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Framing an eclectic practice; Historical models and narratives of product design as professional work

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Acknowledgements

Preface

This thesis explores the theoretical traditions that have been proposed to give structure to and to critically reflect over product design practice. The field of design theory has provided a wealth of narratives on this practice, but as this thesis shows, the theory herein is eclectic, and the advices for practice are based on premises not always obvious. The thesis takes up the models, the common generalisations, and the positions that underlie these theories. In short, the thesis examines the many ways of framing design practice that can be found within this field.

If designers are to develop their practices, it requires a conscious use of abstractions and theoretical frameworks for inquiring into this practice and to further the knowledge in the field. It necessitates questioning how one documents professional experiences, and how one questions and critically examines different professional practices.

Contents

1 - Narratives and knowledge in product design

The investigation reported in this dissertation takes up narratives in design theory relevant to product design. Motivating this investigation was the observation that the literature in the design field comprises a variety of abstractions and models of design practice. Given that the literature holds a central role for inquiring into and reflecting over professional design work, the diversity indicated a general uncertainty towards the project of generating and documenting professional theories and knowledge for the product design profession; a methodical uncertainty which seemed to impact the capabilities of the profession itself.

Following WWII, the development of professional knowledge in the form of theories, textbooks and exemplars of best practice, has been regarded as a scientific project. The widespread ideal of a *research-based* practice has among its characteristics that theories which documents practices and aid practitioners in their work should be the outcome of methodical research efforts carried out in a rigorous, purposive, and informed manner.

For all its merits, this scientific image of professional knowledge often receives criticism as a limited perspective on the kind of knowledge practitioners draw from in their work. Issues that appear to be omitted are such as situatedness, the contingencies of practices, or the value of experience. In the design domain particularly, the fact that designers' professional jurisdiction spread widely, that the transfer of knowledge in the field rests with analogies between projects and products of different nature and contingencies, and that its canonical authors have drawn from a range of theoretical thinkers, renders the scientific accounts of professional knowledge here open to debate and contesting claims.

Due to such inherent challenges, several narratives have emerged as theoretical frameworks for how design practice should be understood, and how theoretical development in this field should take place. These narratives abstract design in different manners and draw on different theoretical premises.

1

The situation may require some consideration. For purposes of documenting and furthering knowledge in the field, i.e. design research, these narratives hold a central, yet obscure, role. As these narratives underlie the understanding of practice and aligns it with different sets of concepts and worldviews, they lay important frames for the understanding of this practice and the development of knowledge in this field. However, there seems to be little awareness over how, and to what extent the diversity lays trajectories for the development in the field. Commonly, the theoretical framing of inquiries in the design field is relegated to off-hand assumptions, and the competing schools of thought often resort to polemical writing against antagonist perspectives rather than regarding the different narratives as a repertoire of approaches for gaining insight on the profession and the challenges of professional work.

For the function of design research as a common field, the situation is problematic. It is obvious that the furthering of this profession's capabilities in the form of sound theories and other items is a necessary project. But it is also a project which requires the ability to inform oneself of the field's history, and to assess the situations, in a wide field, where different narratives have their valid and intended uses. The need for secondary and introductory literature to the field is therefore pressing; a way to understand the characteristics of different narratives, their limits and their potential.

1.1 Narratives in the product design literature

In a practical field as product design, the literature that supports design work holds a central, yet usually tacit position. The literature documents and communicates the "common professional wisdom" in the field in the form of theories and textbooks that guide professional work and document principles for good practice. It thereby serves an instrumental role of guiding practical work and providing exemplars and metaphors for this practice.

Throughout existing literature on design, one will find a great degree of diversity and eclecticism in the depictions and models of design practice (Buchanan 2004). Contributing to this state is both the fact that the product design profession, and design in general, reach quite widely in their claims for professional responsibility, subsuming a wide range of tasks related to making, and that design theory, due to historical reasons, has attracted the attention of scholars from a variety of academic backgrounds.

The many narratives, as the traditional ways of depicting design practice are here termed, assert different generic qualities to the design field. There is for instance a large tradition that sees 'design' as primarily a cognitive domain and employs cognitive science to further our understanding of the field; there is a tradition that sees design as a professional practice, drawing from pragmatist thinkers; and a tradition that sees design in the vein of artful creativity, drawing on aesthetics and art theory.

To exemplify this state of diversity, and the consequences for normative and practical guidance, one may consider the commonly used models of the *design process*; models that state how idea-generation takes place and develops into a fully fledged concept or product. Establishing a typical design process as a theoretical leitmotif has been a central issue in design theory. Since design is a varied practice, a common abstraction for how work typically is carried out is central for purposes such as organisation and general reflection. It requires, however, making a range of assumptions: identifying central elements and characteristics to the process, asserting how designers understand the problem, steps in the creative process, and typical challenges in this process.

For one, Ulrich & Eppinger's textbook Product Design and Development (2007), a state-of-the-art approach to product design and development, sees design as a managerial challenge, needing transparency and structure:

- The product design process is understood as a generic decision process with distinct phases ranging from the planning of the product to detailed design and physical embodiment of the solution.
- A design process is motivated by the perception of a market opportunity or need. From this onset, designers should establish target specifications for the product,

generate several product concepts in parallel, select concepts by formal ranking and scoring of the concepts and successively carry out the detailed design and embodiment.

- Throughout this process, designers must take care to identify and include aspects pertaining to success criteria as early as possible in the process, since the cost of changes to the product will increase at later stages in the process.

Together, Ulrich & Eppinger present a structured methodology for design. The rationale underlying this model is to make the decision process explicit, and to provide a methodology that may serve as a checklist in design processes (Ulrich and Eppinger 2007, p. 7). This requires that one is structuring the design process according to its phases, and that one is fairly meticulous in carrying out these phases.
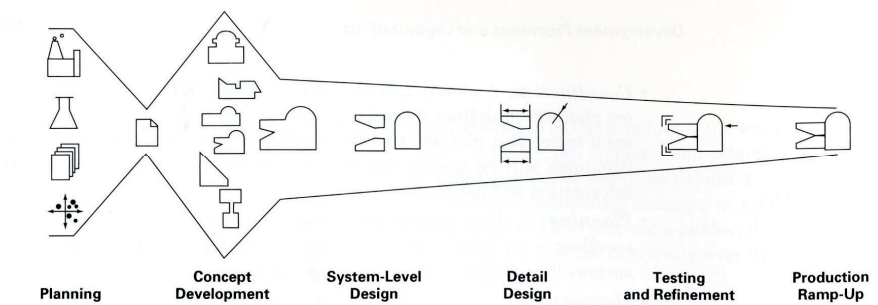
Figure 1.1 - Ulrich and Eppinger's generic design and development process. From Ulrich and Eppinger (1995)

Contrasting Ulrich and Eppinger's decision-process with Vincenti's model of design processes (Vincenti 1990), a different set of heuristic principles emerges. Here, the design process is understood as primarily social. It is suggested that design processes seldom are carried out in the structured way of the decision-making model. Instead, the view is that when designers are faced with a design problem, they need to differentiate between the problems they know how to handle, and the unknown problems that require trial-and-error. For familiar problems, designers will have fundamental design concepts, knowledge, theoretical tools, and rules-of-thumbs that can be employed more or less automatically. Unfamiliar problems however, require trial-and-error, more demanding in terms of resources and time:

- Vincenti holds that, in practice, design processes are organized based on the degree of unfamiliarity that the individual problems pose to the designer. Most problems will be trivial; the real challenge is to identify and solve the unknown ones.

- Decisions are not only rational judgements on how solutions fit with the specification. The knowledge that designers draw from is based in their practical experience and the professional community they belong to. The knowledge types range from rules-of-thumbs to scientific theories. The actual decision is therefore secondary to that of having an experienced professional and community involved in the design process.
- Understanding and abstracting typical problems is a crucial factor in professional design work, therefore, the way the professional community as a field develops solution strategies (professional knowledge) is important. Vincenti proposes that professional communities come up with metaphorical models that have enough precision to aid judgement, yet are sufficiently open to include a wide range of problems.

In general, the principled view of design processes in Vincenti's account is that these always will be complex and difficult to structure. The focus of the theory is the challenge involved in developing precise understandings of the issues they tackle in a process and the role of the professional community in this respect. Belonging to a community which holds sound and operative theories for the design problems encountered is seen as a more central issue than the organisation of the process in decision-phases.
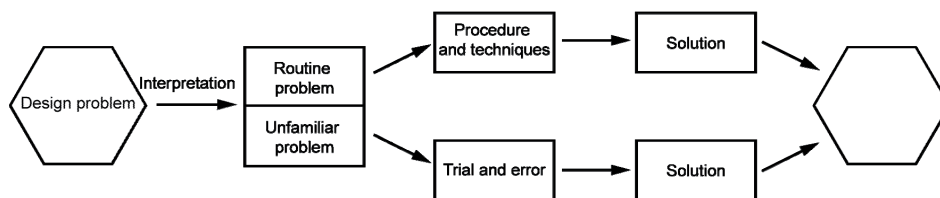
Figure 1.2 - Vincenti regards design as a two-tier process; differentiating between routine professional problems and unknown problems. Interpreted from Vincenti (1990)

Another alternative account is Schön's theories on *reflective practice* (1995); a pragmatist model of design work focusing on how designers develop their understanding of the design problem in the course of work. The understanding is seen to develop through interaction with clients and materials such as sketches and models, emphasising the didactical elements in professional work, as well as the value of practical experience.

- The design process is challenging first and foremost in that the designer has an initial and inadequate understanding of the design problems. The elaboration of

product concepts and solutions necessitate that the designer co-develop the problem-diagnosis and product solutions simultaneously.

- Throughout this process, the elaboration requires the use of materials and tools which are the natural elements of design practice, and with which the designer is acquainted, e.g. sketches and models. The interaction with these provokes new insights on the design problems, but in a tacit and automatic way.
- A design process takes place as a successive series of restructurings of the designer's initial understandings. The design process requires the testing and elaboration of designers' own preconceptions and lead to successively improved understandings and specifications of the product concept.

Under this view, design practice is challenging to explain and assess, as it relies on tacit knowledge and experience. Learning design is "learning by doing", and therefore a form of apprenticeship under the guidance of experienced professionals, where designers learn the common ways of understanding and thinking about professional problems. The model of design as reflective practice therefore emphasise reflection with the materials at hand in a process. It also argues that an openness towards different perspectives on the design problem, and a will, on the designer's part, to question own preconceptions, are central elements in good design practice.
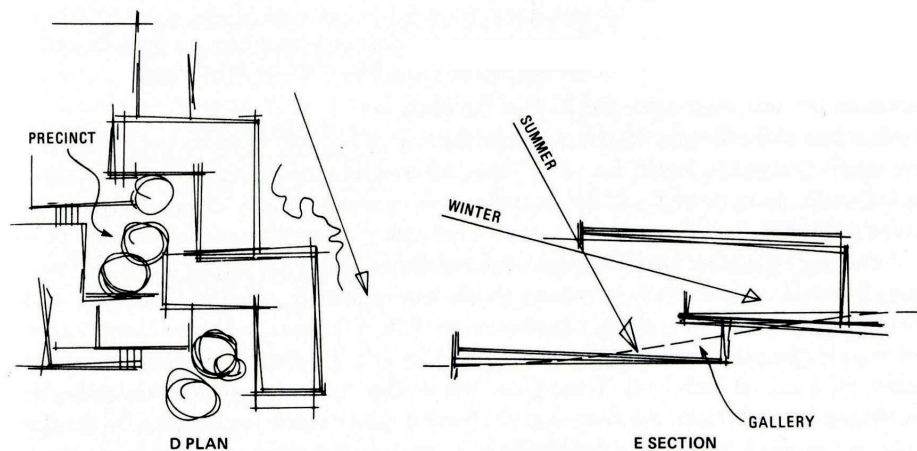
Figure 1.3 - Schön's didactic theories on professional practice were developed from protocol-studies where designers discussed their work over physical materials as sketches and models. Example of architectural sketch from Schön (1995)

More industrially focused, product design can also be regarded as essentially a collaborative process between different professional groups, such as with Integrated Product Development (Andreasen and Hein 1987). Here, designers are seen as holding a particular professional responsibility within an industrial organisation and a central managerial challenge is to facilitate the smooth collaboration with other departments within the organisation:

- An implicit norm for design processes is to aim for the inclusion of competencies and perspectives as early as possible in the design project. Since any given designer will have only a limited understanding of the many aspects relevant to the product, it is therefore important to include the perspectives of other professional groups holding an interest in and responsibility for the product.

- A central challenge with design processes is thus that different professionals have internalised different perspectives and preferences. The stakeholders in a design process will understand the product and its associated professional problems differently. Correspondingly, design processes are difficult in that they include problems of communication, in that the participants hold different *object worlds* (Bucciarelli 2003).

