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PROBLEM FORMULATION AS A DISCURSIVE DESIGN ACTIVITY

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ABSTRACT
In the design methodology literature, design is often described as a rational problem solving process. This approach has been very successful; it has lead to the creation of design process models, tools, methods and techniques. Design methods teaching along these lines has become an indispensable part of any engineering design education. Yet the assumptions behind the rational problem solving approach to design do not sit well with some of the experiences we have in design teaching and design practice. Problem formulation is one such area where we might have to look for a different way to describe what is happening in design, beyond the problem solving approach. In this paper an extensive educational case study will be used to see whether a framework for describing design as a discursive activity (based on the notions of 'discourse' and 'paradox') could be more appropriate to describe the intricacies of problem formulation in design. Key notions in design methodology, like 'design problem', 'design solution' and 'ill-structuredness' are reconsidered in this light. This directly leads to identifying further lines for investigation, and an agenda for design research.

Keywords: Design paradox, problem formulation, discursive activity

1 INTRODUCTION
In design methodology literature, designing is generally seen as a rational problem solving process. Simon [1] captures this by describing a 'design problem' as an ill-structured problem, and designing as a special kind of problem solving. This special kind of problem solving is characterized by:

1. First analysis to define the problem, and thereafter synthesis to create an appropriate solution – followed by testing and evaluation.
2. An important part of the analysis is to transform the ill-structured 'design problem' into a one or more well-structured problems, where solutions can be determined by an algorithmic approach, i.e. applying a mechanizable (systematic) search technique and a predefined stopping criterion.
3. The designer is (or strives to be) a rational problem solver.

It is important to realise that much of our thinking about design is informed by this set of thoughts. And the way we think and talk about design in turn informs the way we teach design and engage in project supervision. Dorst [2] writes that understanding designing as a rational problem solving process, "*has become the normal 'language' of the thinking and talking about design.*"
However, in our professional practice as design teachers we experience that it is not always productive to view a student design team as a rational problem solver. We may need a different description or additional descriptions of design to capture those situations.
Let's begin by sketching such a situation from our educational experiences in which the limitations of the rational problem solving approach to design show up quite clearly. Each of the authors has more than 15 years of experience in teaching design and product development at university level. All of us have had the pleasure to supervise many large teams of design students, 6-10 students working in a design team, carrying through their design project based upon open problem descriptions. When working upon an open description of a problem it becomes an important task of the team members to clarify their understandings of the problem and reach consensus on a common and productive problem formulation, i.e. what aspects are important to take into account - and does the team believe it is possible to synthesise an attractive solution based on these priorities? This task of problem formulation is often very difficult because it is not easy to identify what is important on the basis of the scant information available at such an early stage of the design project, and it is doubly hard for

team members to reach a consensus on this. Often we as tutors are enrolled to comment upon a team's obtained clarification and consensus.
In these situations it is not appropriate to try and understand the design team as a rational problem solver. What we are dealing with here is the clash of the team members' conflicting understandings of what important aspects to take into account in the design project. These understandings are built upon their perceptions of what information is available to them, filtered through their own earlier experiences in design and in life, and the sets of expectations these students have of where a certain priority might lead them (and their own subjective judgement of whether they like that direction or not). This is very shaky territory from a rational problem solving point of view – not much rationality there – yet this process of problem formulation is an absolutely crucial part of the design activity! The decisions taken here will have overriding consequences for the whole design project and its potential outcomes.
Therefore, we ask ourselves from a research perspective: what mindset or thinking pattern could be introduced for a better understanding of these situations? And from a teaching perspective: how can we get beyond the paralysis that often accompanies these situations, what actions can we take as tutors?
In a recent paper Dorst [2] has proposed that it could be fruitful to describe designing as a discursive activity. In Dorst's model of designing the key-concepts are the 'design paradox' and the 'design discourse'. A 'design paradox' is the conflict between two possible and both seemingly well reasoned interpretations of a design situation. The paradox is that they both exist, so when a design paradox occurs the designer has to make a redefinition. Or rather, a translation in the direction of a synthesis – the designer cannot just choose another task. A 'design discourse' is a chain of statements about an issue, e.g. usability, cost or sustainability, which points towards or can be interpreted into a need, a goal, a requirement, a solution principle or an idea. The discourses are embodied in a design situation by the roles and value systems of the different actors involved. In this new model of designing, the 'design problem' is seen as a *paradoxical design situation*, where the designer is struggling with a number of conflicting discourses, and where he/she has to synthesise a solution that transcends or connects the discourses.
The idea in Dorts's description of design problems has similarities with Rittel & Webber's [3] description of planning problems as wicked problems. Rittel & Webber describe ten properties of wicked problems, but they do not discuss the characteristics of wicked problems. Dorst describes design problems in terms of two characteristics, viz. the 'design paradox' and 'design discourse'. In this paper we develop the idea a step further by proposing the content of the characteristics, i.e. examples of discourses from an empirical case study and a first typology of paradoxes.
The research challenge we see is to enhance and improve our understanding of the content and nature of design problems based on a view of designing as a discursive activity. With this paper we aim to start a discussion within the design research community, drawing it into thinking about design (and problem formulations in particular) in terms of design paradoxes and discourses. We will use empirical material from a first semester design project at the Technical University of Denmark to informally test the validity of the framework. From there we go into a more fundamental critical analysis, with the aim of identifying promising lines of further enquiry. The structure of the paper is as follows: in section 2 we present our empirical material and we formulate the research questions. In section 3 we use the empirical material to reflect on the nature of paradoxical design situations. We focus on three aspects: the description of a design problem formulation in terms of paradoxes and discourses, types of paradoxical design situations, and strategies to carry through the problem formulation activity. In section 4 we conclude the paper by identifying some lines of enquiry and sketching an agenda for future research.

