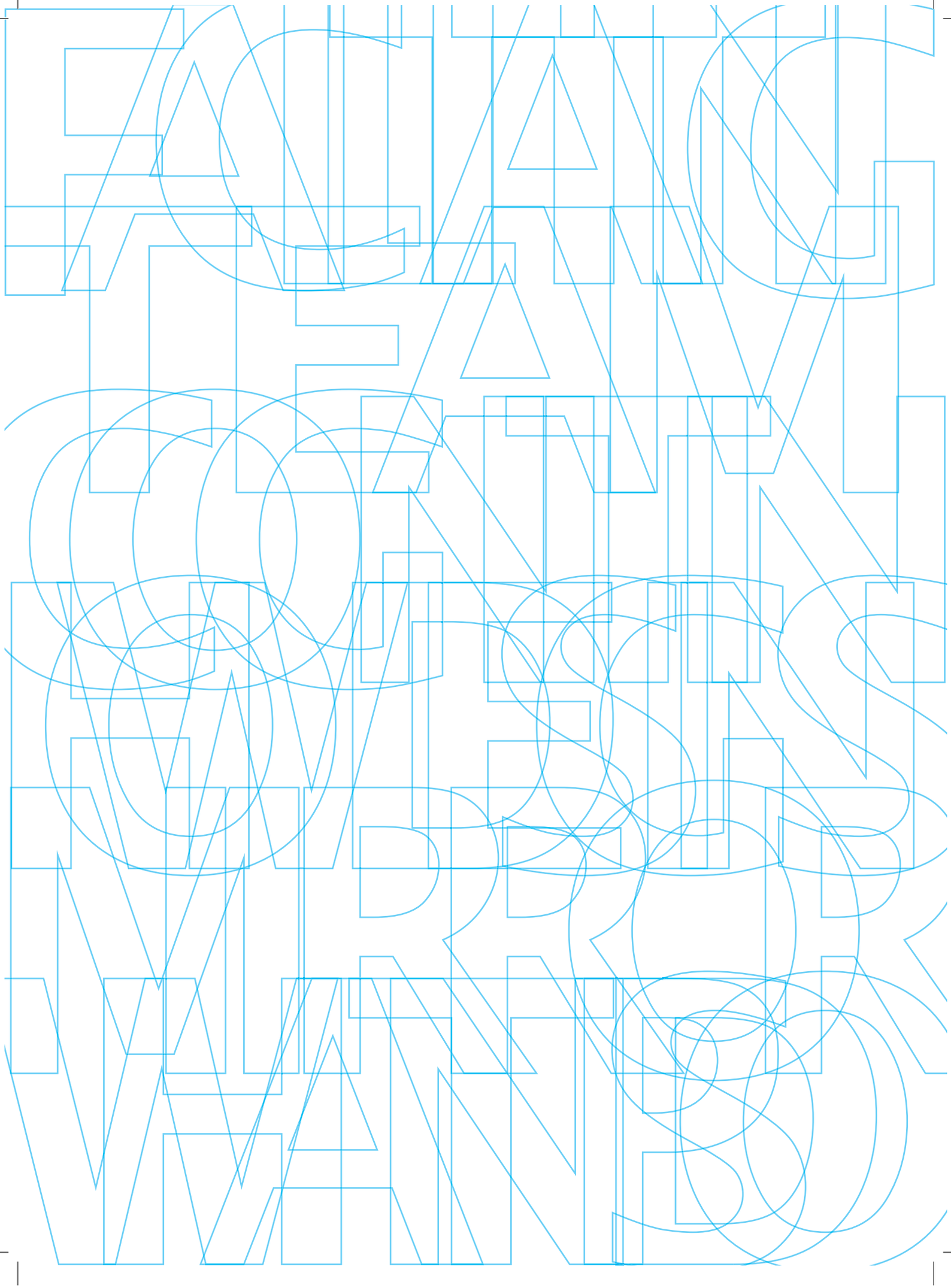

Facilitating Team cognition

How designers mirror what NPD teams do

Facilitating Team cognition
How designers mirror what NPD teams do

Summary of a PhD thesis
Delft University of Technology, The Netherlands
Faculty of Industrial Design Engineering

Subject headings: new product development, knowledge management, user-centered design, collaborative design, sensemaking, reflective practice, design thinking.

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Facilitating Team cognition

How designers mirror what NPD teams do

Proefschrift

Proefschrift
ter verkrijging van de graad van doctor
aan de Technische Universiteit Delft;
op gezag van der Rector Magnificus prof. ir. K.C.A.M. Luyben;
voorzitter van het College voor Promoties,
in het openbaar te verdedigen op maandag 11 september 2012 om 15:00 uur
'Lekenpraatje' op maandag 11 september 2012 om 14:30.

door
Guido Stompff

ingenieur industrieel ontwerpen,
geboren te Terneuzen.

Part

1 The hidden designers in teams

Introduction

This thesis explores the contribution of designers to multi-disciplinary New Product Development (NPD) teams. A gap exists in the body of knowledge on design: designers as members of multi-disciplinary NPD teams. A preliminary research showed that designers add 'something' to 'collective thinking' in teams, named team cognition in the thesis, but designers are unaware of this contribution. This unawareness becomes problematic for distributed teams, as interactions between team members are severely reduced.

The study concerns an exploration of new product development (NPD) and design at Océ Technologies BV. Océ, part of the Canon Group, is a large multinational provider of document management and printing systems for professionals. Like many complex products, to develop the Océ products large multi-disciplinary teams are needed. The teams deal with many topics that require the expertise of several specialists simultaneously. One of those specialists inside the NPD teams is a designer, focusing on the usability and experience of use of products.

In the vast body of literature on NPD, designers are remarkable absent. Also, in the literature on design, multi-disciplinary teams are hardly mentioned. There is a gap in the field of knowledge between the world of designers and the world of NPD: knowledge that concerns the contribution of designers to multi-disciplinary NPD teams. Since 1996, I am a designer at Océ and part of large multi-disciplinary NPD teams. The knowledge gap on what designers contribute to NPD teams became problematic for me when I started to work for so called distributed teams. These are teams in which the members are spatially, culturally and/or organizationally separated. In these teams the expectations of a 'designer' were reduced to cliché-like images and the designer's contribution was restricted to the outer skin of a product. Only after a long time of collaborating, the design activities started more and more to resemble design activities in co-located teams, but why? This observation caused doubt: not only in the literature there is a knowledge gap; also I was hardly aware what designers contribute to NPD teams. This thesis attempts to fill the knowledge gap and studies designers in-the-wild, interacting with many others team members.

