differences is proposed in Chapter 4. This combines the notion of boundaries from cultural activity theory (Akkerman & Bakker, 2011; Engeström et al., 1995) with the notion of differences from the production of space theory (Lefebvre, 1972, 1991). The chapter includes findings from three studies of design projects in which boundaries between multiple organisations have emerged. In the Netherlands, design projects in construction typically involve many organisations that are not related by a clear hierarchy. These organisations need to collaborate to deliver the design object and, at the same time, to compete in the market for new projects. The boundaries emerged from this contradiction between the collaboration for use value and the competition for exchange value.

The most common complaint heard in the interviews was the need for rework due to poor work across boundaries. In order to avoid that, some companies tried to push the adoption of collaborative technologies, such as Building Information Modelling...
They believed that sticking to a more contracted form of representation would concentrate the communication efforts better into one single channel. Previously, the team members had to communicate through many channels—emails, phone calls, meetings—and, eventually, important issues got lost in the shuffle.

The contraction of design representations was expected to contribute to the optimisation of work processes in the design projects studied, but they ended up in the alienation from design possibilities. In addition to that, the homogenisation of differences between the design disciplines and their epistemologies (what is considered to be relevant knowledge) hindered the co-creation of knowledge. These contradictions were linked to the priority given to the competition for exchange value. From these initial case studies, it became clear that learning to cross boundaries was key to aspiring designers in the Netherlands.

In order to study how design students learn to cross boundaries, a double stimulation experiment was conducted with facility design students to play the hospital board game mentioned in the previous section. There were two groups of students: one that just played as prescribed by the rules. They went bankrupt in a few rounds; and, another group that discovered a flaw in the rules and succeeded in building a profitable hospital.

Players in both groups crossed boundaries, albeit, with different motivations. In the first group, players wanted to influence the others for their own benefit, whereas, in the second group, they tried to build something that initially was good for the hospital. The conclusion of this study is that boundaries are not bad for competition or for collaboration. Boundaries are places where differences are confronted, be this for co-destruction or for co-creation. The impact of boundaries at design projects depends on the way each professional and the collective deal with them.

The experiment also suggests that players—and perhaps design professionals—need to resist the homogenisation of differences by standardised process, contracts and collaborative technologies and produce their own differences. They need to go beyond the quantitative differences prescribed by the rules—in the case of the game, income scheme and decision power—and develop
qualitative differences, such as negotiation profiles, sense of belonging to a group and common goals. These differences become complementary instead of mutually exclusive, moving the multi-disciplinary team a step forward towards the collaboration for use value.

Characterising expansive design and reductive design

Throughout the empirical studies, there was a divergent pattern of design practice with respect to the way contradictions are dealt with in design. When the contradictions are made present and become aware to the senses, design becomes expansive, inclusive, chaotic and transformative. In contrast, when the contradictions are hidden in design, design becomes reductive, exclusive, logical and conservative. This section characterises expansive design and its opposite reductive design.

Chapter 1 refers to the publication where expansive design was first introduced (Engeström, 2006). The chapter draws on the idea of a shared object between design activity and user activities, collaboratively constructed by a joint effort, to analyse how the representations of space created by the designers — initially, an instrument — became a space of representations for the users — a shared object. A range of representations of space was used to construct this shared object — printed floor plans, a computer simulation and paper-and-pencil sketches. The participation of users in the design activity contributed to the expansion of their own activities, yet not in the way the design activity intended, as reported in Chapter 2.

The expansion of activity is supported by a specific technique. This is based on a dialectic of parts and wholes (Ackoff, 1973, p. 663). In the expansion technique, the first understanding of the whole is abstract, impartial and isolated. As the dialectic unfolds, the whole becomes related to its inner parts and to outer parts from other wholes. The interactions among parts and between parts and wholes become the focus of attention. Since these interactions are changing all the time, it is necessary to keep a historical perspective, i.e. looking back at the origins of
interactions and following their trends. The abstract thought is gradually replaced by a concrete concept that is much richer in relationships.

*The concrete concept is concrete because it is a synthesis of many definitions, thus representing the unity of diverse aspects. It appears therefore in reasoning as a summing-up, a result, and not as the starting point, although it is the real point of origin, and thus also the point of origin of perception and imagination. (Marx, 1993)*

The concrete is the opposite of the abstract, but it cannot be grasped by thought — and transformed by action — without the help of the abstract. In fact, the abstract corresponds to the means of reaching the concrete, although sometimes this means becomes an end (Lefebvre, 1975). It is easy to understand why: the abstract seems to be more logical, organised, clean, and, therefore, superior to the initial concrete. This value judgment is responsible for the adoption of levels of abstraction as a measure of development in design. For example, in some design practices, the programme or brief is supposed to be as much abstract as possible to allow flexibility at the further phases of design (Pena & Parshall, 2001; Voordt & Wegen, 2005), whereas the construction plan should be as least abstract as possible to prevent construction workers from doing something different than designers specified to be done (Ferro, 1982).