2 A CASE STUDY OF PROBLEM FORMULATION

Our data material for this research is based on the design specification documents of 10 teams of novice designers. The novice designers are first semester undergraduate students of the Design & Innovation study program at Technical University of Denmark. The 10 design teams constitute the 2006 cohort. In their first semester design project the task was formulated as: "What if the fruit outdoor-market in centre of Copenhagen was to be improved? Can you design more attractive market spaces?" Thus, the design brief has an open formulation - a need is not identified and a design problem is not specified. Each design team is challenged to identify core needs and formulate a design problem.

In the first project phase the design team members collect information based on a socio-technical approach ([4], [5]), where the design team identifies a relevant actor-network and collects information from the actors. For human actors, e.g. the authorities of Copenhagen, interest groups, citizens and users, the information collection is based on observations of actors in action and interviews. For non-humans actors, e.g. legislative requirements with respect to fire safety, hygiene when selling fruit and general workplace regulations, the information collection is carried out by a discourse analysis of documents. Also, information about existing socio-technical solutions is collected. The idea with this socio-technical approach is in line with Krippendorff's idea [6] that the designer should develop a 'second-order understanding' of the artifact to be designed, i.e. an understanding of *how others understand* the artifact. The *others* are all the relevant human actors, which emerge during each student design team's identification of the actor-network.
In order to collect so much information from such diverse sources it is customary for each student design team to split up in smaller sub-groups, which each has its own task. For example one sub-group could have the task to contact the fire brigade regarding safety regulations, and another sub-group has the task to contact several sales persons at the fruit outdoor-market for interviews and observations of their daily work and routines. The outcome of the sub-groups' information collection activities are diverse understandings of the different actors' needs or goals, certain design possibilities, a view of the context, and a feeling for some of the limitations in the design situation. Thus, each sub-group has a certain ownership of information and may represent these actors, and each sub-group's insight may lead to certain discourses regarding the fruit outdoor-market. Based on these different insights and the challenge to design an attractive market space, satisfying the need for a fruit- and flower market, the design team has to articulate a project goal and formulate a set of relevant specification statements. Only then can the student design teams begin writing the design specification document. For many teams this is a frustrating process. The team members have to agree upon important goal elements to include into the design specification and imagine feasible solutions. Many teams make unsystematic experiments with different types of statements, e.g. criteria, open questions and comments to observations, and structuring principles of the design specification document. By the end of the writing process each design team hands in their design specification document to the teacher. The data for our research consists of the 10 design specification documents handed in.
We have studied the design specification documents in order to identify the different actors and their potential discourses comprehended by the student design teams. Then we have summed up actors and discourses, which have been identified by several student design teams. Thus, it is not a total summation of actors and discourses, but it is an indication of actors and discourses, which are relevant and important to take into account when designing an improved fruit outdoor-market, see table 1.

Table 1. Some important actors and their potential discourses.

Actor	Potential discourses
Lord mayor	A landmark of Copenhagen
Interest group	An integrated part of Copenhagen townscape
Food administration	Food hygiene level
Fire brigade	Fire safety and rescue
Customers	Easy shopping, shopping must be an experience
Sales persons	Good display of fruit, protected against theft, shelter for sales persons and fruit
Design team	We have to design an attractive market space

To design an improved fruit outdoor-market in Copenhagen the design team has to take the different actors' and their potential discourses into account and prioritize them. Thus, the design team has to answer the questions which actors and discourses are most important, and whether it is possible to synthesize an attractive solution based on this starting point.
Our experience as project supervisors tells us that it is *not a rational choice* for a design team to prioritize the different actors and their potential discourses. It is much more a matter of deliberation and negotiation between the design team members with respect to articulated discourses and ideas for solutions. This experience is in line with empirical research of Badke-Schaub & Gehrlicher [7], who have identified five patterns of decision-making behavior in design. Thus, we see the design team

members carrying through *a discursive activity* in order to clarify their understandings and reach consensus on the project goal and important specification statements.