A preliminary research was conducted, with the aim to pinpoint fruitful directions that provide guidance to the inquiry. The findings suggested that designers and their activities seem to facilitate 'collective thinking' in teams. Collective thinking is about team members who have to decide together if something is a problem; negotiate whose problem it is; propose multi-disciplinary solutions; and align their activities into a seamless whole. A large part of this thesis is about understanding this elusive topic, which is named team cognition. Team cognition is defined as the binding mechanism of aligning and coordinating activities in a team, while team members interact and encounter (unexpected) events. Consequently, understanding the relation between what designers do and team cognition is the subject of the thesis. Three research questions are put forward that also structure the thesis:

- What factors constitute team cognition in the context of NPD?
- What factors in the work of designers moderate team cognition?
- What can designers contribute to team cognition in the situation of distributed teams?

Method

As a designer and a researcher I have a dualistic position: I conduct an inquiry into my own practice. There are no off-the-shelf methods for practitioners to research their own practice. For that reason a method was developed based on a philosophical perspective, pragmatism, for which interventions and learning by doing is pivotal. According to pragmatists, one can learn by participating and not by observations alone. The chosen method, named a Deweyan inquiry, starts from a 'doubtful situation': a situation which constitutive factors are not well understood, causing doubt. The situation requires an inquiry and thereby theory and practice are equal partners. In Figure 1, an overview of a Deweyan inquiry is shown. It includes four steps:

- The institution of the problem: what seems to be the problem at hand? In my inquiry, a relation was established between team cognition and what designers do.
- Determination of problem and solution: doing observations in order to reconstruct an *existing* situation. In my inquiry a complex multi-disciplinary problem in a co-located team provided the context for analysis: the development of error recovery to solve paper jams in a printer. Much data was gathered, including interviews, observations captured in my journal, meetings that were filmed, photos made and objects. After a considerable time these were analyzed together with co-researchers.
- Reasoning: distilling what seems to be the cause of the doubtful situation at hand and also possible solutions to solve it. These solutions are named 'productive propositions': actionable hypotheses, which can be validated in practice. In my inquiry the distinctions between a co-located teams and a distributed team served to distill propositions.
- Experiment: conducting experiments in the situated context of the doubtful situation. Only if the experiments show that the doubtful situation is understood and one knows what to do, 'warranted assertibility' is obtained. In my inquiry, distributed teams at Océ provided the context for the experiments.

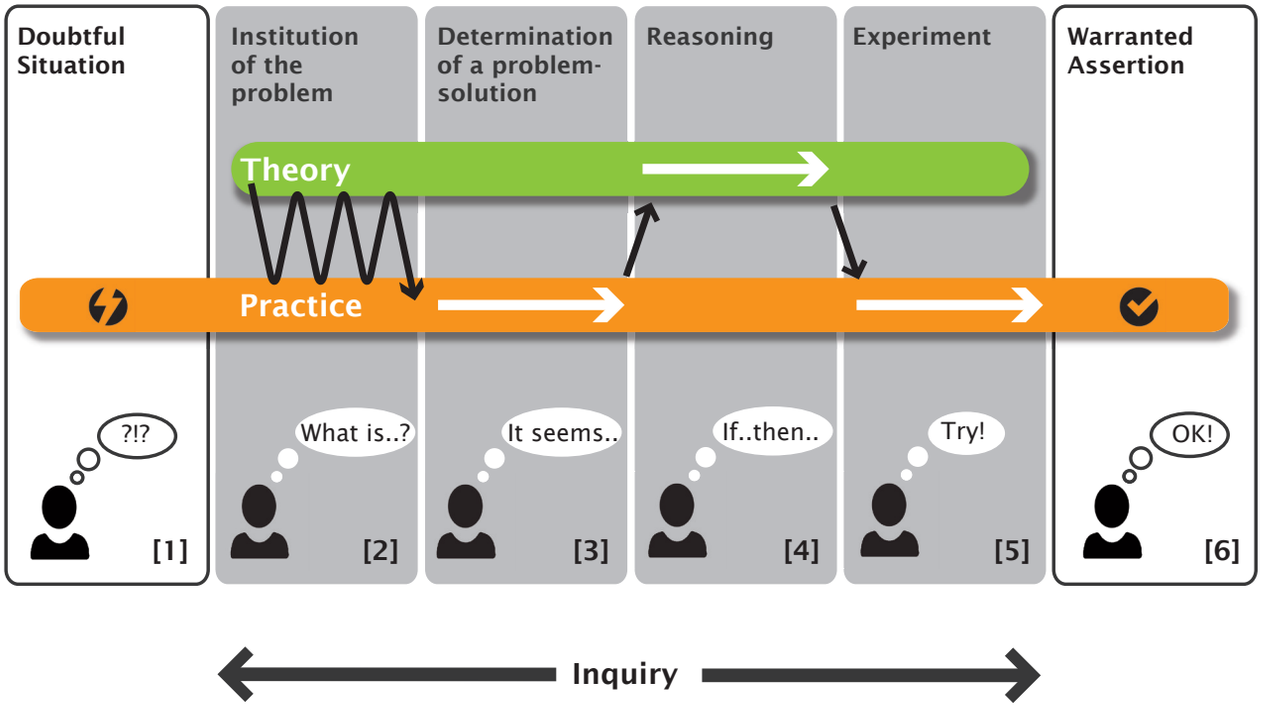


Figure 1
An overview of a Deweyan inquiry, which serves as the foundation for the research design. Pivotal is the continuous movement back-and-forth between practice and theory. It underscores learning by doing. The premise of an inquiry is that only by intentional intervening in the subject matter one can validate insights.

Part

2

Understanding team cognition

Analysis

This part of the thesis concerns the first research question: what factors constitute team cognition in the context of NPD? Team cognition concerns both the level of individuals and the level of the team, as alignment and coordination of activities of individuals can only be observed at the level of the team. The insights of the inquiry provide explanations both for the level of an individual and for the level of the team.