The concept of expansive design refers to the attempt of ascending from the abstract to the concrete still in design phase. This is achieved by making use an integral part of design, rather than an *a posteriori* fact. When participants try design prototypes or design games, they are “using before use” (Ehn, 2008; Redström, 2008) or, in other words, anticipating the use situations (Bijl-brouwer & Voort, 2014). Participants play out imaginative scenarios based on their previous experience with the activity and evaluate if the instrument pushed by design can fit into these scenarios. This is certainly more concrete than having designers trying out their own creations based on their limited experience with the activity, but there is a major determination left out: when the instrument is produced in its final shape, the activity might not be the same as it was.
Design games are tools specially crafted for ascending from the abstract representations of space to the concrete space of representations, where participants can enact change in social relationships. However, design games originated from a reductive design practice: scenario planning (Carroll, 1995; Garde, 2013; Voort & Tideman, 2008), which is very conservative (Brand, 1995). Scenario planning deals with the future by expanding the space of possibilities, not the possibilities of space; the goal is to develop strategies to preserve the current social relationships embedded into space.

As Chapter 2 has emphasised, design games can go beyond this conservative practice by supplanting the reductive design discourse with action. This is a necessary step since the reductive design discourse hides contradictions under words such as “optimising”, “improving” and “saving”. These words address a proclaimed scarcity of resources, which is preventing the activities targeted by design from developing any further. The discourse goes on by saying that there is a need for a better way to use these resources. For example, if time is scarce, there is a need for better time management. At the next step, better is equalised with rational consumption of resources and the scarcity is totally accepted (Till, 2014). There is no question of finding other resources that are more plentiful; only “optimising”, “improving”, or “saving” are considered. The only way is to produce more with less.

To produce more, the first measure is to reduce waste. Waste is produced by the consumption of raw materials as much as by the consumption of human labour. This is measured in time or standard-rate man-hours. The tensions, conflicts and contradictions that require extra time to be worked out are treated as technical problems. Their historical origins are not investigated and the people implicated are not involved in design, in part due to a fear for escalating the conflicts even more. The technical solution deals with conflicts by working around them and changing the activity structure so radically that conflicts lose their underpinning. The underlying assumption is that conflicts are caused by dysfunctional organisation structures and, as such, can be eliminated by improving the same structures. If a piece of technology, a type of space, or a person are sought to cause
conflicts, another may replace them. In this way, the waste of human resources can be avoided.

These measures give priority to exchange value over use value as it does not matter how unique a piece of technology, a type of space or a person is; what matters is the amount of value they can produce in exchanges. If an activity does not produce value, it should be removed from the system (Koskela, 1997). Reductive design formalises social activity into a system of tasks that can be moved anywhere in the organisation or even outsourced.

In summary, reductive design could be understood as an applied logic. The relationship between the parts and the whole can be grasped through logical inquiry, since they are expected to be logical by nature. The unexpected, contradictory or irrational changes that occur in the world appear as such due to our lack of logical understanding of them. In fact, change is reduced to the combination of pre-existing pure forms of which some we know, some we do not. In reductive design, the dialectics of activity and space becomes a matter of discovering the logical equilibrium, match or fit between heterogeneous forms and functions.

Table 2 – Characteristics of reductive design and expansive design compared.

<table>
<thead>
<tr>
<th></th>
<th>Reductive design</th>
<th>Expansive design</th>
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<tbody>
<tr>
<td><strong>Self-awareness</strong></td>
<td>Logics</td>
<td>Dialectics</td>
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<tr>
<td><strong>Approach</strong></td>
<td>Formal</td>
<td>Informal</td>
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<tr>
<td><strong>Procedure</strong></td>
<td>Analytical</td>
<td>Synthetic</td>
</tr>
<tr>
<td><strong>Goal</strong></td>
<td>Optimise</td>
<td>Transform</td>
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<td><strong>Driver</strong></td>
<td>Determination</td>
<td>Contradiction</td>
</tr>
<tr>
<td><strong>Production</strong></td>
<td>Planned</td>
<td>Emergent</td>
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<tr>
<td><strong>Humour</strong></td>
<td>Serious</td>
<td>Playful</td>
</tr>
<tr>
<td><strong>Organisation</strong></td>
<td>Centralised</td>
<td>Peripheral</td>
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<tr>
<td><strong>Boundary uptake</strong></td>
<td>Integration</td>
<td>Complementarity</td>
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<tr>
<td><strong>Development</strong></td>
<td>Homogeneous</td>
<td>Uneven</td>
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The dialectics between expansive design and reductive design

Expansive design and reductive design has been characterised as opposite concepts, but in practice they emerge together. Any reductive design practice may become an expansive design practice if enough tension is raised from contradictions. The relationship between these two concepts in practice should be seen as a dialectic wherein the opposites interpenetrate each other and continually interact. The following section describes how this dialectic unfolded in the empirical studies on which this thesis is based.