2.1 Research questions

The "What if ...?"-formulation of the first semester design project is an open formulation, where a need is not identified and a problem is not specified. Thus, it is each design team's task to identify a need and formulate their problem. Our description indicates that a 'design problem' is not a static and objective entity. The 'design problem' is evolving during the design process – at least until the design team has created an attractive solution concept, i.e. a solution concept in which the team can commit itself to basing further design work on it. Thus, the early activities of the design process contain the design of a 'design problem' based on collection of information and preliminary explorations into the solution space.

We will now combine the empirical observations outlined above with Dorst's [2] model of designing seen as a discursive activity, and focus on the following research questions:

- Can design problem formulations be validly described in terms of paradoxes and discourses?
  - What (in these terms) is the origin of a design problem?
  - What (in these terms) could be the general content of different discourses?
- How can we identify types of paradoxical design situations?
- How does this description of design problem formulation link in with design strategies?
  - In which ways can a design team approach the design problem formulation activity?
  - How can a design team discussion around the key paradoxes be structured?

In the conclusion we will reflect upon our answers to the research questions, i.e. we will focus on the following two questions: is the description of design in these terms a fruitful one, i.e. does it lead us in new directions of inquiry, towards a greater insights into aspects of design? And does the description perhaps lead to new mindsets and methods?

3 THE PROBLEM FORMULATION AS A DISCURSIVE DESIGN ACTIVITY

In this section we will combine our empirical case study with Dorst's [2] model of designing as a discursive activity and confront it in a critical discussion with our three research questions.

3.1 The origin and content of a design problem

The authors of this paper see designing within the context of product development. When an industrial company launches a new product to the market the goal is to obtain a viable business. Asimow [8] writes, "*Engineering design is a purposeful activity directed toward the goal of fulfilling human needs, particularly those which can be met by the technological factors of our culture.*" Thus, the idea of a need is a first origin of a design problem, or in other words: the need can be seen as a capstan around which the design work is taking place. Asimow [8] concludes the first chapter with a list of principles, and some of these express his understanding of a need. According to Asimow a need is linked to individual human beings or the society, i.e. needs are subjective, and they do not have an objective and isolated existence. A design team therefore cannot interpret a need isolated from its origin, whether that is consumers, users, or the society at large.

In table 1 we showed important actors and their potential discourses related to the design of an improved fruit outdoor-market in Copenhagen. As we mentioned earlier a design discourse points towards or can be interpreted into a need, a goal, a requirement, a solution principle or an idea. The design team has to answer the question: what is a productive need formulation based on the discourses we believe are relevant and important? A productive need formulation opens the solution space for explorations, and constitutes a good starting point for the ideation. Following Asimow's line of thinking we observe that it is a non-trivial activity to identify a productive need formulation. It requires the design team's imagination and good insight into beliefs and values of the actors. The design team has to interpret the potential discourses into need statements, and thereafter to imagine feasible explorations into the solution space. In table 2 the potential discourses of the important actors are interpreted into need statements.

Table 2. An interpretation of potential discourses into need statements.

Actor	Potential discourses	Need statement
Lord mayor	A landmark of Copenhagen	Being recognized as a visionary political leader of Copenhagen
Interest group	An integrated part of Copenhagen townscape	Do not obstruct the existing Copenhagen townscape
Food administration	Food hygiene level	Avoid contamination of food commodities
Fire brigade	Fire safety and rescue	Avoid obstacles, which hinder access for fire engines or evacuation of persons
Customers	Easy shopping, shopping must be an experience	A marketplace, which is worth visiting
Sales persons	Good display of fruit, protected against theft, shelter for sales persons and fruit	A good marketplace, which attracts many customers
Design team	We have to design an attractive market space	Being acknowledged for creating the right design

Can a student design team identify a productive need formulation based on the need statements in table 2? The lord mayor's need "being recognized as a visionary political leader of Copenhagen" could point to a solution like "a *famous designer* creating a landmark of Copenhagen", which is non-productive for a student design team. However, for a student design team a productive need statement could be "A good marketplace for the sales persons and a marketplace which attracts many customers" because this formulation opens the solution space, and constitutes a good starting point for the ideation. Another productive need statement could be "Shop installations respecting the market culture and basic economic, hygiene, and work condition criteria." This formulation also opens the solution space, *but from another perspective.*

Dorst [2] states that many discourses may have to be taken into account in the creation of a solution. Hansen & Andreasen [9] propose the product idea model as an articulation of the origins of ideas in product development, see figure 1. According to this model a design team may in an initial paradoxical design situation find relevant discourses in at least the eight dimensions of a product idea. For a design team clarifying their paradoxical design situation the product idea model can be applied as a guideline or checklist, and the model frames the immense width of the design space.