The level of individuals

It is found that members of NPD teams experience an extreme indeterminacy in their daily activities. Four factors have been found, of which I'll mention two. First, in multi-disciplinary teams problems arise as an unexpected consequence of previous activities. The situations team members face at any given moment are (partly) enacted by their own prior choices. For example, in the inquiry it was observed that many of the problems a team needed to solve were enacted by the choice to build a compact printer, long time before. Although the team members were aware of the consequences of the compact engine, many problems were not conceived by team members and only discovered much later. Team members learned that additional relations existed in their activities (see Figure 2).

Second, the state of affairs of what can be observed of the 'as is' system is always lagging behind to what team members know. For example, it was observed that building a prototype required ample time and preparations. In between, team members continued their development activities: the eventual prototype depicted the state of affairs of some time ago. Consequently, team members often asked others questions in order to assess what the other knows. Team members attempted to construct the non-observable state of affairs of their collective activities before the mind's eye.

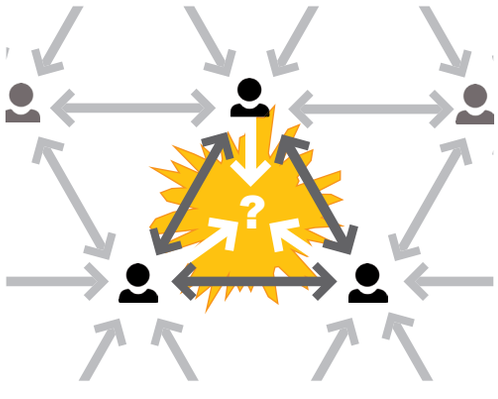


Figure 2
A model of team members inside NPD teams. Each team member needs to understand the relations in his work with the work of others: the arrows between team members. The orange zone in the middle, with the question mark, concerns the problems or opportunities that are discovered only when the collective work of several team members is enacted into an object. Nobody conceived the problems beforehand and only in hindsight the new relations between team members can be understood.

To deal with the intrinsic indeterminacy, each individual team member needs to 'fit' his activities to those of others. There is no all overseeing director who explains who should do what. The basis of team cognition is the principle that only individuals can establish the relations between their activities and those of others. Establishing the relations between activities of team members is named 'interrelating'. An individual learns to interrelate his activities to those of others by means of two mechanisms:

- Interactions with other *team members* and with *objects*. Interactions with others concern meetings, sketching together and so on. While interacting, team members learn what the relations are between them (see Figure 3), i.e., the mutual consequences and dependencies of their activities. Objects concern artifacts of prior activities, such as a drawing, a prototype or a model. Team members learn about their relations in activities by interacting with these objects, even without ever meeting or speaking to each other.
- As a result of these interactions, each team member can envision the larger system he contributes to. For NPD, the larger system concerns both the *'as is' system* in the here and now and the *'intended system'*, which is the system the team is developing. There are many representations that refer to the 'as is' system, but for the 'intended system' only few representations exist, especially in the early stages of an NPD project.

Figure 3
Members of NPD team learn to interrelate their activities to those of others by means of interactions. On the left an informal meeting, showing interactions between team members. They learn while collaborating how their activities are related. On the right an example of interactions with objects that are produced by past activities. It shows a team interacting with an object, an integrated prototype, in order to understand a problem that seems to underlie that their collective work. Only by means of the object they can make sense of the situation at hand.

Because everybody interrelates his activities to those of others, in time a network emerges. The activities interlock and the nodes of the network are those things, which are meaningful to many team members. Nodes can be objects or typical words used by many, specific events experienced together and/or roles everybody interacts with: the jointly constructed practice (Figure 4). Practice concerns what someone does and a joint practice is what team members do together. Vivid examples in the inquiry are the integrated prototypes that many team members interact with, or specific events like customer trials. Joint practice provides the anchors for team members to learn about their interrelations and subsequently align and coordinate their activities. At the same time, joint practice is a result of prior activities. This highlights the dynamical and mutual constitutive relation between joint practice and individual activities.
An important finding of the inquiry is the significant contribution of *tangible* objects to the joint practice. Because, for example, team members smell a hot-running motor, problems become manifest or new solutions are considered. These bodily experiences are relatively the same for all involved and thus easily span disciplinary boundaries. In the inquiry, many problems and/or solutions were only found or discussed as a result of interacting with tangible objects. Possibly, tangible objects are the most important constituent of joint practice.

A second important finding is that even when a multi-disciplinary development has successfully ended, team members discuss and frame the results fundamentally different. This finding suggests that team members are able to align and coordinate their activities into a unified whole, without having a shared or common understanding.

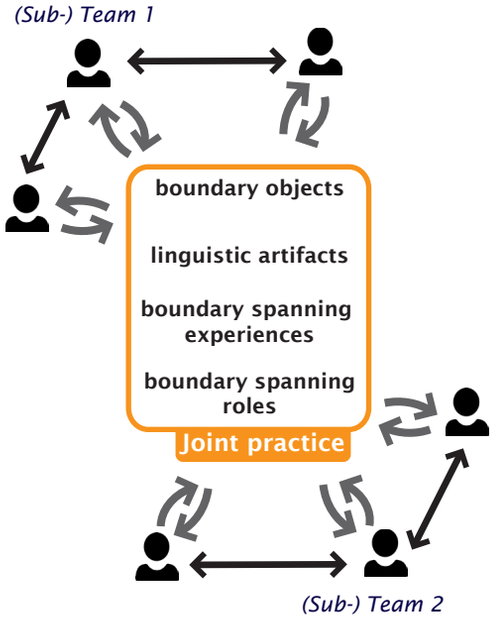


Figure 4
A model that visualizes joint practice. Two sub-teams are shown that for some reason hardly communicate, for example because a boundary exists between their practices. All do activities and produce artifacts as a result of these activities. If these activities or artifacts are observable by all, they can be interpreted by other team members for their consequences. Some of the activities or artifacts become part of the joint practice and constitutes the practice of many. Joint practice 'sits' amidst the team members. Four distilled constituents of joint practice are presented in the middle and are discussed in depth in the thesis.