In the medical imaging centre project, the design team initially was trying to reduce user activities to a list with rooms and associated users. Since this was not enough to settle the existing disagreements and vagueness, the project managers, together with the researchers, developed new instruments that could represent user activities in a more expansive way, such as the healthcare simulator and the knitting game. These instruments were not employed in an expansive way, though, since the unit of analysis was kept the same — operations oriented to conditions. However, when future users of the centre used these instruments, they expanded the unit of analysis beyond the limit provided by the instrument. The knitting game is an example: the representation of activity was so reductive that one user group refused to play. Yet, the refusal was instrumental for the users to claim the opportunity to redraw the floor plan with paper and pencil.

Soon after this project, the knitting game was transformed into a parametric design tool and brought to an experiment with design students. With the parametric tool, students redesigned the medical imaging centre, mainly at the operation level. However, they expressed their awareness for the narrow focus. They criticised the tool for the spatialisation of workflow — not being possible to represent the position of bodies at a certain time — and the idealised modelling — paths would not be followed in the same way always. These critical comments led the researchers to
realise the instrument’s bias towards reductive design and, ultimately, to the formulation of this concept here.

The Expansive Hospital game was designed in a later stage of this research project. This was when the bias of the parametric design tool was already realised. The game was introduced in a bachelor course based on a well-known textbook about systematic engineering design (Pahl et al., 1984). The course readings also include papers challenging the reductive design endorsed by the textbook (Cicmil & Marshall, 2005; Fry, 2009; Henderson, 1991; Whyte et al., 2007).

The pedagogic intention of playing the game was to let the students realise the difficulties of doing reductive design in a project with conflicts of interest. The game has specific features that facilitate the development of reductive design strategies — centralising the decisions in a neutral leader, dividing the work into small pieces and taking decisions based on quantities (Pahl et al., 1984). However, players have the chance to play against these strategies with improvised tactics. The design students knew the importance of these strategies for the common interest, but they could not give up self-interest easily. Every time the students negotiated their work, they had to face the contradiction between exchange value and use value again.

The group of students who focused on exchange value failed to build an expansive hospital. This failure cannot be attributed to the practice of reductive design. However, reductive design did not prevent the failure from happening. Players could neither eliminate boundaries nor contradictions using the techniques associated with reductive design (Pahl et al., 1984). In fact, the collective success in this game depended on being able to go beyond reductive design.

The Expansive Hospital game and all other instruments developed in this research project are, in themselves, reduced representations of a certain reality. They reduce activity to movements in space, they caricaturise professional roles and they exclude many important factors that are at play. However, if designers or users manage to overcome their internal bias, they can be used for something else other than reduction. The point here is that reduction is not inherently bad; reduction can and
must be used for expansion. When that happens, reductive design becomes expansive design.

The transition can be explained as follows: by reducing reality and enforcing this reduction back onto reality by means of design, reductive design increases the tension between activities. At some point, this tension will lead to a crisis and expansive design might arise from it. It is also possible that both practices happen simultaneously at different levels, for example, automating an operation to allow the expansion of an action into a new activity. Admittedly, it is difficult to tell when one practice begins and the other ends, but the conceptual distinction is important to guide research toward some aspects of design practice that have been neglected by the predominance of reductionism in design and architecture.

Conclusion: designing with contradictions

This thesis proposes that design is an attempt to overcome the contradictions of activity and the contradictions of space, but this is done through different approaches: by including or by excluding contradictions. Modern architecture strived to design spaces with no contradictions (Venturi, 1977) and the result is that human activity was largely reduced by it (Augé, 2008; Lefebvre, 1991; M. Smith, 2001). For instance, the activity of dwelling was reoriented by modern architecture to the minimum conditions for living; a set of needs that could be objectively identified (Lerup, 1977). Post-modern architecture welcomed contradictions (Venturi, 1977), but only as formalised orientations between conditions and operations. Contradictions are manifested in the form of the building through mixing styles, opposing heavy and light masses and all sorts of visual ambiguity. These contradictions are reproduced by the operation of seeing the building as a visual effect that disorients the viewer from its immediate conditions. The justification is that architecture is exposing — or denouncing — “the contradictions of our times”, which are never explicitly stated. This superficial approach to contradictions have drawn some criticisms within the movement (Goodman, 1971) opening
up the possibility for exploring contradictions, not just between visual operations and physical conditions, but also between activities/motives and action/goals (Tschumi, 1996).