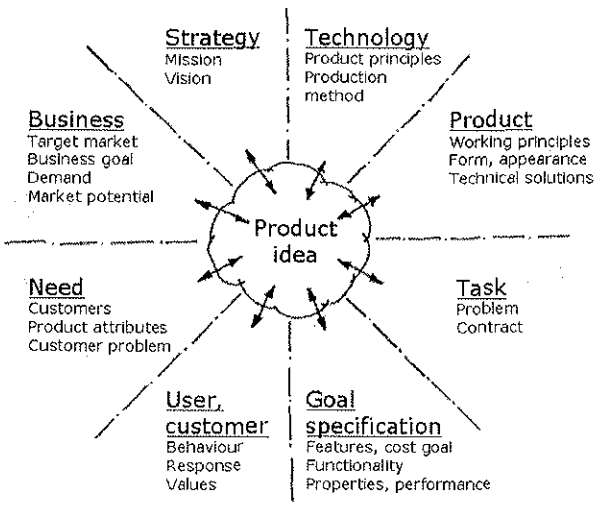

Figure 1. In an initial paradoxical design situation the design team may find relevant discourses in at least the eight dimensions of a product idea, Hansen & Andreasen [9].

Let us imagine a student design team working on the need statement "A good marketplace for the sales persons and a marketplace which attracts many customers". Their initial solution ideas could be: "a tent like design" which is easily erected and dismantled, "something disappearing in the ground at

night" to avoid transportation to a night storage, and "a lightweight market stall" because the existing stalls on the fruit outdoor-market are heavy to erect and dismantle for the sales persons, also the erection and dismantling is noisy for the neighbors. To unfold the design problem the student team has to consider the identified actors and their potential discourses and interpret the discourses into goals and requirements, e.g. the food administration's discourse "food hygiene level" could be interpreted into a requirement "easy to control food hygiene" and into a goal specification "cheap daily clean-up". The tutor might encourage the student design team to consider the business aspect, e.g. who shall build? And who shall be the owner? Thus, the student design team's paradoxical design situation can be mapped in the product idea model as shown in figure 2.

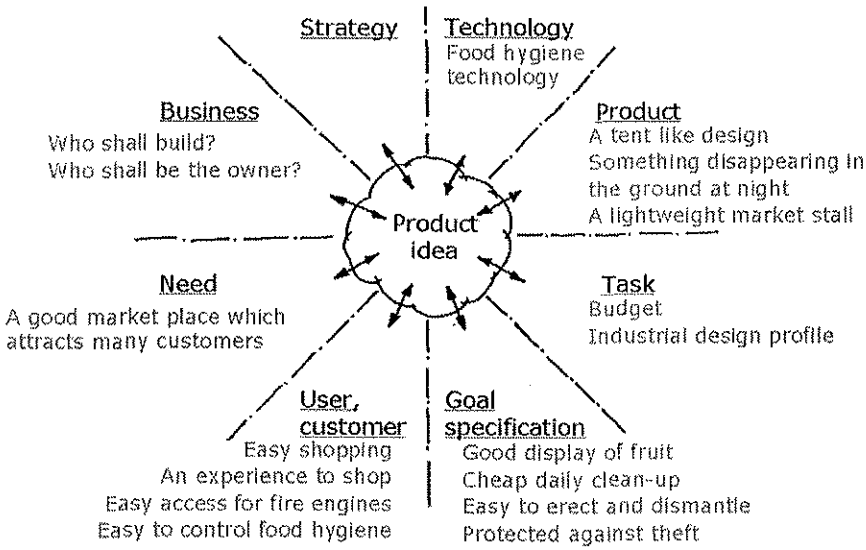

Figure 2. A paradoxical design situation for the solution idea "a tent like design".

Since we are using empirical material from first semester design students, we are observing design behavior of novice designers, i.e. designers lacking experience and constructive foresight. What could we imagine an experienced architect – a famous designer creating a landmark of Copenhagen – would do? First of all, he or she would probably not carry through a comprehensive information collection based on interviews and observations of daily practice on the fruit outdoor-market. The architect could apply a historical perspective on the development of the Copenhagen townscape, could argue for the raison d'être of the created solution concept with respect to activities taking place on a market, and combine it with a new and radical form, which challenges the conventional concept of an outdoor-market. What this famous designer brings to the problematic situation, apart from his or her superior experience in problem formulation and designing, is also the ability to formulate and defend a wholly different set of intentions that will guide the design effort. These intentions, and the ability to articulate a design that addresses these intentions, is what clients are looking for in a 'star' designer, and the lord mayor would probably argue that the choice of the famous designer is a result of visionary political leadership of Copenhagen.

3.2 Types of paradoxical design situations

The deceptively simple notion of paradox plays a central role in this descriptive framework. That is quite problematic: the notion of paradox is a very complex one, and its application in the design arena should be handled with care. Even the simple case study in this paper already gives rise to a need for deeper discussion. We can only validly use the word 'paradox' in the context of design when we have some closer idea of what we mean, i.e. through a typology of design situations.