The team level

A framework and a vocabulary have been developed for team cognition. The framework is grounded in the (pragmatist) premise that cognition concerns the perception and interpretation of the flux of events in the world, in relation to the expectations the team members have. What is observed is prepared by the expectations we have, which are developed by means of past experiences. The cognitive system is dynamical, because our expectations are adjusted to what we learn while interacting with the world.

Two components of team cognition are named: team consciousness and team mind. The first concerns the alignment and coordination of activities for which *explicit* communication can be observed. The latter concerns alignment and coordination without the need for discussions or reporting things: team members *implicitly* 'know' what to do in the context of their practice, even when unexpected events occur.

Four cognitive processes have been distilled at the team level:

- Imagining and/or reasoning
  Imagining concerns, for example, activities that attempt to provide explanations or solutions for an unexpected event. Reasoning is about extrapolating consequences, for example of an idea. Imagining and/or reasoning are supportive to the other three cognitive processes.
- Minding: team members know what to do and progress relatively on their own and hardly communication can be observed. They interact and respond to events. They are mindful to the flux of events and involve others when they consider a problem is encountered they can no longer deal with themselves. It is captured by the dictum: *now that I know what we think, what do I need to do/create?*
- Sensemaking: team members experience doubt, but do not agree if there is a problem, what causes the problem, who is responsible, who needs to be informed and so on. As described by Weick (1995, references are in the thesis), sensemaking processes are collective interpretations of the situation at hand, in order to create a plausible image that rationalizes what is observed. Team members have to articulate what they know and combine this, in order to interpret the consequences together. Sensemaking requires an open dialogue, seeing each other face-to-face en deploying objects that show what the team had developed together and provide rich and varied cues. *How can we know what we think until we see what we created?*
- Reflection-in-action: the acts of team members are guided and structured by a strong frame, in line with Schön's writings on the reflective practice (1983). Multi-disciplinary proposals, 'moves', such as a small sketch, a proposal, or the building of a prototype, are put forward within the frame. Team members reflect collectively on the results of the move. Often reflection-in-action processes deal with a multi-disciplinary problem recognized by all involved, but which has not been solved properly. *Now that we know what we think, what do we need to do/create?*

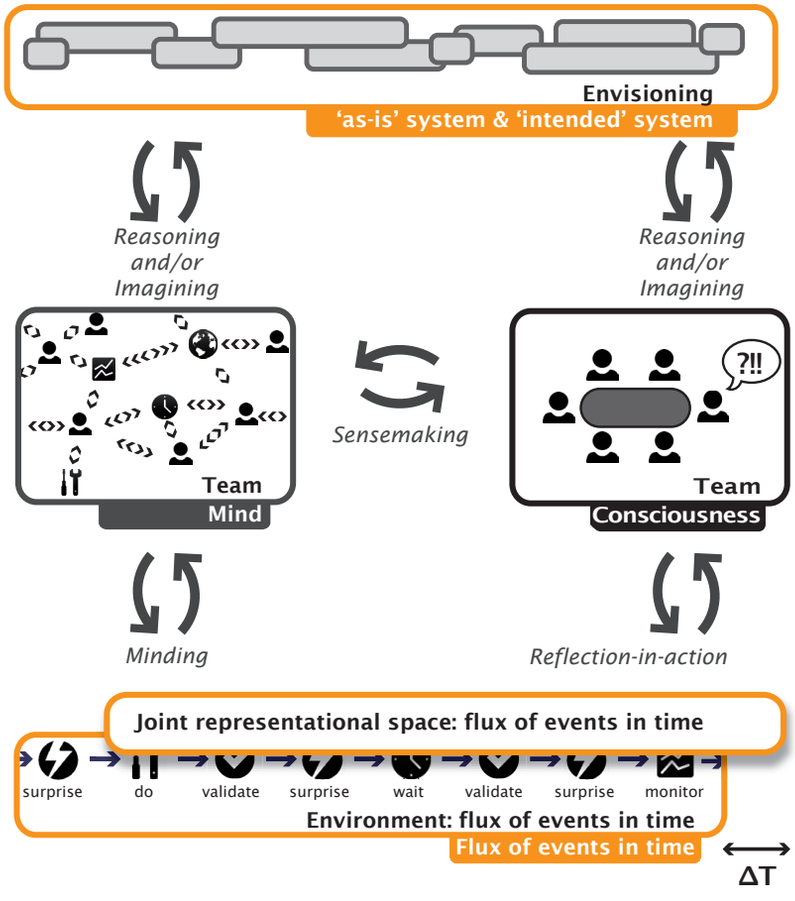


Figure 5
A framework for team cognition. On the bottom the flux of events is shown, which can be observed by all, such as objects. Events can also be observed in the joint representational space, such as CAD models. On top the expectancies of the team members are shown, constituted by the larger system team members envision. In between cognitive processes are shown: reasoning and/or imagining; minding, sensemaking and reflection-in-action. These are explained in the text. Some of these processes lead to explicit communication, which is named 'team consciousness' as team members consciously align and coordinate their activities. However, the bulk of aligning and coordinating activities is done without verbal or textual communication: team members know what to do in the context of their practice, minding the flux of events. 'Team mind' is operating. Note that the cognitive system includes the environment.

It is found that these processes have a 'natural' sequence. When individual team members observe an event they can no longer deal with themselves, team mind no longer accommodates the event. Consequently, a collective sensemaking process starts. Once a strong guiding frame is developed, reflection-in-action processes start: moves are made and reflected upon collectively within the new frame. When team members know what to do within the guiding frame, explicit communication is no longer required and team mind is operating. Quintessentially, sensemaking is the process of reframing at the level of the team as a result of a surprise.

Part

3 The contribution of designers

Analysis

The second research question is: what factors in the work of designers moderate team cognition? To answer this question, analysis was done to understand what discerns a designer from other roles. The activities of the designers showed to be an important ingredient for team cognition.

What discerns designers from other roles is best illustrated by means of the bar charts depicted in figure 6. These are findings of an analysis conducted of a filmed meeting that was crucial for progress in the team and included several key actors. On the left (Talking users), the relative amount of user related arguments is shown of the persons in the meeting, according to their formal role. Three roles were part of this particular meeting and the chart shows that designers truly 'talk users' as approx. 40% of their arguments were identified as related to users.