According to this perspective, design processes should be organised to facilitate cooperation between groups of professionals. The process must attend to different interests and kinds of seeing professional problems in such a way that cooperative design is encouraged.
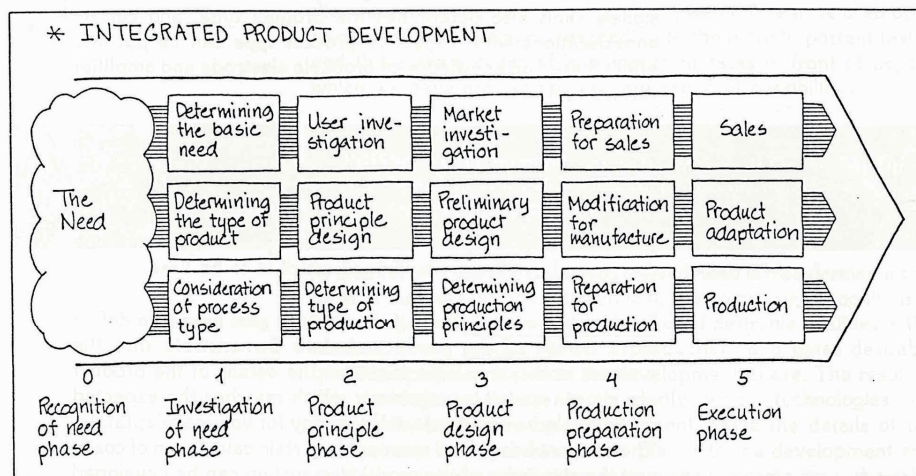
Figure 1.4 - Integrated product development sees design as a collaborative process. From Andreasen & Hein (1987)

The examples illustrate the diversity existing in the literature for product design: Central concepts and models differ, the diagnoses that underlie these accounts are different, the advices and heuristics they give are different; ergo: they will produce different results. Ulrich & Eppinger argue for a structured process. Vincenti, however, suggests that the design process is messy, and should be organized on basis of the knowledge-gaps that designers identify early in the process. The pragmatic model of Schön accentuates an issue with designer's use of models and materials, whereas the collaborative view sees design as a process of facilitation, taking place between many professional groups.

The advices that these accounts give for any concrete design process are quite different. Following Ulrich and Eppinger, one would hold that the design process should be carried out by the development of concepts in parallel and the formal evaluation of concepts. If one were to follow Vincenti, however, this would be a too bureaucratic approach. One should instead opt to identify and categorize the challenges that are familiar from those that are unfamiliar. The models of Schön, on the other hand, advocate experimentation and trial-and-error as the natural first step in any design process. And the collaborative models advocate an "open" approach to the design process, which seek to include other perspectives in an early stage of the process.

The diversity of narratives in the design literature point to a potential problem: Apparently, for nearly every normative position on how to organise and carry out a design process, one may locate an opposite position, basing its claims in a different diagnosis of design practice, providing different guidance. The "meta-understanding" of the literature's authors will shape the theories and models to such a degree that individual theories may appear contradictory on their advice and insight on design practice.

This suggests a modicum of scepticism when engaging with design theory. If different agendas can be grounded with different narratives, then what are the consequences for how theory and knowledge in the field develops? To what extent can one trust and believe individual accounts if "the common professional wisdom" of the profession can be construed to support a large range of theoretical positions and practical heuristics?

The question warrants a closer look at professional knowledge in design - i.e. how designers develop their ability for judgement and reflection for solving professional tasks, and the role of literature and research in this respect.

1.2 Design research and professional knowledge

As stated earlier, the design literature holds a central place in the development of professional knowledge for the design profession; it is from here design practitioners draw the larger theoretical and intellectual "wisdom" of the field; common principles for work and organisation and exemplars of best practice.

These concepts require some explication. Professional knowledge is here understood, quite simply, as the mental structures and entities that designers draw from when judging and reflecting in their work. The literature for design thus is seen as the systematic efforts at formalising and documenting good practices and principles to adhere to in practical design work.

The conventions and accepted methods for these systematic efforts raise larger questions pertaining to philosophy and science. For the purposes here, suffice to say that these efforts are commonly regarded as a scientific project. For design however, the scientific schema has been argued to raise some problems. Conceptually, the "problem" is that knowledge for designers cannot be regarded as a theory-base, in the form that cumulative science aims for, but rather as an eclectic field of various local, and situated practices; a situation leading to the narrative diversity existing.

In the following, it is argued that a central aspect of these narratives is that they comprise abstractions and models. This is significant because 'design' is a wide and eclectic field where abstractions can be expected to hold a particularly central role. Abstractions are central to make sense of this wide practice as they are pivotal elements in knowledge-transfer. This raises a question on the diversity of abstractions of design available in existing literature, and the possibility of assessing and successfully employing these abstractions to make sense of design practice.

1.2.1 Professional knowledge

Post 1950, the main strategy in the professions, has been to liken the theoretical domains of professions with the theoretical domains of science. A scientific ideal, where the development of professional knowledge has been likened to the development of scientific knowledge has been the dominant and influential schema for the documentation and formalisation of professional knowledge; effectively pursuing an ideal of *research-based* professionalism (Abbott 1988; MacDonald 1995). One of the effects of this ideal is that professional knowledge often is regarded as a form of applied science. By carrying out methodical research in an area of interest to the profession, the practical work can be carried out in a more certain and efficient manner. For instance, the profession of medicine has been regarded as the application of physiological

research. Engineering has been seen as an application of mathematics, and management has been seen as an application of social science.

Motivating this association between professions and science is both that professions gain access to rigorous methods for the examination and development of their intellectual structure, but also that the profession's intellectual content gains the authority and status associated with science, effectively defending the profession from interlopers (Abbott 1988).

The research ideal contains an important template for the development of literature for professional practice. To avoid myth and furthering of ill-founded practices, theoretical accounts should be purposive, methodical, informed and peer-reviewed. The development and dissemination of professional knowledge should take the form of a common project, where methodical conventions are adhered to, and scrutiny of others is encouraged.

However, the scientific image of professional knowledge has been generally criticised as alien to how professionals themselves understand their profession and its valuable knowledge. The scientific image risks missing out that professionals' knowledge is both different - it isn't necessarily explicit and expressible - and more flexible - in that it applies to a range of practical situations, with varying degrees of similarity between them.

Schön, for instance, pointed out at that professional knowledge could arise from experience and practice, and not necessarily as the application of scientific and laboratory studies (Schön 1995). Polanyi's theories on *tacit knowledge* express another concern; that humans in practical situations will know much more than they can state or verbalise (Polanyi 1964). The prime example is that riding a bike will entail more psychomotoric skill than one can possibly express. Similarly, accounts from the sociology of professions argue that while the intellectual structure, i.e. theories, models and metaphors, associated with professions often may appear scientific, they are socially contingent. They are based in a certain worldview and perspective, scientising, and objectifying the knowledge that is local to the communities of a profession. Their function, it is argued, is often to appear scientific (in the sense of objective and rigorous truths), whereas in reality, they promote a worldview inherent with a profession as a social group (Abbott 1988; MacDonald 1995).

In the design field, the relation between the scientific ethos and the realities of a highly practical domain are mirrored and possibly accentuated. The project of establishing formal and valid theories on design, i.e. design theory, has taken place within the frames of academic research, and thereby ascribe to the common research conventions for academic research in the same way that other professions have formalised their professional knowledge. Exemplified by journals such as Design

Studies and Design Issues, the research community seeks to document insights on design, exemplify methods and render them amenable to critique and improvement. Typically, such research is expected to follow the conventions expressed by Cross, which holds that research in this domain should be (Cross 1998):

- Purposive – based on the identification of an issue or problem worthy and capable of investigation
- Inquisitive – seeking to acquire new knowledge
- Informed – conducted from an awareness of previously related research
- Methodical – planned and carried out in a disciplined manner
- Communicable – generating and reporting results which are testable and accessible by others

In other words, design research aims for a cumulative science, where theories and insights build upon previous theories and insights. Knowledge in the field grows through individual inquiries carried out by researchers, academics and practitioners on areas of practice that are thought to be of central importance, or represent a particularly pressing challenge.

Central in this project is the necessary step of idealising and defining 'design' as a homogenous idealisation. Any scientific endeavour relies on a social agreement on how the subject issue is to be idealised and depicted; i.e. a principle of similarity across this field. This agreement identifies the characteristics that are general and provide coherency across individual instances in a field (Hendricks et al. 2000).

But looking beneath such surface descriptors of 'design' one will see that there is eclecticism and variance that extend beyond the idealised depictions one find in theory. For one, the 'design' field is wide in that it covers many kinds of practices, implying that the potential topics that fall under its jurisdiction go beyond singular domains and the disciplinary boundaries of science. Secondly, the profession of product design is practical, and not theory-based; deducing professional knowledge from first premises or a common agreed definition of the profession is unlikely. And thirdly, the design literature draws from a variety of practical and academic cultures, rendering the theoretical project of developing professional knowledge a cross-disciplinary endeavour.

Against this background, the emergence of theoretical diversity in the form of several narratives appears quite natural. The numerous accounts of design work have been put forth to answer the needs for knowledge and explanation, but they have been based in different historical perspectives and understandings of what design is and the ways in which it is challenging. The narratives suggest different conventions for the

common project of developing and furthering the professional knowledge in the design domain.

But even though these narratives are natural, the diversity of them presents a practical problem. The narratives have a central role in the development of professional theories. But as they may be employed to support a variety of stances, the situation requires awareness over the premises with them, and the ways in which they impact results and advices. They raise the question of how theoretical development in the design field takes place. The methodical principles by which professional knowledge can be arrived at are important for the development of design theory. Principled perspectives of how professional knowledge comes about will differentiate valid claims from non-valid ones, and underlie the authority and credibility of design theories.

The aspect of narratives in focus here is that they comprise abstractions - models and metaphors - which ground reflection on design practice. Both in practical situations, and in instances of more formal research, the abstractions within different narratives serve as ways of generalising and idealising design practice and thereby underlie how one understands and learns from concrete projects and instances of design work. In this way, the narratives in design theory lay trajectories for how one generally understands this profession as well as how design theory develops.

To further this perspective, the following sections argue that important characteristics to the theoretical fields associated with product design are that the theoretical structure of the field is not based in a theoretical domain but holds what may be termed a project structure; the empirical and historical reference for practitioners are the projects that designers accomplish and the products that designers make. These serve as exemplars for designers in professional work, and therefore constitute a central source for reflection and judgement. Such reflection requires, however, the attentive use of said abstractions. The main source for abstractions today is the field of design theory, and the question is raised whether the theoretical conventions today pose a problem in that abstractions are mostly implicit and tacit.

1.2.2 The "project-structure" of the product design field

Central to the intellectual structure of any profession is the jurisdiction of the profession; the tasks that normally fall under the purview of a practitioners, implying the role and responsibility that profession normally is expected to hold (Abbott 1988). The jurisdiction is the tacit background against which theoretical accounts are produced, so obvious it seldom requires stating, and providing the purpose and meaning against which theoretical accounts are written. The development of theories relies on a common understanding of roles and responsibilities, the central challenges, typical professional inferences, and typical challenges in this respect.

In product design however, the exact jurisdiction is somewhat uneasily located. As a profession, product design is concerned with the conceptualisation and making of products in an industrial context. Normally, this work takes place through projects carried out in cooperation with other professions, such as other kinds of engineers and designers, marketers, industrialists, and logisticians. The job requires the ability to solve professional problems across several domains; from the functional and aesthetical domains of product use to the technological domains of production.

Valtonen analysed the role of product designers in Finland and Scandinavia post WWII (Valtonen 2005). The examination shows that the profession has undergone changes both in terms self-perception as well as jurisdiction: In the 50's, designers were perceived as product creators, aesthetically trained innovators working in a workshop tradition. In the 60's the role was seen as a team member, where design was an element in the product development process. In the 70's designers were considered user-specialists, with a particular emphasis of ergonomics. The 80's saw an emphasis with management and the coordination of design work, whereas the 90's saw designers as creators of brands and experiences. Since 2000, according to the account, design has been intertwined with innovation, where the role of designers is seen as contribution on a strategic product level (figure 1.5).