The present research adds five propositions to this debate:

1. Design cannot avoid reproducing contradictions;
2. Design transforms contradictions of activity into contradictions of space and vice-versa;
3. The expansion of space does not guarantee the expansion of activity, i.e. the overcoming of contradictions. The expansion of space may also reduce activity;
4. Design activity cannot overcome contradictions on behalf of other activities, but design can make contradictions present and aware to the senses and within reach of other activities;
5. Expansive design is designing with contradictions.

Instead of excluding contradictions or hiding them under an aesthetic style, expansive design includes contradictions as a material to be perceived through interactions. The contradictions are embedded into a space where people can interact with each other, realise the contradictions, and take action to overcome them. Design provides initial triggers based on partial knowledge about contradictions, but the space emerges out of people’s interactions. Every interaction has an effect on this space and, therefore, can also be considered expansive design — provided that the purpose is to overcome contradictions and expand human activity. This space becomes the fulcrum where scattered design actions converge to form a collective design activity. With new triggers being created, expansive design can go on virtually forever. However, most of the time, it will give space to reductive design when the contradictions are judged already overcome or impossible to overcome.

In the empirical studies conducted by this research project, many spaces have been designed to reproduce contradictions, with different degrees of success. Among them, the spaces created by playing design games, described in Chapters 2 and the board game described in Chapter 4, were quite successful. The contradictions could have been brought in a more analytical or detached way by the participants — as is usually done in Change
Laboratory interventions (Virkkunen, 2013) but, by playing games, the participants embodied the contradictions and dealt with them by interacting with other players. A contradiction was not something that could be ignored or solved because this would imply removing a person out of the game, an undesirable measure. This social characteristic of playing games allowed keeping the materiality of contradictions until it could be overcome by the emergence of shared objects between players. This was by no means a guaranteed effect of playing the game given that some players could not even achieve that. The design games were meant to represent contradictions without resolving them.

Playing games to include contradictions in design is not a new practice. In the 1920s, the Surrealist and Dadaists artists used games to impose a contradictory structure to their collective creation process. They did so also with the purpose of expanding art beyond galleries and to demonstrate that anyone could create art by adopting the same structures (Brotchie & Gooding, 1995). In the 1960s, the Situatonists group played games that explicitly embedded the contradictions of urban life and inspired an alternative urbanism (Sadler, 1999; D. Smith, 2005). In the 1970s, architects involved with participatory design created games to mediate participation (Sanoff & Adams, 1979) or to test theories about design activity (Habraken & Gross, 1988). In the 1980s, researchers from the former Soviet Union organised game sessions that lasted from 5 to 8 days in which the activities of an organisation or an entire city were reimagined and tested out (Rotkirch, 1996; Shchedrovitskii & Kotel'nikov, 1988). In the 1980s, interaction designers and computer scientists have played games to anticipate the implementation of information technologies in organisations, also in the spirit of participatory design (Ehn et al., 1990). As for the 2010s, we have contradictory design games in urbanism (E. Tan, 2014; Venhuizen, 2010), healthcare (Garde, 2013) and service design (Vaajakallio, 2012).

The contribution of this thesis to this research stream is a broader theoretical concept that can justify playing for the transformation of work. This is necessary since much of Marxist research has neglected play in favour of work (Lefebvre, 2014a). Chapter 2 makes the point that play can also be part of work as a means to
develop a critical stance towards work and trigger transformative actions within it.

For architectural design, accepting the irreducible — the contradictions inherent to space — open a new avenue for a critical, yet playful profession. This avenue is not laid by the accumulation of descriptive knowledge on contradictions and games, but by enjoying them in the transformation of practice. This approach refreshes the subversive utopianism of Henri Lefebvre and his quest towards the architecture of enjoyment:

_The presence of the irreducible, in its expansion (theoretical and virtually practical), transforms knowledge. It frees of its reductive nature, which binds knowledge to power. It gives to this conceptual development (expansion) an active character: accusatory — not merely critical — a subversive project of another reality (not unreal or surreal but differently real). Theoretical violence, implementation and accusation, prepares and virtually supplants practical violence while opening a path to enjoyment (Lefebvre, 2014b, p. 147)._

As for service design, designing space with contradictions may be more ethical than trying to design activity and people, which is considered undesirable or even impossible:

_What differentiates service design from all other forms of design is that is primarily the design of people, rather than the design of things, environments or communications for people. This makes service design unavoidably political. Human-centred service designing claims to negotiate these politics by enabling improvisation in service roles, rather than scripting them non-negotiably. How best to not-over-design people in service relations? [...] In which case, is service design treating humans like objects, something that ought not be done and in most cases cannot in the long term be done? (Penin & Tonkinwise, 2009)_

Designing with contradictions means including people in the production of the design space even if they are expected to enact conflict by doing that. Conflict is seen as a useful resource to make contradictions more apparent and to press people to deal with contradictions instead of avoiding them. This is considered a necessary step to give rise to a design that transforms the
relationships between activity and space, aiming at spatial-temporal breakthroughs that overcome contradictions in both sides (Lefebvre, 1991, p. 54). Design games have been used productively to provoke the emergence of design from conflicts in a safe way, but there might be other ways of designing with contradictions. The purpose of designing with contradictions is to expand human activity, as well as human space; hence the title of this thesis being “Expansive Design”.

**Conditions for the emergence of expansive design**

Expansive design is not guaranteed to happen, even if intentionally provoked. I cannot offer recommendations about that. However, I have some thoughts on the conditions for the emergence of expansive design. These conditions should not be seen as a comprehensive list or a formula for expansion. Instead, they should be seen as a very limited rule-of-thumb developed from the analysis of the empirical cases included in this research project. In these projects, there was no conscious attempt to provoke or stimulate expansive design. However, expansive design did indeed emerge for some moments. These conditions were not necessarily all present and it is very likely that other unrecognised conditions were brought into play.

**Open-ended games employed in collaborative design may trigger expansive design.** Games propose a minimum structure for interactions between participants of collaborative design that can still generate visible consequences. A reflection about the consequence of not interacting in a certain way may push participants to actually engage with such an interaction. For example: the conversational interaction between architects and users in Chapter 1.

**People can learn dealing with contradictions by playing games about social conflicts.** Dealing with conflicts is a skill to be developed. However, going through conflicts in practice can be painful. Playing out conflicts is an opportunity to relate to existing conflicts in a safer way or to try out possible conflicts. The pretext of play allows participants to have an excuse for being sharp in
their jokes and telling things they would not tell otherwise. Chapter 2 has some evidence of this, especially in the environmental centre project.

**Ambiguity stimulates people to develop their own meaning out of contradictory situations.** Contradictions do not have solutions. Therefore, dealing with them in terms of certainty of meaning might intensify their tension instead of alleviating them. Ambiguity is a resource that can be used to stimulate recognising both sides of a contradiction and, perhaps, supports the development of the third, the creative change, which is, by definition, unknown. The parametric design tool of Chapter 3 has this ambiguous characteristic but, nevertheless, could not guarantee that every student work produced a third.

**Embracing uncertainty ends the anxiety for closure.** The feeling of discomfort for being under conditions of uncertainty can be reverted by embracing uncertainty as the condition for the development of the third. Contradictions do not have a pre-defined manifestation as it is constantly generated by the interaction of opposites. Understanding this characteristic of contradictions reduces the anxiety for closure and control that design activity typically produces. This was partially realised by the designers of the medical imaging centre (Chapters 1 and 2) when they brought users in the design process and dealt with contradictions in a productive way.

**Recognising that contradictions cannot be solved helps to move on when the process is stuck.** The emergence of a third element in the dialectic process cannot be forced. The process is stuck when the opposites are considered in an alternative fashion, each one trying to rule the other in their turn. Switching to another topic can skip the polarisation for a while and they return back to it once there are new elements to play by. Some of the design students who participated in the experiment of Chapter 3 displayed this behaviour. They iterated between designing space and activity, switching perspectives every time.

**The prioritisation of use value in favour of exchange value raises motivation for both designers and users.** Working for the production of exchange value is one of the main frustrations of capitalist workers. People like to believe they work for something
else other than money. Refocusing the work motivation structure towards prioritising use value, instead of exchange value, might help connect designers and users to a common object. This was an insight that came from the experiment with the hospital board game of Chapter 4.

**Limitations of this study**

The above conditions are sketchy because the expansive design concept was applied *post-factum* to the design interventions, just as a comprehensive explication. Although the concept emerged within the design interventions, it was not until the thesis writing that it achieved the status of a generalised practice. During the interventions, the concept was indeed present, but in an embryonic stage that could not reach full consciousness. It is possible that the results would be different if the expansive design concept were put into trial by the design interventions.