In the middle (Orientation to problems) the occurrences of arguments is depicted that show a specific attitude to problemsolving. Team members with a 'disaggregation' approach attempt to understand a problem thoroughly, in order to solve it. They abstract the situation at hand, model it in order to make predictions and tend to ignore other problems at hand. Team members with a 'holistic' approach do not have an inclination to understand all problems in depth, rather they like to know sufficiently in order to develop and build 'something' that can be reflected on. Designers showed to have a holistic approach to problemsolving, embracing ambiguity rather than solving sub-problems one after another.

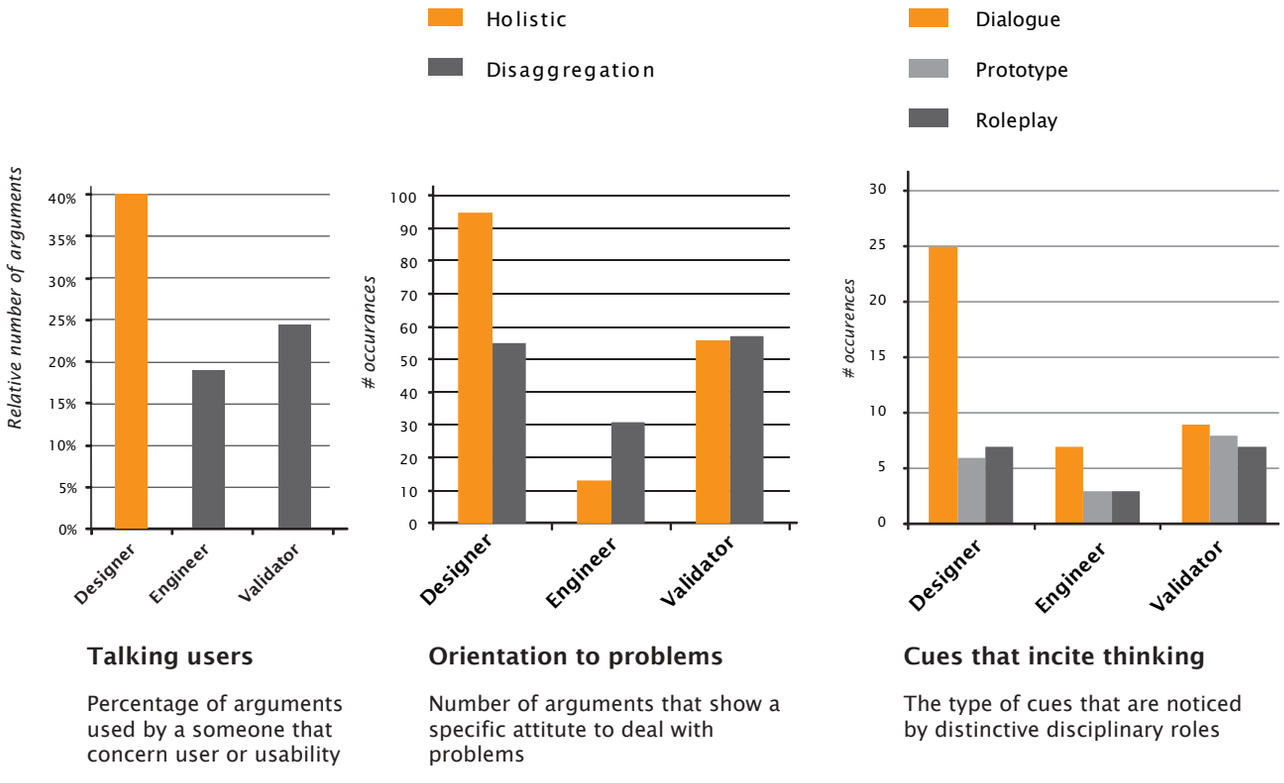


Figure 6
A crucial team meeting was filmed and analyzed in depth. Above the bar charts show three distinctive findings. An explanation is provided in the text.

The third bar chart (Cues that incite thinking) shows the type of cues that were noticed by team members in distinctive roles. Cues are extracted events or things in the world that are potentially meaningful for our being in the world and incite thinking. Three types of cues were discerned: 'dialogue, 'prototype' and 'role play'. The first concerns cues that are noticed in the dialogue: team members responding to each other. 'Prototype' concerns cues that are noticed at the prototype, like the sound of tearing paper. 'Role play' concerns cues that are noticed when a role play is conducted. The figure shows the imaginative skills of designers, as they are more than others responding to something that was said, rather than something that was observed in the world.
Thus, what discerns a designer from other roles in NPD teams is their framing of any topic encountered:

- Outside-in: designers tend to frame any problem or solution at the level of the product, instead of parts and modules. If, for example, a problem is noticed in a module, designers tend to discuss the consequences for the product and devise solutions that operate at the level of the product.
- User centered: designers ongoing question what the implications are of what they see for users and the user-experience. Their argumentations are for a large part comprised of user related topics, they 'talk users'.
- Holistic: designers tend to embrace ambiguity, dealing with many problems simultaneously, rather than sequentially. It explains the finding in the inquiry that the typical working methods of designers are a natural fit with sensemaking processes in teams.
- Imagining the 'intended' system: designer continuously and swiftly translate anything they encounter to the 'intended' system of the eventual product and user.

Consequently, the activities of designers adhere to the 'intended system'. They discuss the consequences of technological choices for the product and the user. They translate what the team is developing into compelling representations of the 'intended' system, such as sketches, demonstrators or mock-ups. They deploy an expressive language that is easily understandable by all. 'Designerly' artifacts become part of the joint practice of NPD teams. These artifacts emerge because designers interpret the work of others and translate it into the 'intended' system.

This contribution of designers is an important ingredient for team cognition. In NPD teams, as a result of specialization, disciplinary boundaries can inevitably be found, for example because the team members do not understand each other's language and practice. A boundary that became manifest in the inquiry was the boundary between the practices of hard- and software, see Figure 7. A characteristic of a boundary is that knowledge is not or hardly transferred across the boundary. An insight of my inquiry is that designers span (some) boundaries unknowingly and without belonging to one of the groups that experience a boundary. Team members on both side of the boundary can align and coordinate their activities by reflecting on the consequences of their collective choices on the 'intended' system. Designers are capable of swiftly translating technical choices of

distinctive practices into the 'intended' system. Stated differently, *designers mirror what the team is doing and the image in the mirror is the future 'intended' system*. The image enables the team to collectively make decisions about issues in the here and now. And hence: to align and coordinate their activities.