The account provokes a question on what kind of knowledge designers draw from when engaging in professional tasks of such different natures. The range of issues in Valtonen's account points towards several larger formalised knowledge domains, each with their own scientific culture. Brands, experiences, and innovation draw from the marketing domain, cooperation draw from the management domain, ergonomics draw from physiology and cognitive science, whereas earlier accounts draw from a crafts-tradition. Additionally, there are domains not mentioned of obvious interest to the profession: ecology and sustainability, semantics; how products communicate, and aesthetics in general. The paradox is that if one were to expect that design theory developed knowledge in all these areas in the way that the scientific image postulates, i.e. as a scientific project that lent itself to subsequent practical application, it would appear as if the field of design theory would grow exceedingly large quite quickly. It would require years of empirical research, publication, peer-reviewing and similar activities over an enormous range of domains.

| 2000's Innovation & Competitiveness | 1980's Design Management | 1960's Involving Industry |
| 1990's Brand building | 1970's The rise of Ergonomics | 1950's Promoting the Nation |

| "global compeition & renewal" "the china-phenomena" | "total experience design - from concept to retail" | "our product portfolio is consistent" | "the user (be it a child or an elderly) is the most important" | "design as part of the industrial product development process" | "We got a prize in Milano!" | typical statement on design |

| vision | strategy | roadmaps | product definition | the entire product development process | product aesthetics "styling" | proximity to the market |

| design as a innovation driver | design for creating experiences for the customer | design as a coordinator | design for user understanding | design as part of a team together with mechanics and marketing | the designer as a creator | typical role for the designer |

Figure 1.5 - Six decades and six different roles for the designer. From (Valtonen 2005).

A way to make sense of this seeming conundrum is to hold that design theory, and the design field implicitly has assigned a central role for physical exemplars, and that this is a way in which the design field differs from the classical sciences. Designers draw knowledge from existing products and projects, inferring analogies relevant for one's own practice, thereby implicitly establishing structure and coherence across the design field.

Characteristically therefore, an important part of the knowledge by which designers ground judgements and decisions, does not reside with mastery of an empirical knowledge-base. The design field has what may be termed a *project structure* - concrete, physical instances of products and projects are the source for insights and normative guidance. And consequentially; a central element in the learning and dissemination of professional insight, is the ability to interpret and examine the projects that (loosely) fall in under the design domain. The theoretical reference for design practice is thus different from e.g. medicine, which can trace its empirical basis to scientific research on the body, or e.g. lawyers, who can trace their empirical basis to legal documents and jurisprudence.

In design theory, one will find indications that a tacit, but de facto function of design theory is to provide documentation and understanding of concrete products and projects, but this theoretical production is constrained against a social agreement on the kinds of

projects and products that fall within the boundaries of the 'design' domain. Theories in the design domain are normally argued to hold value and relevance across the field, but they extensively make reference to existing products and projects in a significant way. Thus, the design field is pragmatically constrained and defined as "the projects that designers do, and the products that designers make". Cross for instance, implicitly references designer's projects in a classical taxonomy of design research (Cross 1999):

- The study of designer behaviour, including theoretical deliberation and reflection on the nature of design ability.
- The study of the processes of design, and the development and application of techniques, which aid the designer
- The Study of the form and configuration of artefacts, which is recently complemented with studies on the design of services and systems.

Since the design field holds a project structure, the traditional learning in the field deviates from the scientific image. The learning of design practice does not take the form of gaining familiarity with a knowledge-base, but rely on "studio teaching". Historically, the model for product design education has taken the form of project learning (Findeli 2001): Normal educational practice is to train designers in the simulated environment of the studio. Here, designers are trained in structuring and carrying out practical professional problems, addressing and resolving issues pertaining to both the cultural and technological domain. This suggests that an important element in the development of professional knowledge is transfer, i.e. the ability to derive insights from one domain and reapply it in another one.

Design professions in this way precede the current academic focus on project- and problem-based learning (PBL). Although the product design profession has a fairly brief history, related disciplines such as architecture have traditions for project learning dating back to the renaissance. In the architecture education that was established at Accademia di San Luca, Rome, 1577, The term project (progetti) was used for assignments where the students were to carry out imagined design projects; a kind of learning that involved skills, the relevant knowledge, and particularly, the reapplication of these skills and insights in concrete design projects (Pettersen 2005).The model of project learning extends to engineering as well. The renaissance engineers were originally trained as an artist in the same vein as architects, before the eventual professionalization in the 1700's led to the current scientific emphasis (Picon 2004).

But learning and reflection in a field with project structure is a complex endeavour. The risks for misconception and construal of projects are obvious. Real-life projects and products will extensively vary. With every design project there will be contingencies; different premises and success factors. There are differences in complexity; product

designer's responsibilities vary from the making of simple products to partaking in large industrial projects. There are also differences in the contexts with which design takes place; contexts which in practice will decide much of the role and responsibility of designers in a concrete project.

1.2.3 Knowledge-transfer in design; the role of abstractions

Since design teaching cannot be broken down to discursive learning in a theoretical domain alone, it suggests a more eclectic or anarchic depiction of the way in which the more general professional knowledge in the field develops. Designers draw important experiences from a range of products and projects, invariably drawing analogies in new and often surprising ways.

A didactic model for the kind of education and reflection which takes place in the design field, where knowledge is acquired in one context for the purpose of reapplication in another context, is *transfer of learning*, which is sometimes also referred to as transfer of knowledge. Transfer of learning occurs when "learning in one context enhances a related performance in another context". It implies that one draws insight from one domain and reapplies that knowledge in another domain. It relies on the student being able to identify some form of similarity between the two contexts, implying that knowledge is mapped across contexts that are in some way similar, but not identical.

This general model from pedagogics, states that transfer occurs by means of two roads, the low road and the high road (Salomon and Perkins 1989): Low-road transfer occurs by the automatic triggering of well-learned behaviour in a new context, whereas high-road transfer occurs by intentional mindful abstraction of something from one context and the application in a new context.

For design, transfer by low-road can be likened to the learning of skills, e.g. sketching, that can be reused in successively new design projects. Transfer by way of the high road however, addresses the meta-cognitive understanding of design work. When solving a problem in one domain, the student has abstracted a solution structure in another domain that allow for solving the problem in the new domain. Thus:

> *…abstraction involves the extraction from or identification in a learned unit of material, in a situation or in a behaviour, some generic or basic qualities, attributes, or patterns of elements… Abstraction thus involves both decontextualisation and rerepresentation of the decontextualised information in a new, more general form, subsuming other cases. Abstractions, therefore, have the form of a rule, principle, label, schematic pattern, prototype, or category (Salomon and Perkins 1989, p. 125).*

Thus, central elements in the "production" of knowledge in the design field are the abstractions which decide general features and characteristics across the variety of products and projects in the field. Both for the purposes of understanding the broad field of design, and for making sense of learning, there must be abstractions which allow for the extraction of general, prototypical features, so that insights can be identified and reapplied in new contexts.

The abstractions comprised in the narratives of design theory may influence our understanding in many ways, yet still appear as a tacit, or self-evident, component. Their influence upon research and the general understanding in design may arguably extend to several areas:

- Abstractions are common ways of generalising design work. They thereby underlie much general discourse and a common understanding of design practice. They provide generalisations, basic categories and concepts that are taken up and used also in more general design discourse.
- For research, the concepts that are inherent in different abstractions serve as parameters and invariants in research. They provide the elements by which design practice is observed and thereby understood
- For education, the abstractions have a role as mindful abstractions. They are a principled constructs that are used by designers in the transfer of knowledge across design situations, or design projects. They thereby provide general frameworks by which design practice may be understood and reflected upon in everyday situations.

The argument emerging from this account is that abstractions have a significant impact on how theories and knowledge in the field develops. They are pivotal elements for making sense of this practice. But because the field of design is only loosely constrained, the development of theories and knowledge requires precise and extensive abilities for abstraction and generalisation, to avoid the obvious danger of dilettantism.

1.2.4 Abstractions in design theory

The question is thereby which abstractions that are commonly used to make sense of design practice, and where to turn to identify common abstractions. The main source for abstractions of design work appears to be design theory. One will here find examples of abstractions comprised in the many narratives. These are different principled ways of regarding designers' work, and the elements considered important in this respect. For example, if design researchers choose, as basis for inquiries, to explain aspects of design in terms of Schön's framework of reflective practice (Schön 1995), the principled abstraction of design practice is that this practice is about interpreting,

interacting and seeking an understanding of the design problem. Correspondingly, the process is explained through concepts such as *frames*, *problem setting, generative metaphors* and similar. If, on the other hand, one chooses a systematic decision-making framework (Simon 1996), design practice is understood in behaviourist terms. It is abstracted as a goal-oriented process of decision-making, and the terms and concepts of this program are such as the *problem-space*, *heuristics*, *structure*, *decomposition*, *evaluation*, and *goals*.

But the abstractions of design within design theory are, in line with normal research practices, mostly tacit. In the history of design theory, various abstractions of design practice have been asserted in different ways: The teachings of Bauhaus, from which product design draws much of its rationale, saw design responsibility as adherences to a particular *aesthetic program* (Findeli 2001; Heskett 1980); i.e. as form giving, in a way informed of modern production processes. Another example is the systematic efforts of the design methods movement, drawing on artificial intelligence and formal logic (Jones 1970). These efforts led to eventual proposals that an ability for *modelling* was the uniting feature of design work (Archer 1979). The critical theory of the 70's saw a focus on designers as *agents for the user* (Papanek 1971; Rittel and Webber 1973), implying a focus on user participation in design processes. The 80's saw a focus on management principles of *collaboration* for purposes of organisation (Andreasen and Hein 1987). And recent theories now propose that the similarity across the design field rest with "design thinking", arguing that a certain set of *attitudes* towards the design process and the user is the uniting feature of this field (Brown 2008).

A cross-sectional look at any journal or textbook confirms the large array of abstractions in the design field: In addition to the aforementioned examples, there exists a range of alternative views, such as design as a hermeneutic process (Coyne and Snodgrass 1992), design as hypothesis-testing (Woods 1998), design as participation and facilitation (Sanoff 2007), design as a special capacity for visual reasoning (Oxman 2002), design as a business process (Hölttä and Otto 2005), and several others.

These abstractions define design practice differently. But they also draw from different theoretical works, effectively aligning and positioning design within several different theoretical disciplines and boundaries. But as stated, they rest with an analogy, and a presumption that design practice should be abstracted in such and such manner. They rest with the author making an analogy between their own theoretical models and the eclectic practical field of design. Drawing such analogies is conceptually demanding. In a subject domain, design, which reaches wide, subsuming aspects that historically have been construed to be cognitive, social, pragmatic, aesthetic, technical, and several others, require considerable abilities for multi-disciplinary thinking. Authors must decide concepts, generalisations, assumptions, principles, common

responsibilities, common tasks, common challenges, presume skills, presume the industrial structure designers work within to mention a few. Understanding aspects of use, understanding aesthetics, establishing sound principles for management and organisation, alignment and cooperation with other practitioners, documenting good practices in all these areas, and so on, are drivers towards a facetted set of narratives in design theory.

In summary, the observation here is that for historical reasons, design theory provides a wealth of theoretical perspectives, i.e. narratives, on design. These are caused by fundamental challenges in the endeavour of establishing and furthering theory for the design fields. But it is a situation which requires a steady hand and deep theoretical knowledge if one is to draw on the history of the field and assess the available repertoire for one's own purposes. The situation can be summed up.

- The focus of the design professions spread quite widely, in that its jurisdiction has changed fleetingly over the years.
- The theory for the field has a project structure. Theory will rely on an inferred analogy between the projects and processes considered relevant to the design domain.
- Many narratives exist. They provide different perspectives and abstractions on design practice. Demanding awareness from researchers on theoretical premises and traditions if the historic field is drawn from or if one's methodical repertoire is to be assessed.

1.3 Problem statement

The question is what this theoretical diversity practically implies for the development of theory and thereby how it relates to knowledge generation in the field of product design.

If one assumes that the growth of knowledge in design field develops by way of individual inquiries on issues of relevance to professional work, then a challenge is that the researchers (and sometimes practitioners) who carry out this research must navigate and make sense of an enormous range of narrative traditions with correspondingly different perspectives on design practice. Researchers must navigate these traditions either to learn from previous research or assess the theoretical and methodical repertoire available to them as researchers.

Characteristically, design research is different from a classic conception of research, in that it usually is problem-based. Whereas classical research can be understood as departing from a theoretical field, finding instances of concrete usage, design theory often is motivated by a concrete problem associated with the profession (e.g. problems of choice, ways of framing professional problems). Since these issues potentially reach widely, the implication is that design research requires a form of cross-disciplinary orientation which established academic disciplines seldom require. Researchers must navigate a wide scope of narrative traditions to seek out explanations and hypotheses to their problems. The situation can be illustrated (figure 1.6).