The germinal stage of the concept is also responsible for the unsystematic way the case studies and the experiments were conducted. Each of the chapters included in this thesis explore a different aspect of the concept, but without making a direct reference to it. The studies were guided mainly by the conditions of the research project: the difficult access to healthcare projects and the strategic choice of producing self-contained journal publications before the thesis. Due to these conditions, the studies were short-lived and could not reach the desired depth to understand the historical formation of the phenomena analysed. Although it was possible to identify the expansive design practice in some of the instances analysed, it remains to be explored via a continued and sustained effort.

The experiments with design students can be criticised for the low stakes involved. Given that the topic was related to conflicts of interests, such a criticism would be well taken. In the experiment with the board game, the conflicts of interest were experienced in an artificial manner, to the extent that the differences induced between participants replaced by produced differences. Also, the experiments did not provide a consistent data set — such as video recordings — and failed to capture how the conflicts of interest
were dealt with. The analysis was not based on the direct observation of the phenomena, but on the self-reports provided by the students. This is why the results could only be generalised for learning, a phenomenon that can be well studied through the reported inter-subjectivity.

The design interventions and the classroom experiments are difficult to reproduce in different settings. Since they were very much tied to the situation at hand, they cannot be fully transported to another situation. In the design intervention, the instruments developed were customised for the specific representation issues found in the projects. These instruments were not tested in other settings to secure their generalisation for other purposes. The employment of instruments derived from the project experience in the classroom did not aim to test their generalization capacity. On the contrary, they aimed at better situating the learning experience of students.

The low level of involvement and short duration of the empirical studies means that the contradictions found in the empirical studies may not correspond to the dialectic process of becoming in society (Lefebvre, 1975, 2009). It is beyond the scope of this research project to provide an in-depth look at these contradictions. Nevertheless, they stand as fair approximations of the contradictions reproduced through design in the contexts of study. The goal of this thesis was not to identify the contradictions reproduced by design, but to describe how design reproduces contradictions.

Given these limitations, the scope of generalisation of these findings is limited. They are mainly applicable to design projects that deal with the relationship between space and activity in an explicit way, such as architectural design and service design projects. Although the concept of expansive design is broad enough to deal with implicit relationships between activity and space in other kinds of design projects, this is not yet fully supported.
Summarising the contributions

The main contribution of this thesis is to further develop the concept of expansive design proposed by Engeström (2006) through the space outlined by Lefebvre (1991). This has enabled a study of design practice as an emergent phenomenon arising from the contradictions between and across activity and space. The expansive design concept refers to the practice of dealing with these contradictions in an inclusive way.

It is not the intention of this thesis to define expansive design as another method, process, approach or professional branch in design practice. Expansive design is just an emergent phenomenon that may happen or not, depending on certain conditions and actions taken by people engaged in any activity, not just professional design activity. Expansive design is also not a universal concept to abridge all kinds of design activities, but a concept that helps us understand how design activities evolve and change by their own force, eventually cutting across disciplinary boundaries and specific notions of what design is. The goal here is not to justify the existence of a specialist, “the expansive designer”. On the contrary, the goal is to highlight the need for crossing boundaries between the specialists and to develop shared objects.

In practice, this corresponds to the anticipation of organisational activities by designing space with the participation of people from the organisation. Instead of using architectural space to control and restrict members from the bottom, expansive design brings people from different hierarchical levels and expertise to work out the contradictions that emerge in design space. Themes, such as division of labour, work procedures, instruments, community identity and shared objects are dealt with an expansive mind-set that does not suffocate conflict, but spreads it out through the unknown. This thesis has described also a set of instruments designed to support expansive design and the companion discussion about their use in practice. This discussion is as much as practical as the instruments since instruments by themselves cannot guarantee expansive design to happen.
Future studies

The core of this thesis has been the dialectics between activity and space, which is deemed to produce a third: design. This dialectic was turned into another at this very last chapter, between expansive design and reductive design. Reductive design is the current dominant side, whereas expansive design represents the alternative path. Expansive design does not negate reductive design, but employs it in favour of expansion. Together, they result in the principle of “reduce here to expand there”. This principle generates uneven development across activities and spaces (N. Smith, 2008; Trotsky, 2008). These are the basic conditions for economic growth in a capitalist society, but also for social criticism and enjoyment (Lefebvre, 2014b). Uneven development can be considered the third of this second dialectic, which means that some activities and some spaces are reduced by design in favour of others.