A paradox occurs when different discourses cannot easily be resolved within the design solution – say, a direct opposition of the solution principle to satisfy an identified need and the relevant discourses of other actors involved. This is how we would describe a simple, *level 1 paradox*. For example, a market stall based on a tent like design might be a good solution for the sales persons, but many lightweight tents on a crowded marketplace could very well be a headache for the fire brigade: what about fire safety and rescue? How to get fast access for fire engines? And are escape routes open and easy to find in case of an evacuation? In this paradoxical design situation *trade-off* thinking is crucial. The fire

brigade's ideal solution is an open field, but an open field is not a meaningful solution for any other actor. This illustrates a simple *level 1 paradox* between a solution principle to satisfy sales persons' need and the discourse of the fire brigade.

Yet there can be different kinds of more complex paradoxes sparked by the variety of discourses that a designer has to synthesize into a design solution. This variety of discourses can become a source for paradoxes when different actors within the design problem as it is formulated at a specific point in the project actually seem to suggest completely different kinds of design solutions. These *level 2 paradoxes* can occur in single-designer situations, but they will be much more common within design teams. The different designers in the team are likely to bring a wider array of discourses to the table, or present varied subjective preferences within the common pool of relevant discourses. This is not a bad thing in itself (this 'richness' is actually one of the very reasons for working in design teams!). But it does mean that the design team has to reconcile these fundamental differences to a certain level in order to move forward. If they do not create a modicum of shared understanding, they will suffer from 'design team paralysis'. As design researchers and design educators, we have to make sure that we articulate this 'tuning' process explicitly, and point it out as a separate concern – perhaps even a separate stage within the design process. A failure to reach enough shared understanding will inevitably lead to conflicts later on in the design project, at a moment when designers have already in their mind committed to a certain way of viewing the design problem, and when precious resources (time and money) have been spent in developing solutions.

Let us imagine a student design team working on the need statement "A good marketplace for the sales persons and a marketplace which attracts many customers". During the information collection activities the team divides into 3 sub-groups, and the first sub-group is concerned with the food administration's legal requirements regarding food hygiene. The sub-group sees the access to water as being very important in order to keep the market stall clean and hygienic. However, the municipal authorities do not accept permanent installation of water to the marketplace. The second sub-group sees the potential in the idea of a tent design, because this is seen as easy to erect and dismantle, which is convenient for the sales persons. However, they have a concern regarding Danish weather conditions, i.e. is it possible to design a tent, which is robust against rain and wind? All the sub-group's ideas to improve the tent's robustness seem to result in a heavier solution, which is more difficult and noisy to handle morning and evening. The third sub-group sees a challenge in developing a new and radical innovation breaking the conventional concept of an outdoor market. In this paradoxical design situation we see three sub-groups each having ownership of certain discourses from different actors: the food administration, the municipal authorities, the sales persons, the Danish weather (a non-human actor which is taken into account), the people living around the marketplace, the lord mayor, etc. Also, each sub-group has some ideas, but it is not easy to imagine solutions which transcend the discourses. Now, let us see what happens when the three sub-groups meet and try to create a design problem and proposals for solution: any member of any sub-group who proposes an idea or a solution principle to the design team will be met by reservations, e.g. "but water is not allowed in permanent installations", "a tent design is not very innovative", or "too many shelves means much time for cleaning – and we have no easy access to water." The design team finds itself in a *level 2 paradox,* because the different actors within the design problem as is it formulated by the design team at this point seem to suggest completely different kind of design solutions. The team is paralyzed in action, and a 'tuning' process is needed. Here the reader might argue that the student design team is not in a *true* level 2 paradox, because our description shows that the design team's paradox can be broken down to three level 1 paradoxes. But this is not helpful for the team for at least two reasons. Firstly, the team does not have solutions for the simpler level 1 paradoxes. Secondly, it is not necessarily productive for the design team to point out a 'core paradox' and try to solve it. Even if the team succeeds in solving their core paradox, it might not be possible to modify or adjust the design solution to solve the two other paradoxes. And what, in these terms, is a 'design solution'? It is something "recognised as such in the context of all the relevant discourses (it should be acceptable by all the stakeholders)" [2]. This may seem a democratic principle, but it is not - it is a pragmatic observation: If the solution is not accepted by the stakeholders, who have decision power, the solution will not survive. Thus, the design team's communication with all relevant stakeholders about what has happened with their discourses during the design process is a matter of the utmost importance.

How to overcome the 'design team paralysis' is discussed in the next section on problem formulation strategies.