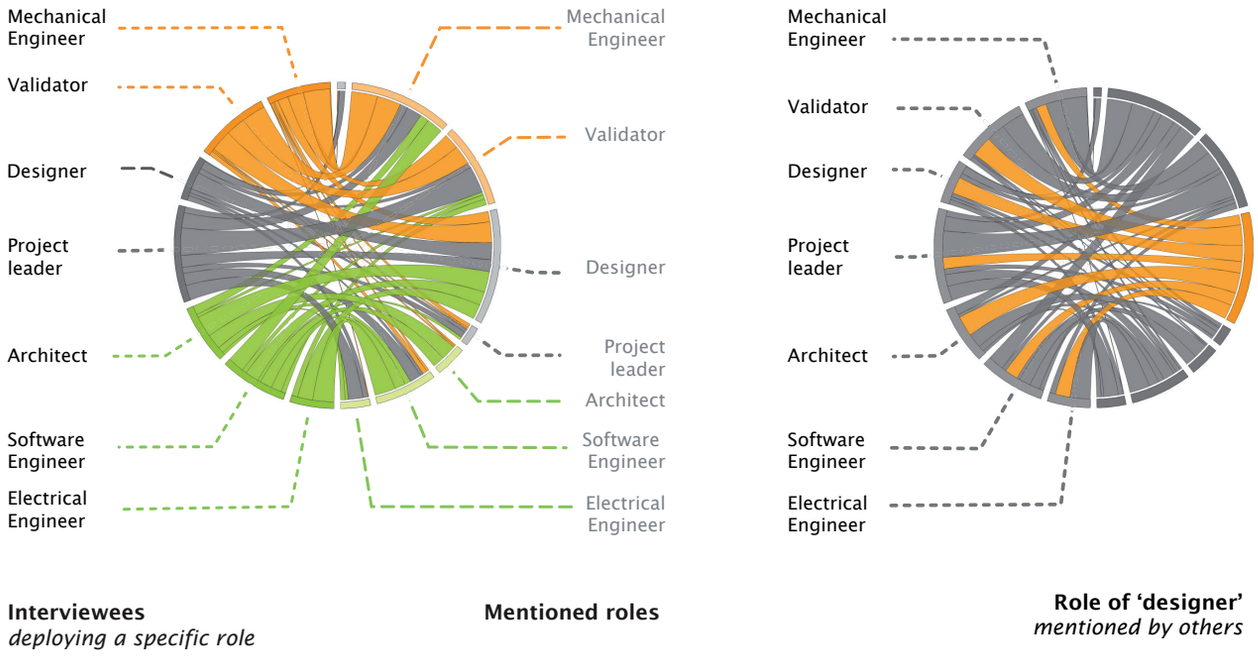


Figure 7
In the figure two visualizations (made with Circos software) are shown of the same dataset distilled from a range of in depth interviews with team members. The left side of the circles shows the roles of the interviewees. The right side of the circle depicts the roles mentioned by the interviewees, with whom they collaborated.
A ribbon connects the role of the interviewees with the roles that are mentioned and a wide ribbon shows these roles interacted often, according to themselves.
In the figure on the left the boundary between the practice of hardware (orange) and the practice of software (green) becomes manifest. Team members at both sides of the boundary hardly discuss the team members at the other side of the boundary, do not know what the role is of the other and have problems recalling the names.
The figure on the right shows how often the role of designers is mentioned by all interviewees. It shows that designers are often named and by all roles, even quite equally distributed. The combination of the two visualizations reveals the boundary spanning capabilities of the role of designers: they 'sit' amidst the practices of hard- and software.

Part

4 Distributed teams

Experiments

The inquiry is incited by a doubtful situation: unawareness of the contribution of designers to teams becomes problematic in the situation of distributed teams. The third and last research question is: what can designers contribute to team cognition in distributed teams? The last part of the inquiry concerns doing experiments in distributed teams in-the-wild, in order to validate the insights obtained in the previous parts.

Apart from the benefits, distributed teams also pose challenging conditions for team members. These challenges not only concern the obvious communication problems, because team members hardly meet face-to-face and speak different languages. Also, their practices are separated, each with specific objects, tools, jargon and so on. A joint practice develops slowly and consequently there are relatively few beacons for team members.

Because designers develop representations of the 'intended system', the expectation was that actively developing such representations should contribute to team cognition in distributed teams. Three series of experiments were conducted with different types of representations: visualizations, 'product stories' (brief explanation what the product is about and what the advantages for a client and/or user) and projecta's (concrete and tangible proposals for a new NPD project, showing the product). The findings of the experiments are:

- A representation of the 'intended system' requires expressive means, so that team members and/or stakeholders can commit themselves with the aims. Note that no representation is neutral and/or objective and thoroughly shapes what team members observe, discuss and do. What the best type of the representation is, is situationally determined. Consequently, several representations are required, each highlighting distinctive aspects, such as business cases, a demonstrator, or a mock up.
- The 'fidelity' of visualization concerns the chosen depiction of reality. The fidelity needs to be attuned to the cognitive process a team is in and an overview is provided in Figure 8. If a team is in a sensemaking process, the visualizations need to incite dialogue, lacking strong frames how something needs to be interpreted. The representations provide interpretational space for others to discuss and reflect. For reflection-in-action processes, quite contrary, the visualizations need to provide a strong guiding frame that encourages specific interpretations and discourages others. For example, for the 'intended' system these representations need be compelling, clarifying and better than the real thing.
- Because of the inherent communication problems in distributed teams, visualizations are crucial in order to develop a joint practice. Consider snapshots, little movies, animations, CAD screendumps or seductive renders. 'Talking visuals' mitigates the communication problems in distributed teams, however developing the 'right' visualizations are also time-consuming.

The experiments show that designers with their imaginative skills and their expressive capabilities can contribute to distributed teams, facilitating the alignment and coordination of activities.