Design research;problem based

| Narrative | Theory Methods | Models Abstractions | Analysis | Real life Problem |

"Classic" research; disciplinary based

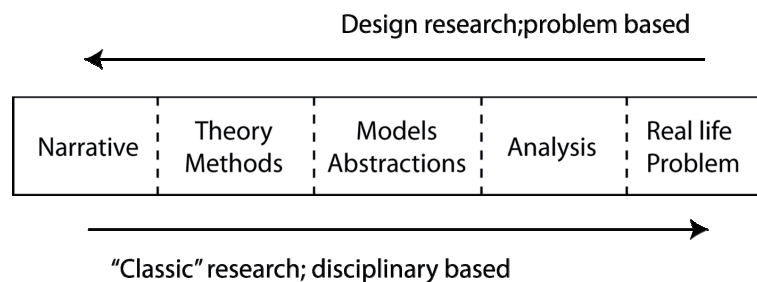**Figure 1.6 - Typical chain of consideration in problem exploration in design research**

However, there are indications that the ability for cross-disciplinary reflection of this kind is hampered. Commonly, narratives appear simply to be inherited; i.e. furthered as a, or the, idealisation underpinning design as a field of inquiry, reducing reflection over the framing of practice to an off-hand assumption:

- The way design practice and projects are abstracted is usually a position that is tacit and implicit with authors. Given that design theory is a practical and applied domain, effort is seldom put into critical reflection over the theoretical perspectives. It appears to be common practice to align one's research with a greater research program, in the form of a brief mention of e.g. cognitive science or management science, before getting down to the "real" research. Simple assertions in the openings of textbooks and papers, such as "design is now generally accepted to be problem-solving", or "design is a reflective practice", hide an underbelly of stances, definitions, assumptions, and historical references. Many of these are by themselves problematic, and could be taken up for critical scrutiny on their own merit. Correspondingly, there is little reflection on the limitations that are inherent with these programs.

- In the cases where design researchers have been engaged in discourse on fundamental stances, these discourses seldom focus on the situations for which different perspectives are valuable and appropriate or what different perspectives really say. Rather, the discourses take place as fundamental disputes between rival camps akin to Kuhn's descriptions of paradigm clashes. Surprisingly often, authors purport instead to hold an essential definition of what design is, and how it should be understood as an object of study. For example, the pragmatic theories of Schön (1995), are often used to argue against classical cognitive design theories. But Schön's theories on reflective practice are susceptible to the criticism, for instance, that it makes use of mentalist, unobservable concepts (Stumpf and McDonnell 2002). The social models can be argued to black-box decision-situations by introducing relativism, managerial models are argued to be too coarse and so on. It seems that counterarguments can be raised against nearly all narratives in design theory, depending on one's perspective.

It is plausible that improved understanding of the narratives in design theory is warranted and beneficial; the abstractions within them, characteristics, limitations, as well as historical knowledge of how they have contributed to design theory. Improved knowledge in this area could have the potential to facilitate improved design research and reflection in several ways:

- For research, knowledge of narrative traditions implies improved ability to look beyond one's received perspective, when formulating hypotheses and theorising design practice. The current discourse often seems to favour particular "schools of thought" rather than regarding design theory as a broad set of methodological perspectives with fair uses given awareness of premises. Thus, one may risk carrying out research in parallel, unaware of previous and relevant research

- For education, knowledge on the different narrative traditions provide the ability to explain a facetted practice from several principled perspectives. A broad, general understanding of narratives and abstractions in design theory should be both beneficial and necessary when design students attempt to transfer insights in a studio learning environment.
- For the general discourse, awareness on narrative traditions may serve as qualifiers when reading and appropriating research findings and theory. Understanding the premises underlying research as well as the traditions inherent with them will facilitate the critical appropriation of findings in one's own practice as well as improve the ability to read and interpret this material.

Therefore, the aim that motivates the investigation in this dissertation is to take stock of existing narratives, and examine how different abstractions that are common with the narratives in design theory may be employed as a repertoire or as a "toolbox" of approaches, rather than as dogmatic depictions of what design "is". The purpose is a cross-sectional look at the common ways of framing product design practice and an improved understanding of how such narratives lay trajectories for our understanding of the practice and its challenges. The general questions that have motivated this inquiry are:

1. *How do different narrative traditions abstract design practice?*
2. *What trajectories do these abstractions lay for the development of professional knowledge in the design field?*

The research goal raises some tough questions of methodology: How can one compare ontologically different worldviews and research traditions? How can such traditions be analysed and presented in a structured and comprehensive way? Chapter 2 elaborates and discusses these questions, and presents the more detailed research questions that are pursued in the thesis.

1.4 Reader's guide and outline

The thesis is written for those who have a professional or personal interest in product design and its theoretical tradition. It presumes the reader has some prior knowledge of design theory and the discourses in this domain. The thesis makes use of general concepts and models from the philosophy of science to establish theoretical perspective and discuss design theory. These concepts are explained and exemplified in some detail.

For readers, this might be perceived as an uneven read. Some claims appear obvious, whereas others would warrant more argument. Such problems of breadth versus depth are inevitably general challenges with cross-disciplinary research. Design theory draws from several scientific and philosophical disciplines, with the unfortunate consequence that many fundamental discourses; for example that between constructivist and empiricist perspectives on design, are only superficially treated.

The text is organized in the following way:

Chapter 2 contextualises this research. It presents the assumptions and definitions underlying the investigation in the thesis, and the background understanding of 'product design', 'design' and 'design research' that motivated this research. The theoretical perspective, research questions and methodology are subsequently presented.

Chapter 3 elaborates the context and theoretical background of six models of professional reasoning which were identified. Chapter 4 is an exemplary exposition of the conceptual structure with three of the models. Chapter 5 takes up the challenges of assuming correspondence between models and real-life practice, and exemplifies how the discourse in design theory can be used to qualify the use of ideal models in concrete instances of research on design. Chapter 6 sums up the findings, derives the transfer-models implied with the different narrative traditions, and discusses how these can be used for theoretical triangulation in design research. Chapter 7 concludes the thesis, discusses the methods used and suggests further work.

2 - Background, perspective and methods

The investigation in this thesis takes up a broad issue pertaining to product design as a profession and the intellectual practices common with this profession. With the goal of identifying narratives relevant to product design and ways in which these influence the development of theory in the field, this chapter presents the theoretical framework and understanding which have guided the investigation, before presenting the research questions and the methods employed.

In the following, the section *motivation* and *assumptions* presents the personal understanding and outlook underlying this thesis. *Definitions* presents the operative understanding of key concepts. The *background* section presents the initial understanding and diagnosis that were the outset for this thesis. As *theoretical perspective*, the semantic view of theories is presented and argued. The *research question* narrows the field to the ideal models underlying the narratives in design theory. The *methods* section presents the detailed account of the methods followed and discusses these methods.

2.1 Motivation and assumptions

The investigation reported in this dissertation addresses central issues pertaining to theoretical description, inquiry and practice in the design field. The initial, professional problems that led to an interest in narratives and theoretical tradition are presented, displaying the personal motivation and argument for the investigation. The assumptions on the relation between these concepts are also stated.

2.1.1 Practical motivation

The focus of this thesis may appear unusually theoretical for a practical and applied subject as product design. It should therefore be noted that this focus emerged from a practical problem in an industrial context. Originally, this work grew out of an applied research project (Hovde 2005), where the purpose of the project was to increase the

knowledge about, and the ability for, design and development in Norwegian wood and timber industries.

The wood industry was largely unfamiliar with product design. Traditionally, the industry is traditionally concerned with bulk production of timber, and few resources are allotted to design and development activities. Production methods and business models have remained the same, in principle, for a long time. This differentiates the Norwegian wood industries from many European counterparts, where both a proportionally larger element of hardwood as well as a more developed industrial systems have contributed to a larger focus on innovation.

The design and development initiatives that could be observed in the national industry were often ad-hoc and incremental innovations. Few companies kept any formal design and development departments or competencies in-house. In those companies that did have design and development projects going, these were carried out, or led, by senior management.

In the projects where designers were engaged as consultants or in other capacities, cultural problems often arose. For instance, when product concepts were proposed, these often led to disputes. Different understandings of design and the boundaries to this activity led to disagreements over how the process should be organised and carried out. Often, professionals in the wood industry and designers would hold different conceptions of e.g. the technology that was feasible to make use of, the room for radical innovation, the understanding of markets, and the industrial requirements of mass production.

Attempts to bridge the gap between the cultures of wood-processing and the cultures of product design proved difficult. In general, designers complained over a conservative and stubborn industry, while the industry complained over lack of competence and unrealistic proposals with product designers. The problems were usually "soft" in the sense that they concerned trust, credibility, or authority. Typically: How to negotiate and implement different ways of understanding business and business practices; how to frame and understand the activities and purposes of businesses, and how to implement changes to existing practices.

When engaged in such projects, it was difficult to arrive at a common understanding on and framing of design and development processes. While most people would agree on the importance of developing one's product portfolio, it was difficult to agree on the framing and organisation of such initiatives. It was difficult to gain acceptance for allocating resources to activities that could support design work, such as analysis, workshops, production of mock-ups, not to mention more demanding long-term efforts.

Judging from the literature on design, such problems are well-known to the product design field, and not restricted to the particular industry here. The more general problem seemed to be about the description of reality. How was it that professionals saw purposes and necessary tasks so differently? This led to an interest in the models that were used to describe design; the models that are the basis for the understanding and organisation of design as a professional practice.

This insight eventually led to a shift in focus, from industry practices to product design theory itself. There seemed to be a need to examine the models and theories that grounded designers' understanding of their roles and responsibilities in design projects. What were the models and theories of business practices that designers "brought to the table"? What were the characteristics of these models? How did they influence design work, and for which situations were they useful and applicable?

Such questions are central in many of the cultural problems that crop up when designers are engaged in industries unfamiliar with design practices. Models and metaphors are central elements in how designers understand their practice and also underlie the strategies that designers follow when engaged in projects. Design theory therefore emerged as the place to look for models and theories that could describe design practice at different levels of detail and precision. Such knowledge could be of practical benefit, because it could, potentially, expand the repertoire by which design is understood and explained also in practical and applied contexts.

2.1.2 Assumptions

The didactical role of design theory

The interest in narrative traditions here is primarily a didactical one. It is assumed that design theory constrains understanding of and reflection over product design practice in several ways. Different narrative traditions will underlie reflection and inquiry, and in this way shape professional knowledge in ways that differ from each other significantly. The main focus is the referential aspects of these narrative traditions; i.e. how they depict and model design practice. Aspects such as the affective properties or the metaphysical status of these traditions are not considered.

Design theory as a scientific field

Design theory is here considered to be a scientific field. Design theory shares many characteristics with scientific discourses in that it is governed by the same principles as these discourses: It is carried out as a common project for the development of knowledge in a domain. Inquiries must be carried out in a methodically sound and accepted manner. There exists a community of researchers holding interest and responsibility for the literature, and lastly, there are institutions (universities, schools, industries) which partake in upholding and maintaining the field. The main consequence

of this assumption is that design theory can be read and analysed by the same theoretical perspectives that are used to analyse scientific theories, since it is subject to the same institutional conventions as scientific theories.

Constructivist outlook

To critically analyse and compare the traditions in design theory, the thesis is written from a constructivist paradigm. As a general perspective on research and science, constructivism emphasizes the historicity, the context-dependence and socio-linguistically constituted character of these efforts. Constructivists hold that realities are apprehendable in the form of multiple mental constructions, socially and experientially based, local and specific in nature, although often shared among many individuals (Guba and Lincoln 1994, p. 110). In this perspective knowledge, including scientific knowledge, is constructed by researchers and not discovered from the world. 'The investigator and the object of investigation are assumed to be interactively linked so that the 'findings' are *literally created* as the investigation proceeds' (p.111).

It is assumed that the narrative traditions in design theory ascribe to such different metaphysical and modal positions when describing and examining the design practice. The differences between individual traditions are here understood as primarily a difference in perspective, as individual traditions assume different concepts, elements and relations when describing design, and that the difference is not a difference in truth or correctness.

This is not the same as assuming that all theoretical explanations of design are equally good and valid. It is merely a statement that the "correctness" or the "truth" of these models is not a concern in this thesis. The interpretive principle for reading and analysing design literature is therefore a sympathetic one. It is not the intention to look for "failings" in design theories, but the central stances governing narrative traditions and the characteristics to those traditions.

2.2 Definitions

For subsequent reading, this section presents the operative definitions of central concepts in the thesis. The first section addresses the 'design' related concepts. The second part addresses the other concepts as they appear throughout the dissertation.

2.2.1 'Design' and 'product design' as theoretical concepts.

Product design

Product design is a professional role holding responsibility for creative making and embodiment of products in an industrial context. The work necessitates drawing on knowledge that spans technological, societal and aesthetic domains in order to plan and foresee the demands posed by the use, production, and distribution of products.