In future studies, it would be interesting to see if uneven development can also be confronted with combined development, which is the coexistence of archaic and contemporary ways of doing things (N. Smith, 2008; Trotsky, 2008). In these studies, it is important not to lose track of the motive for development in capitalist societies, which is economic growth. Currently, there is a debate if it is possible to develop without economic growth (Jackson, 2011; Victor, 2008), which also brings the question of wealth distribution (Piketty, 2014). Design activities are starting to grasp this relationship and propose alternative means of wealth distribution and economic growth (Fuad-Luke, 2013; Thorpe, 2012). What can come out of this dialectic is currently unknown. I believe that if design researchers, activists and practitioners can pursue such a dialectic, expansive design could finally occupy its place as the dominant form of design in capitalism, contributing to economic growth and to wealth distribution.
Figure 9 – Dialectics pursued by this thesis and dialectics that can be pursued by future studies. The dominant side of the dialectics is on the left. The right side is the alternative strengthened by the present research with the purpose of generating the third element above, which is also the beginning of a new dialectic.
References


Franck, K. A., & Lepori, R. B. (2007). *Architecture from the inside out: from the body, the senses, the site, and the community.* Wiley-Academy.


Garde, J. A. (2013). *Everyone has a part to play: games and participatory design in healthcare.* University of Twente.


Gottlieb, S., & Haugbølle, K. (2013). Contradictions and collaboration: partnering in-between systems of production,


Nordic Conference on Service Design and Service Innovation (pp. 101–109). Espoo, Finland.
Doctoral Education in Design Conference (Vol. 2011). Hong Kong.


Scholl, I., & Aicher, O. (1951). *School of design – Research Institute of Product Form*.


## Appendix I

**Table 1 – Summary of representation instruments and unit of analysis shifts in dealing with user activities’ issues described in the case study sections.**

<table>
<thead>
<tr>
<th>Case study section</th>
<th>User activities’ issues</th>
<th>Representation instrument</th>
<th>Unit of analysis’ shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>From the business plan to the spatial conditions</td>
<td>Financial sustainability</td>
<td>5D animation</td>
<td>Contraction from activity to operation</td>
</tr>
<tr>
<td></td>
<td>Technical problems (radiation, noise, energy consumption)</td>
<td>Floor plan</td>
<td>Contraction from action to operation</td>
</tr>
<tr>
<td></td>
<td>Spatial needs (room size, room adjacency, daylight)</td>
<td>List of requirements</td>
<td>Expansion from operation to action</td>
</tr>
<tr>
<td></td>
<td>Sharing diagnosing machines</td>
<td>List of requirements</td>
<td>Contraction from activity to operation</td>
</tr>
<tr>
<td>From spatial conditions to individual actions</td>
<td>Optimization of care logistics</td>
<td>Floor plan</td>
<td>Contraction from action to operation</td>
</tr>
<tr>
<td></td>
<td>Possible troubles caused by space</td>
<td>Floor plan</td>
<td>Expansion from operation to action</td>
</tr>
<tr>
<td></td>
<td>Overlapping activities</td>
<td>Floor plan</td>
<td>Expansion from action to activity</td>
</tr>
<tr>
<td></td>
<td>Waiting room and dressing room capacity</td>
<td>Floor plan</td>
<td>Contraction from activity to operation</td>
</tr>
<tr>
<td>From individual actions to healthcare operations</td>
<td>Existing spatial conditions in the hospitals</td>
<td>Hospitals’ existing spaces</td>
<td>Expansion from operation to action</td>
</tr>
<tr>
<td></td>
<td>Future spatial conditions in the centre</td>
<td>Floor plan</td>
<td>Contraction from action to operation</td>
</tr>
<tr>
<td></td>
<td>Nurse and patient walk paths</td>
<td>Workflow diagram</td>
<td>Contraction from action to operation</td>
</tr>
<tr>
<td>Activity Description</td>
<td>Method</td>
<td>Result</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------------</td>
<td>---------------------------------</td>
<td>---------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Dressing room’s capacity</td>
<td>Discrete-event simulation</td>
<td>Contraction from activity to operation</td>
<td></td>
</tr>
<tr>
<td>Existing spatial conditions in the hospitals</td>
<td>Project manager’s and nurses’ bodies</td>
<td>Expansion from operation to action</td>
<td></td>
</tr>
<tr>
<td>Nurse and patient walking paths</td>
<td>Knitting game</td>
<td>Expansion from operation to action</td>
<td></td>
</tr>
<tr>
<td>Manoeuvring patient stretchers</td>
<td>Floor plan</td>
<td>Contraction from action to operation</td>
<td></td>
</tr>
<tr>
<td>Division of labour between researchers, radiologists, and radiographers</td>
<td>Users’ sketch</td>
<td>Expansion from action to activity</td>
<td></td>
</tr>
<tr>
<td>Connection between MRI and CT</td>
<td>Users’ sketch</td>
<td>Expansion from action to activity</td>
<td></td>
</tr>
<tr>
<td>Room and corridor size</td>
<td>Construction site</td>
<td>Expansion from operation to activity</td>
<td></td>
</tr>
<tr>
<td>Arriving, parking, and entering the building</td>
<td>Construction site</td>
<td>Contraction from action to operation</td>
<td></td>
</tr>
<tr>
<td>Connection between MRI and CT</td>
<td>Designers’ sketch</td>
<td>Contraction from activity to action</td>
<td></td>
</tr>
</tbody>
</table>
Appendix II

The following tables are appended together to enable understanding the inversion from induced to produced differences in the experiment with the Expansive Hospital game.