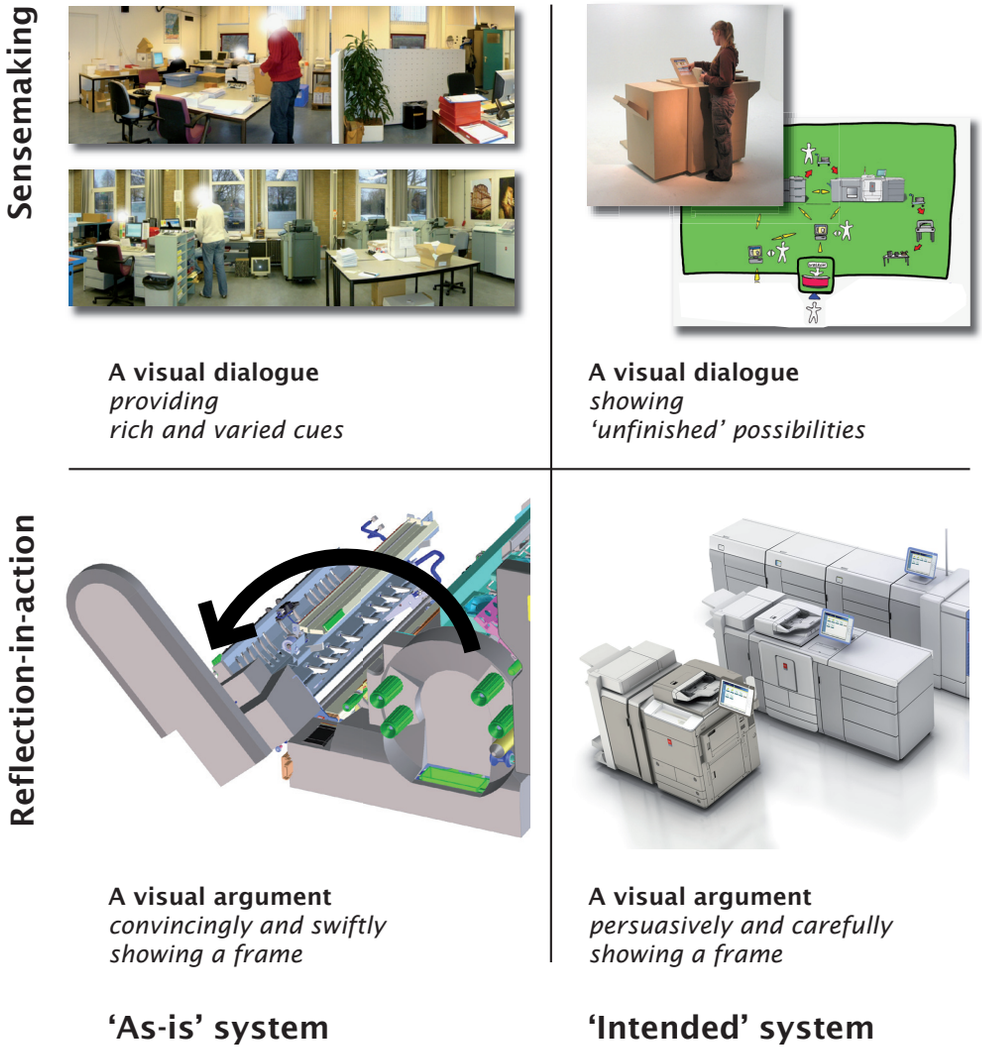


Figure 8
A two by two matrix depicting the distinctive types of visualizations that serve sensemaking and/or reflection-in-action processes in NPD teams. Sensemaking is about dialogue. For the 'as-is' system, visuals should lack frames as far as is possible, showing accurately the world as observed. For the 'intended' system, visuals should look open-ended, for example by means of crude sketches.
Reflection-in-action requires quite different visualizations and propose a strong frame, how something should be interpreted. For the 'as-is' system anything will do as long as it is swift and showing a problem and/or solution straightforwardly. For the 'intended' system compelling, better than life visuals are required in order that others commit themselves, including stakeholders.

Conclusions

The inquiry opens up the 'black box' of NPD teams and provides a colorful view in the practice of modern NPD of complex products. The main contribution of the inquiry to the field of knowledge is threefold and is discussed below.

NPD literature

The inquiry extends what is known in literature. The developed framework of team cognition shifts the focus from 'communication' to 'interactions'. Developing a joint practice is considered pivotal to align and coordinate team activities, rather than merely focusing on communication. Above all, tangible objects have a considerable contribution to the joint practice. Also, it is found that surprises occur at any moment in time in NPD projects and are intrinsically part of multi-disciplinary teams. Surprises may lead to delay and additional costs, but are also the source of many innovations.

The insights lead to a range of recommendations for NPD practice:

- Facilitate the construction of a joint practice, such as by means of tangible objects that are accessible to all team members, or by actively developing a 'project' jargon.
- Organize interactions between team member so that they learn what their mutual relations are, by means of (temporarily) working together on a topic; doing integration test collectively; visiting a client together.
- Manage doubtful situations within a team as team sensemaking processes. Sensemaking concerns the collective interpretation of a doubtful situation and cannot be resolved by means of bold and swift decisions. Better is to organize workshops with a variety of experts, deploy objects that represent accurately the state-of-affairs of collective activities. Also a sensemaking process for NPD teams is only finalized by means of a compelling story, in order to obtain commitment of other team members or stakeholders.
- Develop representations of the 'intended' system, deploying a range of means, ranging from business cases to compelling photorealistic renders of how a product will look like. It provides anchors for team members to interrelate their activities to those of others. These representations need to be redrafted ongoing, mirroring the current state of affairs of the collective activities of the NPD team.