3.3 Strategies for problem formulation

By which strategies can a design team approach the problem formulation activity? Here it is important to notice that the 'discursive design activity' does not run from 'a problem' to 'a solution': the prioritizing of the requirements and discourses of the various actors doesn't just depend on their importance in the problem arena, but also on the potential impact they have on the design-to-be-developed. For example, it could be that the requirements of a major actor have little impact on the design activity, because they can be very easily accommodated within the design (or, alternatively, that they have little additional impact because they are so much in line with the discourses of the other actors). On the other hand, it could be that the requirements of a relatively minor important actor contribute to the pivotal paradoxes that are going to have to be leading in the design project. For the fruit market example a design team could view the sales persons as a major actor. However, to satisfy the sales persons' requirements is probably not very difficult; at least it is easy to find many, many existing solutions of displaying fruits and other types of food and creating shelter for persons, fruits and food by visiting supermarkets and shopping malls. The design team would then view the lord mayor as an actor of minor importance, and 'just' design a functionally improved market. However, taking on the lord majors' challenge to really create a new landmark for Copenhagen could lead to difficult and subtle design considerations on the current landmarks of Copenhagen, i.e. what characterizes Copenhagen as a townscape? (and what is a 'landmark'? New York is the Big Apple; Amsterdam has canals and Paris the Eiffel Tower - what different types of landmarks exist?). But what would be the risks involved in taking this ambitious route?

To take this matter of risk assessment into account, the process of problem formulation requires an amount of 'constructive foresight' into what might be problematic later on in the design project. This is a key area of design expertise, and one that has to be built up over years of design experience. Novice designers, lacking this experience and thus the ability to conjure up this constructive foresight, will have to do many design projects in order to build it up – mostly through first hand experience (in fact, trial and error). A major part of the studio conversations between design tutors and their students in the early phases of the design projects is about this kind of foresight, with the tutor demonstrating how this foresight can be used. This is a key design skill: only through developing and using this foresight will the young designer be able to handle design situations efficiently, avoiding dead-ends in the design space.

According to the rational problem solving paradigm, problem solving starts with an analysis to clarify the design problem, and the analysis is followed by a search for solutions. However, our case study and several other empirical studies make us question this understanding. Cross and Dorst [10], [11] emphasize the co-evolution of problem and solution spaces towards a matching pair, i.e. the designer's understanding of the problem and his/her ideas or solution proposals have to fit together. Kruger & Cross [12] report a protocol study of nine experienced designers performing a task individually in a laboratory setting. The experiments were conducted as 'think–aloud' studies, and the sessions were videotaped. Kruger & Cross use the protocols to identify four cognitive strategies, which they characterize as follows:

1. Problem driven design. The designer pays attention to careful reading the design assignment. The designer's focus is on understanding and defining the given problem.
2. Solution driven design. The designer quickly scans the assignment for basic requirements. The design problem remains ill defined, and on this basis the designer generates solutions.
3. Information driven design. The designer spends a lot of time reading the assignment and gathering information. The strategy while reading the design assignment is to look for pointers to other information sources.
4. Knowledge driven design. The designer carefully reads the design assignment, and compares it to his knowledge about similar problems. New aspects are explored through gathering information.

Although the cognitive strategies identified reflect an individual designer's way of working we assume that a design team can be either information or knowledge driven. Hansen & Andreasen [13] unfolds the cognitive strategies by the following line of thinking: If the design team is information driven we can ask: what can the team gather information about? The design team can gather information about the relevant actors' viewpoints and potential discourses and gather information about technological possibilities and existing socio-technical solutions. With respect to being knowledge driven a design team can work based on its knowledge about similar problems or the team can begin generating

solutions. By this argument Hansen & Andreasen unfold two dimensions in determining a design strategy: an information-knowledge axis, and a problem-solution axis, see figure 3.

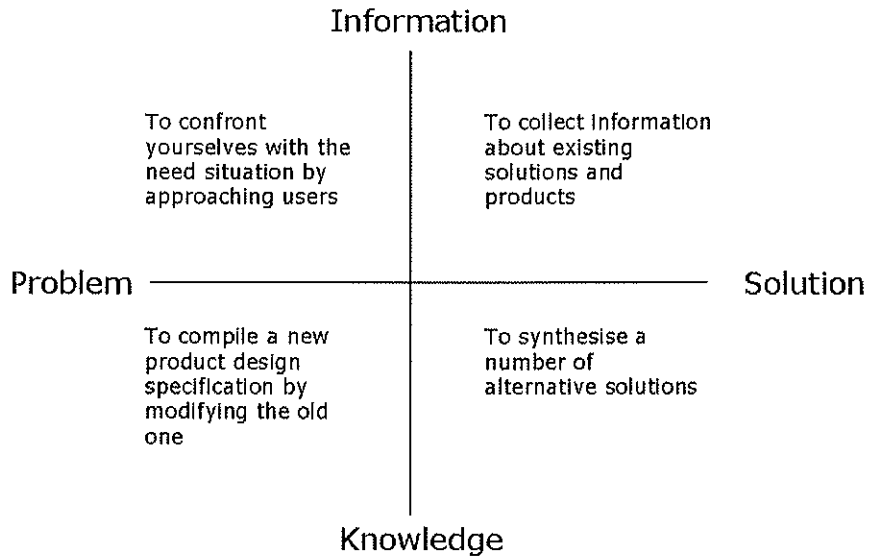

Figure 3. The two dimensions for a team to consider when deciding upon a design strategy, Hansen & Andreasen [11].