*Table 1 - Differences induced to players of the Expansive Hospital game as if each role an activity system was.*

<table>
<thead>
<tr>
<th>Subject</th>
<th>Object</th>
<th>Outcome</th>
<th>Instruments</th>
<th>Rules</th>
<th>Community</th>
<th>Division of labor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nurse</td>
<td>Patients in the queue</td>
<td>Treated patients</td>
<td>Satisfaction points</td>
<td>Patients may leave treatment</td>
<td>Healthcare team</td>
<td>Managing the patient queue</td>
</tr>
<tr>
<td>Facility Manager</td>
<td>Treated patients</td>
<td>Program</td>
<td>Building blocks</td>
<td>Must keep track of assets to earn</td>
<td></td>
<td>Suggesting the blocks to be built</td>
</tr>
<tr>
<td>Director</td>
<td>Program</td>
<td>Budget</td>
<td>Contracts</td>
<td>Income depends on investments</td>
<td></td>
<td>Choosing a contract</td>
</tr>
<tr>
<td>Architect</td>
<td>Budget</td>
<td>Building layout</td>
<td>Budget</td>
<td>Design should be holistic</td>
<td>Construction team</td>
<td>Defining the blocks’ position</td>
</tr>
<tr>
<td>Engineer</td>
<td>Building layout</td>
<td>Pipework</td>
<td>Pipe tiles</td>
<td>Profit from service synergy</td>
<td></td>
<td>Designing the pipework</td>
</tr>
<tr>
<td>Contractor</td>
<td>Pipework</td>
<td>Building blocks</td>
<td>Building blocks</td>
<td>May charge inspections</td>
<td></td>
<td>Gatekeeping the blocks</td>
</tr>
</tbody>
</table>
Table 2 – Differences produced by design students from group A and B, in italic.

<table>
<thead>
<tr>
<th>Gr. Subject</th>
<th>Object</th>
<th>Outcome</th>
<th>Instruments</th>
<th>Rules</th>
<th>Community</th>
<th>Division of labor</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Nurse</td>
<td>Patients</td>
<td>Profitable hospital</td>
<td>Care plan</td>
<td>Operational</td>
<td>Healthcare team</td>
</tr>
<tr>
<td></td>
<td>Facility Manager</td>
<td></td>
<td></td>
<td>Building inventory</td>
<td>efficiency</td>
<td>Collaborate among each other and try to interfere with the other team</td>
</tr>
<tr>
<td></td>
<td>Director</td>
<td></td>
<td></td>
<td>Contracts, personal income</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Architect Engineer</td>
<td>Design</td>
<td>Integrated facilities</td>
<td>Budget</td>
<td>Design</td>
<td>Construction team</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Design efficiency</td>
<td></td>
<td>Collaborate among each other and try to interfere with the other team</td>
</tr>
<tr>
<td></td>
<td>Contractor</td>
<td></td>
<td></td>
<td>Building blocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Nurse</td>
<td>Patients</td>
<td>Logical path for patients</td>
<td>Building blocks</td>
<td>Strategically</td>
<td>Whole group</td>
</tr>
<tr>
<td></td>
<td>Facility Manager</td>
<td>Available blocks</td>
<td>Unneeded blocks</td>
<td>Building blocks</td>
<td>positioning</td>
<td>Try to influence other actors</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Building the most</td>
<td>the blocks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Director</td>
<td>Credibility rating</td>
<td>Team orientation</td>
<td>Contracts, expenditures</td>
<td>Income</td>
<td>Push orders to the construction team</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>statement</td>
<td>depends on</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Architect Engineer</td>
<td>Income</td>
<td>Useless building that</td>
<td>Building blocks</td>
<td>Design for</td>
<td>Choosing a contract</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>cannot treat the patients</td>
<td></td>
<td>service</td>
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</tr>
<tr>
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<td></td>
<td></td>
<td>in the queue</td>
<td></td>
<td>synergy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Engineer</td>
<td>Pipe tiles</td>
<td>Build nonsense pipework</td>
<td></td>
<td></td>
<td>Designing the pipework</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contractor</td>
<td>Building blocks</td>
<td>Charge as much as possible</td>
<td></td>
<td></td>
<td>Gatekeeping the blocks</td>
</tr>
</tbody>
</table>