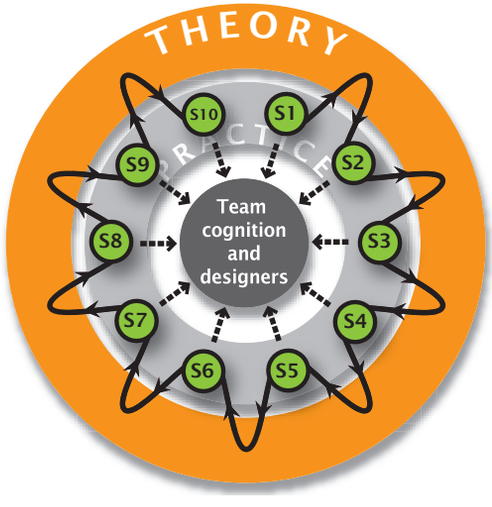
Design literature

The inquiry adds new insights on the topic of what designers contribute to multi-disciplinary NPD teams. Designers have an additional contribution beyond their formal role, because their activities adhere to the 'intended' system. Consequently, the practice of design spans troubling disciplinary boundaries inside NPD teams, such as between hard- and software, or between marketing and R&D. These disciplines hardly develop a joint practice and can only align activities by discussing the 'intended' system. The insights lead to a range of recommendations for the practice of design:

- Interact with other team members and their artifacts. Work transparently: show preliminary design sketches and do not only show end-results of a design process. Even if this may feel as a burden, as it incites many discussions, it constitutes team cognition.
- Develop compelling and expressive representations of the 'intended' system. Be aware of the 'fidelity' of the representations in relation to the team cognitive processes. Quite often, a nearly perfect sketch or render is contra-productive for the aims of the team.
- Incite or even provoke discussions about the 'intended' system, for example by showing alternatives instead of sticking (too) closely to the design brief and/or list of requirements. These discussions instigate sensemaking processes: *how can we see what we intend, until we see what we (might) create?*

Research methods

The third and last contribution of the thesis to the field of knowledge is the description of a Deweyan inquiry. Figure 9 provides an overview of the inquiry, showing the characteristic meandering between theory and practice and also how in time the study resembles a string of beads. Undoubtedly a Deweyan inquiry is a practitioner's method. The thesis shows that an in depth research by a practitioner is possible, balancing rigor and relevance. Above all, the step to validate insights by means of experiments is highly beneficial. There is also an inherent drawback to the methodology: as it concerns reflection-on-action, I had to step out of my own practice in order to finalize the inquiry, inevitably loosing the feel of my own practice. A Deweyan inquiry requires an intrinsic motivation to explore beyond the daily practice and an organization that embraces organizational learning.



Institution of the problem

s1 Stakeholders analysis (Appx. 1)

Determination of problem/solution

s2 Rival theories (Chapter 4)
s3 Analysis of journal (Appx. 2)
s4 Team reflective practice (Appx.3)
s5 Cues and frames (Appx.4)
s6 Roles (Appx.5)
s7 Interviews: team members (Appx.6)

Experiments (Chapter11)

s8 Experiment 1: visualizations
s9 Experiment 2: product story
s10 Experiment 3: projecta's

Figure 9
An overview of the inquiry as conducted in the thesis, which resembles a string of beads of distinctive studies. Each study evolved into a next one in a progressive way. Fledgling insights or remaining questions provided research questions for a next study. All studies are grounded in practice. Theory both guided the distinct studies (for example, providing methods) and served to explain the often unexpected findings (for example, providing frameworks). All studies together were directed to understanding team cognition and what designers contribute.

A glossary of key notions

'As-is' system	The larger system in the here-and-now that an individual envisions he contributes to and subordinates his activities to.
Boundary	An imaginary/felt demarcation between specialists, departments or functional units. Hardly no knowledge is transferred across the boundary.
Boundary objects	A broad range of objects, observable by many team members, that are plastic enough to adapt to distinctive practices; yet robust enough to maintain a common identity across practices.
Boundary events	Meaningful, demarcated events experienced by many team members, plastic enough to adapt to distinctive interpretations within practices; yet robust enough to maintain a common identity across practices.
Boundary spanning roles	Roles that facilitate the sharing of knowledge between groups that are separated by location, hierarchy or function
Cues	Extracted events or things in the here-and-now that are potentially meaningful for our being in the world.
Design	Devising products (tangible and intangible) in which human needs, likings, tasks and particularities are placed centrally. Focus is on the product's usability; experience of use; meaning attribution; and elicited emotions.
Distributed teams	Teams that are composed of sub-teams that are spatially, culturally and/or organizationally separated.
Frames	Perceptual frameworks that categorize what we see and what we know and guide our conscious thinking.
'Intended' system	The larger system the team is developing that a individual envisions he contributes to, and subordinates his activities to.
Interrelating	Team members interrelate their activities, when they establish the relations between their activities and those of others, and subordinate their acts accordingly.
Linguistic artifacts	Meaningful words, deployed by many team members, plastic enough to adapt to distinctive meanings within practices; yet robust enough to maintain a common identity across practices.
Practice	What people do: recurring and improvised activities; the tools and objects deployed; social identity; how work is done; how knowledge is produced.
Roles	The expectations which prescribe how someone should behave and contribute in a specific position in a group.
Surprise	An unsettling event that is unanticipated, not meeting (implicit) expectations.
Team	A set of people who interact dynamically, interdependently and adaptively towards a common goal/objective/mission; with specific roles or functions to perform; and have a limited life-span of interest.
Team cognition	The binding mechanism underlying the observable alignment and coordination in activities of team members interacting and dealing with situations that are encountered.
Team consciousness	Explicit alignment and coordination of activities at team level, either by means of communication or by means of standards or procedures.
Team mind	Implicit alignment and coordination of activities at team level as a result of heedfully interrelating team members.

About the author

Guido Stompff was born in 1968 in the Netherland, near the sea. He has been a designer for his entire life, as already as a child he was designing boats. He started studying Maritime Engineering, but soon found out that the design component was somewhat missing. Consequently, he studied at the Faculty Of Industrial Design Engineering in Delft. He graduated in 1993 with honors degree. After working for two small design offices, he joint Océ Design in 1996 as a product designer. He was awarded several (international) design awards. He deployed several roles within Océ, ranging from team leader to the curator of the renowned modern art collection, for more than 7 years.

His wide interest combined with his reflective working attitude resulted into a variety of publications. Topics are product design in relation to brand identity (Stompff 2003, references in the thesis); design for emotion (Hekkert, Mostert & Stompff 2003); usability methods (den Bouwmeester & Stompff 2006); fourth-order design (Stompff et al. 2008); organizational culture in NPD (Stompff 2008) and user-centered design in large NPD teams (Stompff et al. 2011). Also he co-chaired the 13th European Design Management Conference in Milan (2009): Facing Change. In 2007 he decided to start a PhD research on a question that kept haunting him for years: how can teams composed of numerous specialists create remarkable coherent and intelligent products? It culminated into this thesis, 5 years later.

Next to his job and his research, Guido loves to spent the remaining time with his family supporting his children in their many activities; cooking and travelling.