The professional jurisdiction associated with product design is somewhat fluid, as product design is teamwork requiring collaboration with engineers of many kinds, marketers, sub-suppliers and other specialists. The exact detail with which this work requires knowledge and ability for judgement will be variations along two axes: One axis stretches from the domains of technology and production to the domains of use (social, functional, and aesthetic). The other axis relates to the conceptual level of detail with which products are proposed and solutions are reflected over (Figure 2.1). The extent to which any concrete design job can be characterised as one or the other will depend on local working culture and traditions.
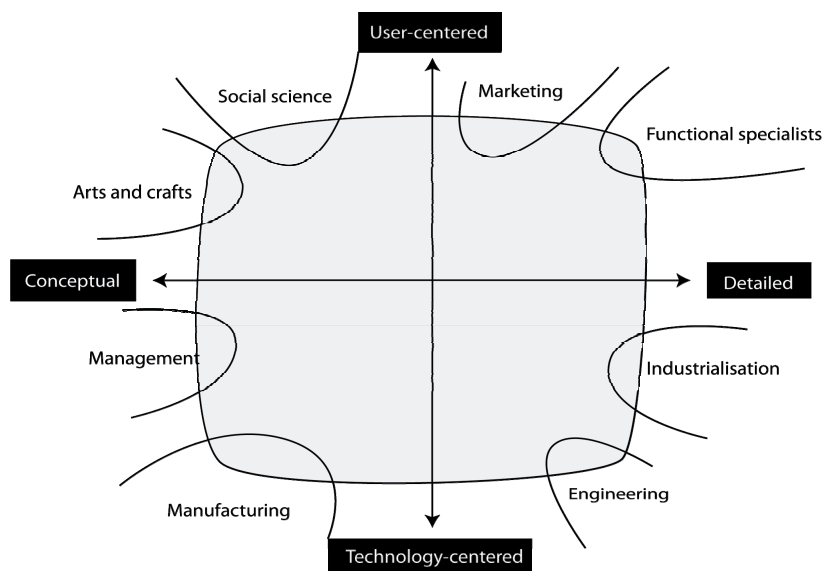

 Figure 2.1 - The continuum of product designers' responsibilities and some neighbouring professions

Design

'Design' denotes a large category of professional roles where the primary responsibility is making: Architecture, engineering, graphic design, planning, parts of computer science, and others. For historical reasons, product design is normally considered a subset to the larger field of 'design'. In this thesis, the 'design' field denotes the intellectual tradition concerned with, and relevant to, all the making professions, including product design.

Design theory

The literature on design is cross-disciplinary in nature. It provides several conceptually different takes on the nature of product design. In addition to authors from the making professions, authors drawing on elements from philosophy, cognitive science, sociology, and other fields have also contributed to design theory.

The intellectual structure of the field is eclectic; in that the different making professions extensively draw on concepts from neighbouring professions. An example is the concept of "wicked problems"(Rittel and Webber 1973) which has been used extensively to characterise the design task in the literature for all and any design profession. The concept was originally coined for planning problems, and its validity has never been argued outside this particular field. Yet, it is now a common concept also for other making professions. This suggests that authors in design theory invariably assume similarities between the design fields, effectively contributing to the furthering of a common field of design theory.

Product design theory

The sections of design theory with a focus on and relevance for product design.

Design research:

Design research denotes theoretical research activities which aim at furthering knowledge on design and expanding the field of design theory. There is a leniency regarding the research methods that are allowed in this area. Due to the practical and non-academic purpose of making professions, as well as the cross-disciplinary heritage of the field, a considerable number of methodological and epistemic stances have been proposed and argued as beneficial for furthering our knowledge on design. Among the perspectives, there is precedence for holding the general position that one can research *for, into* and *through* design (Frayling 1993); in other words, design research can take the form of research aiming for theories and models for improving knowledge and abilities of designers, the form of research into the products and outcome of designers work, or even through the making of new products themselves.

Product design research:

Design research with a focus on and relevance for product design.

The design process

Since a precise definition of what designers do is elusive, and establishing theoretical coherence between different design practices is challenging, a common leitmotif in design theory is 'the design process'. This is an ideal entity referencing how designers supposedly work. Typically, the process starts with an idea or need, and through successive iterative phases ends in the embodiment of a product. (See e.g. Gedenryd 1998; Jones 1970; Kroes 2002; Roozenburg and Eekels 1995)

The design process is ideal in the sense that very few design projects actually follow these phases. Often, design work is ad-hoc in its organisation or follows merely parts of the process. The pragmatic argument in favour of the design process model, however, is that it serves as a common reference in an otherwise eclectic field.

2.2.2 Other Central Concepts

Narratives

Narratives are here used in the sense of a shared conception of what design, or a sub-field to design, is. A narrative is metaphysical, in that it defines how design should be understood, and normative, in that it defines how design should be pursued theoretically.

Examples of narratives are when a group of researchers agrees, and shares as a convention a particular view on design. Such conventions can be traced in literature through aligning and definitional propositions such as "design is problem-solving", "design is professional practice", or design is "hypothesis-testing", to mention a few.

'Narratives' are probably best considered as "sensitising concept" in the tradition of Herbert Blumer (1969), in that the concept raises awareness on traditional differences in design theory, as well as in limitations to these traditions that would otherwise remain tacit.

Ideal models

In this thesis, ideal models are the object of analysis. These denote the shared and conventional understanding of a research issue in abstracted manner. The design process is a prime example of an ideal model, as it abstracts the eclectic field of design work into a singular abstract entity upon which researchers can compare and reference their findings.

Abstractions

Abstractions are ideal reproductions of real-life objects or events. It is a simplification of the object or event in question. Ideal models are examples of abstractions.

Ontology

The term ontology is here used in the same sense as in the information sciences, denoting a set of concepts within a domain, and the relationships between those concepts. As an example, a reflective account of design practice conceptualises the practice through the use of concepts as problem setting, frame experiments, problem resetting and others. These concepts are here seen as forming the ontology of this theory. This differentiates the term from its philosophical uses, where it is associated also with metaphysical reflection on being.

Knowledge-transfer

Throughout this thesis, both transfer of learning and knowledge-transfer are used to denote learning and drawing insights from one context which enhances a related performance in another context". It implies that one draws insight from one domain and reapplies that knowledge in another domain. It relies on one being able to identify some form of similarity between the two contexts, implying that knowledge is mapped across contexts that are in some way similar, but not identical (Perkins and Salomon 1992).

2.3 Background

Taking the role that design theory has for the product design profession, and the social conventions which guide production of such theory, opens questions pertaining both to epistemology and the professional role and responsibility of design professions.

Here the personal perspective and initial assessment of this relationship is presented. Firstly, the characteristics of the product design profession are taken up, and the question of how existing narratives for this profession have emerged is discussed. Particularly, the scientific conventions in the development of narratives for design professions are emphasised. It is argued that the disputes surrounding positivism is a central and relevant for the design professions and the consequences of this general tendency are probed.

2.3.1 The product design profession

As profession, product design is creative, collaborative and cross-disciplinary. It is creative because it implies the elaboration of novel concepts and solutions, collaborative because today's industrial context requires the inclusion of many different professionals and stakeholders, and cross-disciplinary because the design of products requires judgements and rulings in several domains of knowledge.

Positioning the profession in the context of neighbouring professions will be contested. In the Norwegian context, it is fair to say, however, that product design is similar to industrial design in its shared focus on making, but that industrial design is more firmly rooted in a humanist tradition. Product design on the other hand, draws more of its heritage from the technical traditions of engineering and management. In real-life practice, one can expect boundaries between product design and industrial design to be blurred, and in the international literature, the terms are used interchangeably.

Historically, product design is a professional role that has emerged with the growth of industrialised society. Product designers can trace their profession's history both to a modernist and aesthetic heritage; the Arts and Crafts movement, the Bauhaus, and the Ulm School of Gestaltung are canons in this respect, and reason and rationale for design practice is often evoked from these institutions (See e.g.Heskett 1980) . Additionally, there is a technological heritage from mechanical engineering which has influenced the modern understanding of design as a professional role in an industrial context (See e.g. Hein and Andreasen 1986). There exists a tension between these two traditions, as the professional identity of engineers and industrial designers is conflicting, even bordering antagonism (Archer 1990)

Since the time of the historical design canons, one should note that the characteristics of product design have been changing. The responsibilities and skills that product designers are expected to master have expanded. Valtonen's examination of role understanding (figure 1.5), mirrors the larger societal changes that have taken place as the industrial economy has changed from national systems of workshop production to a globalised industrial system.

Following such changes, the intellectual component of design work has also changed. The traditional role of product design presumes competence in areas such as materials and technology, form giving, aesthetics, ergonomics, and production processes. But from the workshop tradition, with its focus on form giving and production techniques, designers have been craving responsibility in new areas such as ecology, human factors, interaction, management, marketing, and emerging technologies. New professional realms include information technology, medical systems, and even the design of services to mention a few. Since the time of the classic design canons, there has been an influx of new managerial and organisational principles, and a rapid development of new tools and techniques that designers use in their work, such as:

- New tools and methods – Traditional methods such as sketching and modelling have been expanded and complemented by techniques such as rapid prototyping and developments in CAD and modelling technology. Product designers are now expected to master and incorporate such tools in their work.
- Globalization – New modes of business organization have also affected product design work. Outsourcing and a global supply and production network implies that designers must master a production context of geographically and culturally diversity. Related, designers also increasingly find themselves catering to an international market. This requires that designers must make use of formal tools and abstractions on the broader context of use in their work.
- New domains of responsibility – The product design profession has witnessed an expansion in the domains that designers are expected to master. For instance, the critical theory of the 70's opened up for participatory design methods, the quality focus of the 80's led to inclusion of quality techniques in design education, and the 90's saw the introduction of an environmental and sustainable focus in design schools.

Differences over definitions and over basic models of product design are therefore common in the product design discourse; various perspectives on the design role, and the characteristics to this role, have been proposed. Krippendorff (2006) has argued that design has shifted from being product- or production-centered to being "human-

centered". The argument is mirrored in writings on "design thinking", which currently is much favoured in design and management circles. IDEO executive Tim Brown likewise argues that we are now experiencing an expansion of designers' roles and responsibilities from a "technology-centered" practice, to the "human-centered" discipline of "design thinking" (Brown 2008).

Such claims and assertions are not, however, new. In 1981, Cross called for a "wider development of a post-industrial basis for design, technology and society" (Cross 1981), whereas Papanek published a call for "design for the real world" in 1971, holding that designers should take into account *real* problems and wider societal concerns in their design work (Papanek 1971). A call presumably provoked by the lofty promises of a "scientific" and "transparent" design process promised by the early design methods movement (Archer 1969)

In general, attempts at exacting the professional responsibility of product design will open a soft underbelly of what these tasks actually consists in; a situation which has lead to a certain unease about the theoretical framing of this practice. Roth can be taken to express these trends, as the design role will mirror the changes in the larger industrial system:

> *The traditional view of the designer as creative genius, or (worse) stylist is evolving to a perception of the designer as team member, interpreter of complex systems, communicator, and problem solver* (Roth 1999, p. 20).

2.3.2 Design theory and design narratives

The fleeting characteristics of the profession raise a question on the theories and models that are used to explain product design work. Like for any other profession, product design needs an intellectual structure; literature which imposes meaning and coherence for the field and contains best practices and sound principles for work. Among the many potential roles such literature fills are:

- Didactical: Providing models and means for reflecting over practical work, and as such provides the framework for understanding and inquiring into the profession's work (Schön 1995).
- Jurisdictional: By presenting the intellectual structure of the profession in a rigorous and near-scientific manner, the profession seizes jurisdiction over professional tasks, and defends the field from interlopers (Abbott 1988). The literature thereby serves a role in the professional project of promoting the profession.

- Practical: The literature provides guidebooks and aids for concrete professional problems; providing best practices and sound principles for the execution of professional work.

Normally, design theory is pursued through design research as a scientific, or quasi-scientific, project. This implies that it is pursued as a common project, that theorising is based on methodically rigorous inquiries, and that findings are made subject to peer-review and publication. Cross' account (in chapter 1.2.1) expresses the general sentiment; Design research should be purposeful, inquisitive, informed, methodical, and communicable.

But the attempts at pursuing design as a formal research project, points to an underbelly of associated complexities. Fundamentally, a scientific project requires a social agreement on conventional perspectives and methods. The traditional view on how conventions for a research field are established, is that other members of the institutional system determine the criteria and expectations that research is expected to fulfil, by institutions such as for instance peer-reviewed publications and conferences (Gibbons et al. 1994; Merton 1973).

Merton subsumes these practices under the term *certification* of knowledge; the perspective that research is a communal effort, where findings and procedures are accepted or rejected by the larger research community. The conventions for research are thereby the standards, methods, and overarching principles, i.e. research practices, that are common and accepted in the institutional system.