The two dimensions which are shown in figure 3 articulate four different generic activities in a design process. In design processes we will often find these activities carried out in an iterative pattern, and the design strategy question is: in which sequence shall we carry through the activities? Our first semester designers are novice designers, and they have to start working information-oriented. However, experienced designers might very well start exploring the solution space by sketching ideas and solution proposals. Also, to design a new variant of a product based on a revised product design specification requires that the designer knows the existing product and the argumentation of its design. Within an overall design strategy, i.e. a determined sequence to carry through the activities, a team can choose between several design methods and approaches depending which methods the team is familiar with and find suitable in the current situation. For example, if we focus on the Problem-Information quadrant we find at least three different approaches in the literature:

1. Analysis of a need. Thomas [14] states that there exist seven aspects of a need: four aspects relate to the *shape* of the need, and three relate to the *temporal* aspects. Thus, an analysis of a need can be based on exploring the seven aspects: subject of need, newness of need, complexity, clarity, frequency, duration, and urgency of need. Exploring these need aspects requires meticulous considerations regarding the subject of need, i.e. who are the relevant stakeholders.
2. Collecting information based on a socio-technical approach ([4], [5]). The team identifies a relevant actor-network and collects information from the actors by interviews, observation of actors in action, or discourse analysis of documents. This is the approach that our first semester students are using in their design project.
3. Playing design games with relevant stakeholders. Brandt & Messeter [15] write, "*The overall aim with our design games is to provide multiple stakeholders with means for developing, negotiating and expressing a shared understanding of users, use contexts and technology as part of concept design activities.*" Playing design games with relevant stakeholders will illuminate and priorities conflicting discourses based on the stakeholders' perspectives. For the outdoor-market a design game could be played with sales persons, food administration and fire brigade illuminate relevant discourses with respect to daily work routines and fulfillment of legislative requirements.

Empirical studies [16] suggest that experienced designers tend to gravitate towards design strategy 4 in the Kruger & Cross list. Their experience allows them to quickly scan and sniff out the 'core paradox' in a design situation, and use the discourses associated with that paradox to lead into the creative phase. All experienced designers within a comparative empirical study (involving 2nd years and 5th year students, and designers with a minimum of 5 years of experience) displayed this behavior, and almost all of them identified the same paradoxes – their approaches towards a solution then differed

considerably from that point on. The students (2nd and 5th years) that were challenged with the same design situation did not prioritize in this manner at all, and only gradually homed in on important issues in the problem arena, sometimes only realizing the 'sticking points' they should have tackled quite late into the process.
As mentioned in the previous section is 'design team paralysis' a critical obstacle in the problem formulation activity. How can we structure the design team discussion around the key paradoxes in a way that is clear, efficient and lead to a solid result that will stand the test of time later on in the project? The key issue here is that these discourses define the very concepts we use to think about a certain design problem, they are the deeper structures of our thinking and as such they will seem 'self-evident' to the thinker and be hard to access for critical appraisal and reflection. We just do not realize we have them. To access them requires a true 'proprioception of thought' [17]. However, in our practice as design tutors we have developed a few tricks that we can use to create a space needed for an open discussion. The tutor can ask every team member to write down their problem interpretation, and then explicitly discuss the differences. These are not easy discussions, yet there is some freedom in that they do not need to be completely resolved: conserving a difference in discourses and approaches would be a good thing, especially if this 'constructive conflict' is a result of different design team members' wish to design based on ambitious discourses and goals, and to avoid mediocre solutions. Yet one will only know further down the line how specific or open the design problem should have been.
If all of this fails, in cases of real deeper going conflict, there is a different kind of discussion that needs to happen. The team will have to concentrate on its own social process and assure the creation of bridges (or enlisting people that can build bridges) that will help all design team members to contribute to the solution. This is where help from the outside might be needed to moderate a free and fair discussion. In an educational situation, this is often a natural role for the design tutor – although of course the students should learn how to do this themselves.
The way paradoxes in the design-problem-at-hand are treated might differ greatly through the design process [18]. In the conceptual stage, designers tend to be searching for fresh perspectives that will lead ways of resolving the paradox completely. In later stages of the design process, after the choice of the basic design solution concept, this road is closed off – in choosing the concept the perspective is effectively set. From that moment (the 'concept freeze' or 'point of no return') on, all the remaining paradoxes have to be resolved within that perspective and framework. Pugh [19] introduces the concept of 'conceptual vulnerability' as, "*Conceptual vulnerability usually manifests itself in two ways: Either the chosen concept is weak due to a lack of thoroughness in conceptual approach, or the chosen concept is strong, but due to lack of thoroughness in conceptual approach the reasons for its strength are not known or understood*" and emphasizes the importance of selecting a strong concept. If a not-so-strong concept is selected the remaining design process might include the negotiation of very complex territory that sits between the relevant discourses, and the choice for design solutions that are sub-optimal from certain viewpoints. This is where design eventually includes the art of constructing unavoidable compromises or making trade-offs.