Inquiry and theoretical production is thereby constrained in important ways by the social agreement on how this project should be carried out. Foucault coined the term *episteme* to denote the set of expectations and beliefs that structure communal inquiry. Any systematic growth of knowledge is shaped by the world-views and beliefs of those that are engaged in research and inquiries, and these stances will underlie what is possible to think and write:

> *I would define the episteme retrospectively as the strategic apparatus which permits of separating out from among all the statements which are possible those that will be acceptable within, I won't say a scientific theory, but a field of scientificity, and which it is possible to say are true or false. The episteme is the 'apparatus' which makes possible the separation, not of the true from the false, but of what may from what may not be characterised as scientific. (Foucault and Gordon 1980, p.197)*

A depiction analogous to Foucault's episteme is Kuhn's historical-sociologist theories on normal science (1977). Kuhn depicts research as evolving in revolutionary steps; periods of 'normal science', where researchers work with a common

understanding of central problems and methodological principles are supplanted by new modes of thinking of and experimenting with the object, commonly known as *paradigm shifts*. During these periods of normal science, the potential modes of thinking and acting for researchers are constrained by *the disciplinary matrix;* the entire cluster of problems, methods, theoretical principles, metaphysical assumptions, concepts, and evaluative standards that are present to some degree or other in exemplary research.

Such accounts illustrate that preceding any empirical inquiry and theorizing, is a set of governing structures; tacit expectations of the role that research should fulfil, and the social conventions for the kind of problems that researchers are expected to address. The issue of social conventions in research that Foucault and Kuhn here illustrate can be explained from many perspectives; but as this thesis is written from what is often considered an applied research tradition, these conventions are here referred to by the common-sense terms of conventions, or narrative traditions.

Turning to design theory, one will observe that there exist several different conventions for how design research should be carried out. As design theory has emerged, several perspectives have been put forth. These differences are sketched out in the following:

Varying definitions of design:

Underlying the many theoretical accounts of design, one will find that several basic definitions of the subject matter – design – have been proposed, and underlie the individual theories and inquiries in the field.

An historically central definition, which defined design in the form of a science, is found with the cognitive research tradition associated with Herbert Simon (1969). Simon saw design as a *science* of the artificial and defined design as a topic within the boundaries of a scientific discourse, as a particular kind of problem-solving: *Everyone designs who devises courses of action aimed at changing existing situations into preferred ones* (p. 111). This wide understanding of design is developed in many design texts, both of practical and scientific orientation. Goel and Pirolli for instance, elaborate Simon's definition by incorporating later findings in the cognitive sciences, and argued that design must be understood as a *prototypical category,* displaying at least twelve common features. (Goel and Pirolli 1992, p. 401). Design is here understood as a cognitive research object that is best pursued through cognitive methods, e.g. laboratory- and protocol-studies (Dorst et al. 1996).

In parallel with the scientific understanding of design, several more practice oriented definitions of design have been employed in design research. In 1971, Archer defined design as *to conceive the idea for some artifact or system and/or to express the idea in*

an embodiable form[1]. Rittel and Webber, similarly, famously argued that if design were to be regarded as problem-solving, it should be regarded as *wicked* problem-solving. The gist of their argument is that design problems always are contingent and unique, and therefore required another approach than the technical formal approaches that emerged from a formal scientific or systems methodology (Buchanan 1992; Rittel and Webber 1973).

Semiotic and semantic theories on design have also held a prominent role in design theory. In a tradition familiar with Jencks and Bairds's architectural theories, Krippendorff defines product semantics as a central area for product design in particular, and design in general, defined as both:

> *A systematic inquiry into how people attribute meanings to artifacts and interact with them accordingly*

and

> *A vocabulary and methodology for designing artifacts in view of the meanings they could acquire for their users and the communities of their stakeholders (Krippendorff 2006, p. 2)*

The semantic, or semiotic, tradition has given rise to a sub-field within design theory concerned with products as conveyors of meaning, implicitly arguing that designers are in need of knowledge and capacity for judgement on how products communicate and convey meaning. (e.g. Vihma 1990).It is also a perspective attracting attention from scholars working on the interface between design and management traditions (Verganti 2009).

More recently, there have been attempts to define design as a sociological object. Ilhan and Wang (2009) argue that design professions can be distinguished from non-design professions through the *disciplinary matrix,* implying that the design field can be distinguished by its symbolic generalizations, shared commitments, values, and exemplars. Central in their account is the view that design should not be defined in terms of its knowledge-content, but in terms of the creative act*:*

> *...so central is the creative act to the design professions that we suggest it is it, rather than the distinct body of knowledge, that resides at the cores of these professions (pp 6-7).*

A parallel sociological account of design is also proposed by Carvalho, Dong, and Maton (2009). Their view on the centrality of knowledge is, however, exactly the opposite of Ilhan's and Wang's:

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[1] Quoted in Norbert F. M. Roozenburg and J Eekels, *Product Design: Fundamentals and Methods* (Wiley Series in Product Development: Planning, Designing, Engineering; Chichester: John Wiley & Sons Ltd., 1995) 397., p.53.

the debate is not about the surface-level descriptors of what designers do, such as the diversity of the knowledge needed to design in architecture and engineering, but what is the form taken by the knowledge that is valued, cultivated, and more generally emphasized within a discipline (p. 486).

Multi-disciplinary influence

The difference with which design is regarded may stem from the fact that there are many stakeholders with an interest in the field. Over the history of the design theory, authors have written from within a variety of perspectives. Drawing the history of this entire field will be outside the scope here. Suffice to say: The many traditions existing have brought different conceptions of the designer and different perspectives towards literature and research for the profession as a common and systematic project. An off-hand account includes:

- A multi-disciplinary tradition: A central tradition regards design as a multi-disciplinary field, comprising sub-sets of individual design domains. The Design Research Society[2], and its associated design conferences exemplify this tradition. Characteristically, for this tradition is the allowing of a broad theoretical and methodological basis (Buchanan 2004).

- The engineering design tradition: The Design Society[3] is central in organizing conferences such at ICED, and EPDE. The engineering design tradition sees product design as a natural subset to the wider field of engineering design. This discipline has retained and developed many of the theories developed within the Design Methods Movement, i.e. systematic and methodical models of design (Cross 1993).

- The industrial design and product design tradition is often defined in opposition to engineering design; the aesthetic and functional qualities of products are habitually regarded as more central than their technological qualities at focus in the engineering tradition. Bodies such as ICSID and the Design for Emotion[4] Society with its conferences exemplify this tradition.

- Architecture has provided historical contributions to product design by introducing basic models and a body of discourse that have had an impact in design disciplines beyond architecture (e.g. Alexander 1964; Lawson 1997).

- Design history is traditionally concerned with historical inquiries, but the field has contributed to design research by providing historical accounts of the field, and canonization of design works, and as such has impacted the perception of design in a normative manner, by defining scope and focus in the design field.

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[2] http://www.designresearchsociety.org
[3] http://www.designsociety.org
[4] http://www.designandemotion.org

- Design management is mostly concerned with management and organisation of design, through bodies such as the Design Management Institute[5] for instance. The field has brought forth models of management of design and proposed theories on the integration of product design with other business functions, and as such been an interface between management disciplines and design disciplines.

- Information Science and HCI are interrelated with product design on aspects such as interaction, use, and the modelling of products. There are several instances of theoretical lumping between these disciplines. The works of the cognitive scientist Donald Norman (Norman 2002) is an example of theoretical works intended for information science that later trickled into and impacted the product design domain.

- Lastly, a crafts-based tradition for design is also influential in the field of product design. The history of the product design profession, with a canonical focus on Bauhaus, and the Ulm School for Gestaltung, can be seen as the development of a craft-tradition to a modern, industrial context (Findeli 1990), exemplified in bodies such as the Cumulus conferences[6]

Antagonism towards science

While design theory commonly is pursued as a topic for research; i.e. that arguments are based on systematic and methodical inquiries, and that there exists institutions for publication and review, one will find in the theory many expressions of unease and antagonism towards the scientific project.

One central theme in the many attempts to ring in and define design theory as a theoretical field or discipline is the need to define design as "something else". Very often, the authors who define design for purposes of research and study often make use of negative definitions, and describe design research in terms of what it *isn't.* Design research is generally argued to possess an important quality of "otherness" that it seems important for authors to render explicitly.

For instance, in the first edition of Design Studies, considerable effort was put into to the definition of design research as something different from both scientific research and research in the humanities. Archer regarded *modelling* as the backbone of a theory of design, and argued that modelling had characteristics that made it stand out as a distinct area of inquiry; *a designerly way of knowing* (Archer 1979).

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[5] http://www.dmi.org
[6] http://www.cumulusassociation.org

Another perspective on design that has resounded with the design community is Rittel and Webber's formulation that design is *wicked*, implying that since design is a social activity affecting different social groups and stakeholders, it should not be understood as a process leading to solutions in the sense of definitive and objective answers (Rittel and Webber 1973).

Frayling gained attention by proposing that research in the field of design could be carried out *for* design, *through* design, and *into* design. The central part of this proposition was that not only *scholarly research* led to new knowledge, but that products and artefacts by themselves should be considered a form of knowledge (Frayling 1993).

Owen has proposed that design research may *extend understanding beyond definitions of classic research used by the sciences and scholarly disciplines*. Owen advocates stepping away from the term *research* in its entirety, and rather ask how knowledge is built, and he attempts to incorporate design practice in the research schema through a *knowledge-using/knowledge-building* model (Owen 1998).

The attempts to define the characteristics of the design field still continue; the currently most downloaded article from the journal Design Issues is (Fallmann 2008): an explorative definition of the relation between research, theoretical traditions, and interaction design practice. Implicitly arguing that design theory still is in the process of defining itself as a theoretical domain

In general, the account here necessarily is superficial. The specific circumstances that have given rise to these various traditions and positions cannot be treated with the thoroughness they deserve within the scope of this chapter. The point to be argued (and illustrated) is merely that within design theory there is an abundance of narrative traditions. The challenge of defining a "fleeting" profession as theoretical object is obviously difficult to resolve. The research community, owing to different academic traditions, different principles for the scientific project, and different interests, has proposed a variety of ways in which this practice should be understood.

It is possible to regard the current situation of multiple narratives as beneficial, in that it opens for richness in perspectives, or alternatively that the situation is troublesome as it leads to vague and confused theory. Either way, the plurality of narratives should be regarded as a characteristic to design theory.

2.3.3 Practical or academic theory?

Given the many cultural heritages and theoretical traditions design theory can be founded with, there exists unease regarding the function and purpose of this theory. Most obviously, there is a split between researchers regarding this theory as an

instrumental project, whose main purpose is to equip designers with methods and theoretical tools aiding designers in their daily work, and those who regard design theory as of more foundational nature. The latter project involves stricter conventions for epistemic argument, and communal publications; i.e. the perspective that design research is an academic, or scientific, project.

The practical challenge

Regarding the first perspective, a tacit expectation throughout much of design research is that this theory should hold value and credibility for design practice. For example, Vincenti argues that the rationale for the accumulation of knowledge in design is that designers must guarantee some level of performance and this requirement will put a premium on certainty of knowledge. I.e. it is the contractual obligations and the demands of the industrial context that designers face in their practice that are the drivers behind the growth of "designerly" knowledge (Vincenti 1990). A similar concern for the "practical application" of theory and literature motivated Roth (1999), whose preceding citation (chapter 2.3.1) was based in a concern that design research simply is too boring or "academic", and that a more creative approach therefore is desirable.

The criterion of practical relevance is a basis for much of the criticism raised against design research. For instance to diagnose the "failings" of the Design Methods Movement: Many of the central figures of this group were so unhappy both with the design research and its lack of practical application that they dissociated themselves from the entire field.[7] They did so by pointing out its failings to provide a normative and predictive understanding of the design process, and the failings in its practical application. It was the form and language with which these methods were presented that were perceived as alien and detrimental by many practicing designers, as it did not mirror how designers perceived and thought about their own practice (Archer 1990).

The view that design research should contribute to the general knowledge of and quality of practice may seem common-sense, but it is a utilitarian view of research that lay some bearings for how design research should be carried out. If design research is considered an applied subject of design practice, then the relation between design research (theory production) and design practice appears to be problematic, and most authors diagnose the relation as such. In the field of design methodology, for instance, Cross concludes a review of science and design methodology with the words that:

> *Design methodology has become a much more mature academic field, but still suffers from a lack of confidence in it by design practitioners, and it has had little (acknowledged) practical application (Cross 1993, p.67).*

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[7] See e.g. Henrik Gedenryd, *How Designers Work* (Lund University Cognitive Studies ; 75; Lund: Lund University, 1998) 227 s., chapter 2, for an introduction and discussion of this episode.

The most positive view regarding the practical application of design research seems to be a cautious optimism. Sheldon for instance, argues:

...a lot of 'blue sky' intellectual design research continues to be prevalent across academia. However, while I have been highly critical in the past, there are now immensely encouraging signs that academic design research in specific areas and specific university design departments are producing intellectually challenging outputs that are being adopted by industry with considerable delight and satisfaction (Sheldon 2004, p. 549).

The exact way in which a theoretical field "contributes" to a practice such as design is, however, difficult to assess. Russo and Stoltermann argue that the perspective that design research should directly contribute to practice in itself is problematic (Russo and Stolterman 2000). They argue that underlying this view are several assumptions, many of which are questionable, or at least open for debate. One central assumption is the belief that it is possible to change the rationality of design practitioners (by introducing them to research results). But Russo and Stoltermann argue that such an assumption seems incredulous. Changing people's rationality and practical behaviour will rely on also other issues such as their self-understanding, their values, responsibilities, resources and many others.

The unease concerning "application" of design research is on the one hand the position that research in this field should contribute to the knowledge and quality with which professional design work is carried out. On the other hand, the counter-argument is that expecting design research to directly contribute to design practice is an undue demand, based on an inadequate understanding of the complexities of the scientific project.

Academic drift

The alternate expectation for research in the design field is to hold that it contributes to an academic field; that knowledge on design is a project worth pursuing for knowledge in its own sake, but simultaneously, that it should ascribe to the conventions we normally hold for research in the academic sense. While this is an ethos that assumedly should lead to more certain and valid knowledge, it is an expectation that also may cause conceptual challenges, particularly the challenge of academic drift.

In the larger society, drivers and incentives for institutions and schools to carry out research for its own sake exist. The danger is that such research may become self-sufficient, in that producing publications for their own (academic meriting) sake becomes the primary goal; i.e. academic drift.

If one looks outside the design domain, to sociological studies of science, professions and education, one finds arguments for the claim that the tension between research and practice can be explained as academic drift. The tensions between practice

and research are not something particular to design research. Rather, these problems are based in societal trends end developments in the education system, particularly the institutions concerned with educating practitioners.

In observing the institutions with an educational and didactical role for the professions; typically lower education and professional organizations, Slagstad has argued that since the end of the 19th century, existing professions have experienced *academic drift*. The professions have sought higher status by attempting to define themselves as *scientific,* and associate their profession with universities and science (Slagstad 2007). Slagstad argues that the scientific research that has taken place in conjunction with the institutions of the professions has been modelled on a positivist conception of natural science. The result is, however, a *quasi-scientific treatment of theory,* with detrimental effects to the identity of the individual professions.

The social forces that encourage research for professions are worth some attention. Studying drivers for research, Skoie (2000) observes that in the OECD area, there has been an enormous growth in mass higher education since 1980. Traditional short-cycle courses and special and professionally oriented educations have been taken up and included in the university system, where teachers are increasingly expected to serve as researchers. The growth in mass higher education has been accompanied by a trend where increasingly, teaching is likened with research. One of Skoie's concerns is that this development will be at the cost of professionally oriented skills, and that the research itself may be low in quality, but will be an important part of the universities' reward systems:

> *Influential faculty groups often seek to improve their working conditions – facilities, teaching loads, prestige/salary level and so on. A career structure which gives particular credit to traditional academic merits with an emphasis on research, quite obviously has great shaping influence in large parts of higher education, probably more so than the authorities are often aware of. By the same token, teaching becomes less rewarding (p. 415).*

As a diagnosis, these general observations seem to bear relevance to the design field. First of all, there has been a marked growth in the number of papers and books on all kinds of design since the 1970's. The first international peer-reviewed journal in the field, Design Studies, was established in 1979. From these beginnings, design research now can count at least 7 international peer-reviewed journals and a large number of conferences and bodies focusing on design (Cross 2007). Secondly, such publications are for the most part authored by the staff of mass higher education; teachers and academics; and only partially by practitioners. Thirdly, there has been an obvious academic drift in the education system for design. Considering the product design educations that have been established at engineering schools for instance, one will see that this is a relatively recent phenomenon, where product design has been associated

with engineering colleges in the same time-frame that these technical colleges have sought the status of university, and the association of its professions with scientific methods. For instance, the Industrial Design Engineering (IDE) education at TU Delft was established in 1969 and the British Innovation Design Engineering program, a joint initiative between the RCA and the Imperial College, was established in 1980. In Scandinavia, the Industrial Design Engineering program at NTNU was established in 1993, the IDE program at Chalmers was established in 1999, and the DTU's Design and Innovation program was established in 2002.

Without making any claims towards the nature of design research in general, it is likely that one should take into account that design research is a relatively recent phenomenon, often driven by the incorporation of a practical subject into scientific and academic institutions. Potential dangers of these developments are the points that have been made by social theory on professions and education: A weak research culture, where a superficial understanding of research and science is used to ground theories and inquiries, little reflection on the characteristics of professional knowledge and how these differ from scientific knowledge, and lastly, academic drift; that design theory is pursued from academic motivation, rather than its professional and practical uses.

2.3.4 Positivism

If it so, that design theory is experiencing academic drift, then a central question is whether this has any practical consequences for the embodiment of design theories and their accompanying narratives. One of the main caveats emerging from the claims that professions are experiencing academic drift is that research on professions is associated with a program of positivism. What does this entail, ultimately?

The general challenges in the common project of design research that have been taken up so far, indicate a common theme that runs through the history of this field. The scientific conventions of positivism, i.e. using a set of positivist criteria for design research, have been pivotal element in the debates and discourses on how design research should be framed, and what one can expect, in terms of outcome, from this research field.

On one side, in the internal discourses on conventions for design research, the attempts to define design research's "otherness" can be read as criticism of and attempts to avoid the most dogmatic positions of positivism, and restrain its influence on design research. Many authors have implicitly argued against a positivist conception of science and research, by arguing for a different kind of research that emphasise the particular characteristics of design practice.

On the other hand, the relationship between research and practice also implicitly references the historical disputes on positivism. One can see this in the expectations that

design research is expected to meet, in terms of "application", and one can see it in the sociologists' claims that research at professional schools displays a tendency to frame their research in a superficial understanding of research, and thereby inadvertently frame this research in positivist conventions.

With a generalization, positivism can be identified as the view that research should be carried out according to the scientific method of a positivist epistemology. It holds all or most of the following positions (Hacking 1981, pp. 1-2):

- *Realism*. Science is an attempt to find out about one real world. Truths about the world are true regardless of what people think, and there is a unique best description of any chosen aspect of the world.
- *Demarcation.* There is a pretty sharp distinction between scientific theories and other kinds of beliefs.
- Science is *cumulative.* Although false starts are common enough, science by and large builds on what is already known. Even Einstein is a generalization of Newton.
- *Observation-theory distinction*. There is a fairly sharp contrast between reports of observation and statements of theory.
- *Foundations.* Observation and experiment provide the foundations for and justification of hypotheses and theories.
- Theories have a *deductive structure* and tests of theories proceed by deducing observation-reports from theoretical postulates.
- Scientific concepts are rather *precise,* and the terms used in science have fixed meanings.
- There is a *context of justification* and a *context of discovery.* We should distinguish (a) the psychological or social circumstances in which a discovery is made from (b) the logical basis for justifying belief in the facts that have been discovered.
- *The unity of science.* There should be just one science about the one real world.

A discussion of positivism should be approached with caution, as there is a risk of arguing with a straw man. Hacking writes: *No single philosopher has ever maintained exactly these nine points, but they form a useful collage not only of technical philosophical discussion, but also of a widespread popular conception of science* (p. 2). This conception has been common to design theory also, and a closer examination of its theoretical consequences can cast some light on the many disputes underlying design research.

For design research, the concrete and practical problem that a positivist conception of research can lead to is that one obscures important assumptions that research and inquiries are based on. I.e. that 'design' is idealised and abstracted into an entity where underlying assumptions and premises are seldom questioned or reflected over.

This raises some problems. Since 'design' as a domain is constituted by the individual practitioners who practice design, design can be seen as a collection of projects, a collection of tasks, and of practitioners working in different cultures and social realities. 'Design' is primarily a social role where responsibilities are defined by the designer's relation to the wider societal or business context, and not a naturally existing object per se. If one idealizes design practice into a literary, technical concept of 'design', one may obscure important assumptions on the nature, role, and context of design practice. If one ignores such assumptions, one risks relegating important premises for theories to the "background" of these theories, for instance:

Values in research: Historically, inquiries in design research have usually been carried out by examining instances of design practice and evaluating this practice against criteria such as the transparency of processes, the resource-usage or the quality of product concepts that are generated. Design research relies on such value-laden assumptions on what constitutes good design work because it will provide the background against which empirical findings are evaluated. These criteria are, however, seldom objective or self-evident, and there is a great deal of controversy concerning such criteria (Rittel and Webber 1973).

Generalization of insights: Empirical data in design research inquiries are usually restricted to individual design projects and cases. I.e. it is held that by examining concrete design projects one can improve one's knowledge on the wider topic of 'design' in general. It is not clear by which theoretical principles that such insights can be construed to the wider profession. Among the characteristics of design projects are contingency and novelty, which means that any validity claims for the wider domain of design will rely with researchers' assumptions about the similarities of this practice across geographical and social divides.

Competence: Although design research often is carried out under the idea that one can derive rules and procedures for this practice by scientific examinations of it, such rule-based accounts of competence are problematic. It is widely acknowledged that experience and competence consists in more than knowledge of rules. One argument is that human knowledge includes not only statements and argumentation, but that design work relies on e.g. *tacit knowledge* (Polanyi 1964). A pragmatic argument is that experience provides more and other insights than the mere accumulation of rules (Dreyfus 1996). And a social argument is that knowledge somehow resides in the social community of practitioners (Bucciarelli 2003).

Concepts and Constructs: If design is understood as an objectively existing entity, it obscures the question of which concepts and categories that are best suited to describe and analyse this practice. I.e. a reflective attitude to the technical terminology of design theory is troubled. Design theory has relied on general abstractions and models such as 'the design process', 'the design problem', 'stakeholders' and others. But there is generally little reflection on whether and to what extent such concepts are the most appropriate or beneficial ones (Coyne 2005).

The accumulation of theory: If design theory is believed to grow through the accumulation of mutually compatible theories that are accumulated into a knowledge-base, then some potentially important differences within these theories may be suppressed. Common sense will support the understanding that there are cultural differences in designer's work across geographical and social divides. It may also seem obvious that the design profession have changed, over the last fifty years. Yet, such differences are not always mirrored in design theory, where the concepts and constructs that Simon used to depict design in the first edition of The Sciences of the Artificial (Simon 1969), are still basis for much research, e.g. the design problem, the solution space and others.

In general, the problem with the positivist schema in design research is that such assumptions are obscured. They are subsumed in a technical concept of design, with the potential consequence that theory is ill-fitted to the realities and experiences of design practice as a real-world phenomenon.

The problem that the positivist schema leads to is first and foremost that important assumptions are simply ignored: On which values are claims based? By what criteria is design practice judged? How are insights and findings construed to be valid across the wider profession? Which concepts and categories are used to depict design practice? Under what set of criteria is theory produced? Under what circumstances can theories be considered disproven? Such questions are important for the general value and credibility of design research. But under a positivist schema, these are implicitly defined out, because the dominating perspective on science and research is one that does not question the idealisation and description that is inherent in theory and language.

The experiences from the attempts to scientise design through The Design Methods Movement (See e.g. Bayazit 2004) provide an important historical experience and in this respect. On the surface, this was an attempt to establish an axiomatic and scientific design theory, with strong affinities to a positivist program. These theories were based on a set of assumptions on design practice. These included the view that design can be considered as a series of decisions, that the challenges of this process were largely cognitive, and that one could establish a rigorous method for the practice of design (Gedenryd 1998).

These attempts were eventually rebuked primarily because of the assumptions they made on design practice. They were rebuked because they did not mirror the way in which professionals worked (Gedenryd 1998), neither did they mirror how professionals thought and spoke about their own practice (Archer 1990).

The analogy between positivist conceptions of science and design research is thus the instances where researchers leave little or no room to reflect over concepts used or language on design, simply because one of the underlying convictions is that the relation between theoretical statements and the real world is largely unproblematic (cf. Hacking's table).

The general claim that is being argued here is that the split between practitioners and design researchers, and the antagonism between design researchers themselves can be explained as a deep-running dispute over what kind of conventions that design research should abide by, and thereby the wider role and function design research should hold. Central to these disputes have been the criticism of and the search for alternatives to the positivist schema.

In these disputes, practitioners often call for a more relevant kind of research. But for design researchers, such calls are not easily answered, as the design research community is in disagreement about the methods and principles that such research should undertake. This problem is not particular to design research, but it is a central problem, and it is one which the research community has not yet "resolved.

Rather than argue the value of any particular approach, the view here is that when approaching design theory, one should accept more lenient criteria for knowledge-production than traditional positivist criteria such as e.g. "falsificationism of theories". One should acknowledge that there are significant challenges with identifying the social reality of design work, and even that a large range of conditional views of design may be a benefit.

2.3.5 Initial diagnosis

The preceding sections have contextualized and elaborated the initial understanding which has motivated this thesis. This understanding can be summarized:

1. Product design is a profession with fleeting characteristics. The profession can be seen as the making of products, but concrete tasks and the development of professional knowledge and focus will range from the conceptual to the detailed embodiment, and from the production-oriented to the market-oriented.