4 CONCLUSION

In this paper we have confronted Dorst's model of designing as a discursive activity with three critical questions of a basically practical nature (considering whether the framework is practically valid and useful). We have used the educational case study to show how this might work - connecting observations and our interpretive framework. The framework has withstood this treatment in the sense that we hope to have convinced the reader it does fit reality to a certain extent (it is valid and useful), and further it does highlight different aspects of design that have been hard to describe before (it is relevant, from the perspective of furthering our insights in design).
In section 3.1 we focused on our first research question: can design problem formulations be validly described in terms of paradoxes and discourses? Based on our empirical material we described the design of an improved fruit outdoor-market in Copenhagen in terms of paradox and discourse. We have emphasized the idea of a need as a first origin of a design problem, and we have proposed the product idea model applied as a guideline or checklist to identify actors and discourses, which have to be taken into account during the problem formulation activity.
Our foray into describing design as a discursive activity sparks many questions – in particular if we consider how elements of this descriptive framework fit the 'classic' notions of design methodology,

in particular those that are central to the rational problem solving paradigm. A line of thinking that needs to be urgently addressed deals with the notion of 'design problem'. We have worked here from the position (that has been argued before, [2]) that there is no simply definable design problem at the start of the design activity (yet how do we define/identify the "start"?). Because Cross & Dorst [10] argue that both the problem (whatever it is) and the solution are synthesized in parallel (in what they called a co-evolution), synthesizing the problem seems to be a mirroring of the solution. It could be that only when we know solution characteristics (as answers) we can derive design problem characteristics (as questions). This directly impacts our developing thoughts on discourses, as they might be more flexible than we have hitherto thought. The notion of 'constructive foresight' could be helpful in describing the process of developing a problem formulation, but doesn't address the issues around discourse stability and how to tell whether all relevant discourses have been identified – which are crucial ones, as the very nature of the paradoxes in a design situation depends on the clashing of all stable and relevant discourses!

In section 3.2 we focused on our second research question: how can we identify types of paradoxical design situations? We have identified two types of paradoxical design situations: a level 1 paradox and a level 2 paradox. The level of a design paradox indicates the complexity of the paradoxical design situation. Thus, it is relevant to compare a paradox's level with the notion of 'ill-structuredness', that we have more or less lost sight of in this paper. One could ask if the level or number of design paradoxes in a given situation would be the same as the degree of ill-structuredness of that situation. Or is the complexity of a design paradox, e.g. number of discourses, the same as or similar to the degree of ill-structuredness?

In section 3.3 we focus on our third research question: how does this description of design problem formulation link in with design strategies? Based on empirical studies ([10], [11], [12]) we argued that a design team can approach the problem formulation activity in different ways by considering two dimensions: an information-knowledge axis, and a problem-solution axis. We also linked a few design methods found in the literature to show that it is possible to link existing design methods to the idea of seeing design as a discursive activity.

If we go through the lessons from the case study, then we have learned that paradoxes can be resolved by: (1) a tuning process, (2) by utilizing "constructive conflict" (3) a keen awareness of the assumptions underlying the opinions people are expressing (a true 'proprioception of thought'), (4) by creating an open space outside all of the discourses, (5) by create bridges between the discourses, or if all else fails, by (6) constructing an unavoidable compromise or making a trade-off. This list is probably not exhaustive. The creation of a proper framework for describing these strategies requires many more empirical studies into design situations in education and practice. This could be the mergence of a major research agenda for the design research community.

Our research agenda is accompanied by an educational one. The ability to deal with many different discourses in design, to create ways of dealing with the different types of paradoxes and to develop constructive foresight to inform design strategic decisions should be a priority in design education. Thus there is a real priority in design schools to make sure that students do encounter many quite different design situations during their study, so that when they enter practice, they will have a broad enough repertoire of design situations and strategies to fall back on (recognizing a the design situation at hand as 'Oh, that is one of those – I know how to proceed now!'). Today, many design education curricula are built up by a narrow idea, basically always confronting their students with the same problematic design situation at ever increasing levels of technical complexity of the design-to-be-developed through the years of study. We propose that it is not only the technical complexity, which has to be considered. The *socio-technical complexity*, i.e. number of actors, types of actors (human and non-human), number of relevant discourses, and types of solutions, has to be increased through the years of study in a modern design curriculum.

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