2. The theory supporting this profession is wide in scope and multi-disciplinary in nature. There is no authoritative tradition for how theories and models should be

certified for making valid claims for the profession, but a range of different schools of thought.

3. There are expectations and incentives in the larger society for professional theories to be developed in accordance with a scientific framework. Since science and research requires a culture and collective historical memory, the danger of these incentives is that they may promote quasi-scientific, potentially superficial, research practices.

4. To improve research practices, theoretical and methodical reflection will be beneficial. Design researchers and design practitioners are presented a wide array of potential narratives and methods. Navigating and understanding these are challenging.

In line with the general research problem, the requirement is therefore a proper theoretical perspective and methodical framework by which one may assess and analyse the theoretical diversity of design theory, and display important characteristics. The selected framework is presented in the following.

2.4 Theoretical perspective

By now, the issue is how one can analyse and compare the many theoretical strategies and conventions which have been employed in design research. Having sketched out the many conventions and expectations that underlie the field, the challenge is to find a suitable framework for comparing the many narrative traditions existing.

Using a common unit of measure, for their comparison, risks deflating differences and subsuming narratives under rival narratives. For instance, the reflective perspective on design attempts to explain this practice with a wide focus on understanding. This implies emphasis on learning and the didactical use of materials, using a mentalist concept as 'frames'. If one uses these paradigmatic stances to analyse e.g. how the cognitive program of Herbert Simon fared, one would miss out the way in which this narrative builds on entirely different premises. From the cognitive program's perspective, the reflective account will be seen as flawed, as it is based on unscientific concepts.

The situation in design research, with many traditional ways of idealising and modelling design, is in many respects similar to classical disputes in the sciences; in periods between normal science, the research community experiences disputes between rival paradigms (Kuhn 1970): Scholars and authors disagree about fundamental paradigmatic positions, and the discourse is somewhat politicized. Such discourses on the proper understanding and perspective of a target phenomenon often lead to disputes about the "true" or correct theoretical understanding of a given phenomenon.

So, the view here is that the variety of stances exemplifies a classical kind of discourse; when design researchers propose different perspectives on design and design research, they propose different strategies for understanding the subject matter, design, itself. The situation necessitates an interpretative perspective on design theory, how it relates to practice, and the elements that are important to consider in this respect; i.e. a larger perspective on the relation between research, design theory, and design practice.

Among the potential frameworks, one will find in design theory several examples of reflective perspectives on design existing. These based in different paradigmatic positions on language and science. One plausible approach is to hold that design theory is governed by different "meta-narratives", and methodically address these meta-narratives through discourse-analysis. One could then examine the discursive formations in the design discourse to identify the governing epistemes of these different discourses; a project that has been referred to as archaeology of knowledge. Such an approach in design theory has been explored by Ask, who has analyzed the *constitution* of industrial design as a profession in Norway (Ask 2004).

A similar approach, but one that to a lesser degree confronts the classical premises of the scientific project, is "paradigm analysis". Attempts to identify the *exemplars* in design theory and the disciplinary matrices that design texts relate to, may potentially identify the limits and common problems that design theory addresses. An example of paradigmatic analysis in design research is the work of Dorst, who compared the "rational problem-solving paradigm" with the "reflective practice paradigm" in design (Dorst 1997).

Another approach with some precedence in design theory is *metaphor analysis.* With basis in Lakoff and Johnson (1980), design researchers have analyzed the metaphors that underlie design texts, under the assumption that these metaphors are the basis for thinking and that they influence and constrain how we think about the world in general and design in particular. An example is Hey et al (2007).

What these approaches have in common, is an interpretative perspective; they hold that the terms, concepts and categories that are used to explain the social world in general, and design practice in particular, cannot be taken for granted, but should themselves be made the object of analysis.

The perspective in this thesis is similar. The semantic view of theories is a perspective drawn from the philosophy of science, which holds that scientific theories refer to concrete and abstract *models* of their subject; theories do not reference real-life concepts and events directly, but idealized models of these. The corresponding view of the design discourse is thus that it relies upon a set of models of practice, whose primary function is to render design practice as homogenous and real-life practice amenable to introspection and analysis.

The significance of ideal models is that in general discourse, theories and hypotheses are deemed true with reference to the model, and not to the real-life events themselves. This implies that theories will be constrained by the assumptions that are laid down in the model, and in this way trajectories for the development of the theoretical field are laid.

Secondly, the ideal models will indicate agreement among researchers; a common and shared way of depicting design practice. Central idealized models are therefore believed to be indicative of narrative traditions. In the following, the perspective is presented and the value of a semantic perspective on design theory is argued.

2.4.1 The semantic view of theories.

The perspective which establishes the vocabulary for differences in the conception of design practice, and in a systematic way approaches the difference between theoretical positions and stances here is *the semantic view of theories*. This is a perspective from the philosophy of science which holds that scientific theories in a significant way rely on and reference concrete and abstract *models* of their target phenomenon (Giere 2004; Suppe 1977).

The semantic view of theories (Giere 2004; Suppe 1977) emerged as a perspective that seeks to explain issues over scientific representation. It holds that the difference between competing theories on the same phenomenon normally cannot be explained with reference to one theory being truer than the other, but with a difference in underlying models of the phenomenon. According to the semantic view, scientific theories do not reference the target object directly, but reference ideal models of the target object. These models are simplifications of the target phenomenon, and an important difference between competing views in scientific discourse hence is the difference in underlying models.

The historical context that motivated a semantic view of scientific discourse followed from Kuhn's critique of the then received philosophy of science (Giere 1996, p. 270). Kuhn voiced a discontent with positivist and logical empiricist accounts of science, and central in this critique was the theory-observation distinction which held a prominent role in these accounts of science. The then received view of theories claimed that a theory of a phenomenon consisted in two parts: Its theoretical terms and its observational terms. The theoretical terms were the elements of the theory that explained causal relations, assumed elements and so on, whereas observational terms were the elements that could be observed empirically. However, the received view leads to several paradoxes. Among the more serious ones is that one can usually specify more than one procedure for attributing meaning to a term, and that the meanings of terms could not be fully captured by correspondence rules (Morgan and Morrison 1999a, p. 2).

A solution to these problems was to propose that scientific theories refer to a *model* of the target object and not the target object itself. The semantics, i.e. the meaning, of a theory can be found if one defines a model for which the theory is true. Scientific theories thus explain phenomena in the world by referencing ideal models that are more or less similar to the phenomena themselves. This can be explained as the view that scientific theories reference *ideal systems* of phenomena in the world, not the phenomena per se. Quoting Suppe (1977):

> *Scientific theories have as their subject matter a class of phenomena known as the intended scope of the theory. The task of a theory is to present a generalized*

description of the phenomena within that intended scope which will enable us to answer a variety of questions about the phenomena and their underlying mechanisms; these questions typically include requests for predictions, explanations, and descriptions of the phenomena. The theory does not attempt to describe all aspects of the phenomena in its intended scope; rather it abstracts certain parameters from the phenomena and attempts to describe the phenomena in terms of just these abstracted parameters. In effect, the theory assumes that only the selected parameters exert an influence on the phenomena and thus that these parameters are uninfluenced by any other parameters in the phenomena. As such, the theory assumes that the phenomena are isolated systems under the influence of just the selected parameters (p. 223).

The perspective here, that how one idealises the phenomenon is a central characteristic to scientific theories, has motivated several analyses of scientific disciplines. Among the examples are an examination of optimality models in evolutionary biology (Beatty 1980), analysis of visual models in 20th century geology (Giere 1996), and how learning in economics make use of models (Morgan 1999).

Central in such examinations, is the view that how the research community agrees to understand and idealise the target phenomenon is a key determinant for how theories will be embodied and the insights that can be drawn from these theories. The scientific theorising will depend on and be shaped by many exterior factors, like the purpose of the research or the conventions in the research community, and is not simply an unproblematic matter of *description.* Giere writes on an example from physics:

If one is investigating diffusion or Brownian motion, one models water as a collection of molecules. However, if one's concern is the behaviour of water flowing through pipes, the best-fitting models are those that treat water as a continuous fluid. Thus, the type of model one uses to represent water depends on the kind of problem one faces (Giere 2004, pp. 749-750).

The consequence for the understanding of theoretical truth is important. In a scientific discourse, the formulation of theories and hypotheses and the subsequent testing or judging of their veracity or falsity are activities that are carried out with reference to the ideal model and its stated entities. If one were to hold, for instance that a phenomenon is best explained with reference to a given model, the observation and eventual confirmation of this model will be carried out under the assumption that the target phenomenon is adequately explained by the model.

Thus, the general scientific perspective here is that scientific theories are not merely linguistic statements in the form of theories, but include elements of abstraction and modelling of the target phenomena. Teller argues:

We should take science to be in the business of providing not just descriptive sentences, statements, or propositions, but a much wider range of abstracta which represent agreement in form. Second, that such representation, whether by description or by form, is rarely, if ever, exact. (Teller 2001, p. 398):
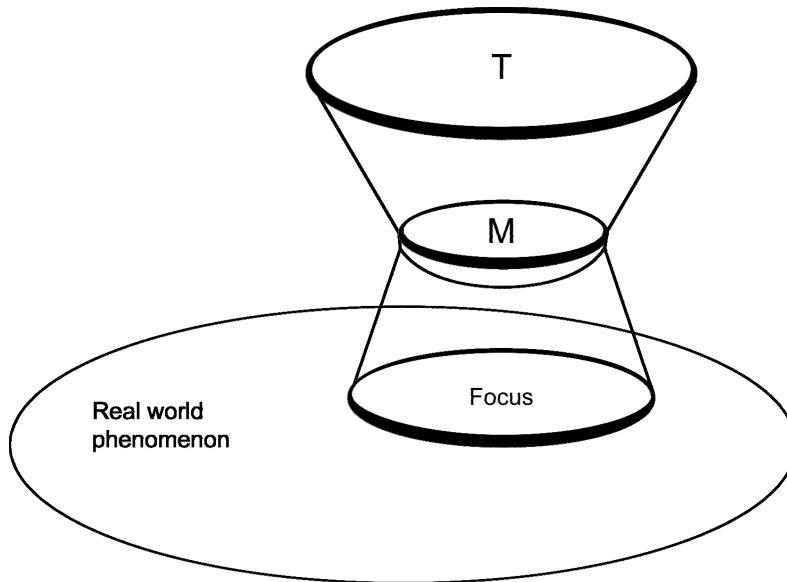

Figure2.2 - An illustration of how scientific theories presume an idealised model: Theories and hypotheses (T) reference a 'model' (M), which is the intended scope of the theory. The model is an abstracted and idealised replica of the target phenomenon.

But if it is so that scientific theories in a crucial way depend upon idealised models of the target phenomenon it opens up a new question: How are we to understand and define 'a model'? On this point, there is a lacuna in our understanding of what models are and how they work. Definitional proposals include fictional objects, set-theoretical structures, descriptions and equations (Frigg and Hartmann 2009).

A general and plausible perspective is that models must be understood in light of the discourse they are elements in. Since the discourse of any field and how its participants understand this field will decide the form of the models, one must be careful making a broad category of 'model'. Teller (2001) argues that 'models' must be understood quite broadly. What distinguishes them as models is simply that they are used as a common, conventional way of understanding and seeing the research object:

What makes a thing a model is the fact that it is regarded or used as a representation of something by the model users (p. 395). And furthermore: Science produces models, which are sometimes concrete physical objects, but which in most cases of interest are abstract objects. Models are connected to the world by theoretical hypotheses, sometimes more, sometimes less explicitly stated]...[Science uses many things as models, such as ordinary functions,

phase spaces, vector spaces, fibre bundles, groups, structures (in the sense of formal logic) and much other abstracta, as well as physical models (p. 398).

In summary, the semantic view of theories conceives science and scientific theory-production as a social project which depends upon the agreement and sharing of a set of underlying models. Scientific insight will be shaped and constrained by these models, as theories will be formulated with reference to the models of the target phenomenon that the research community shares. The insights that can be derived from a scientific theory are thereby constrained by the assumptions that are laid down in the underlying model (figure 2.2).

2.4.2 A semantic perspective on design theory

For analysing design theory, the semantic perspective on scientific discourse implies that theories are formulated with respect to one or several idealised models, and that these ideal models are conventions which are shared by groups of researchers. The semantic view is a conceptual framework which explains the variety and the many different research strategies one can observe in design theory. Under this persepctive, these are seen as different ways of understanding design practice; different idealised systems that emphasise some aspects and elements at the cost of others.

Under this view, much of the difference between narrative traditions can be observed in their different conventions for idealising and modelling design practice (figure 2.3). Using the semantic perspective to analyse and assess models allows questioning how different theoretical traditions in design theory describe and understand design practice.
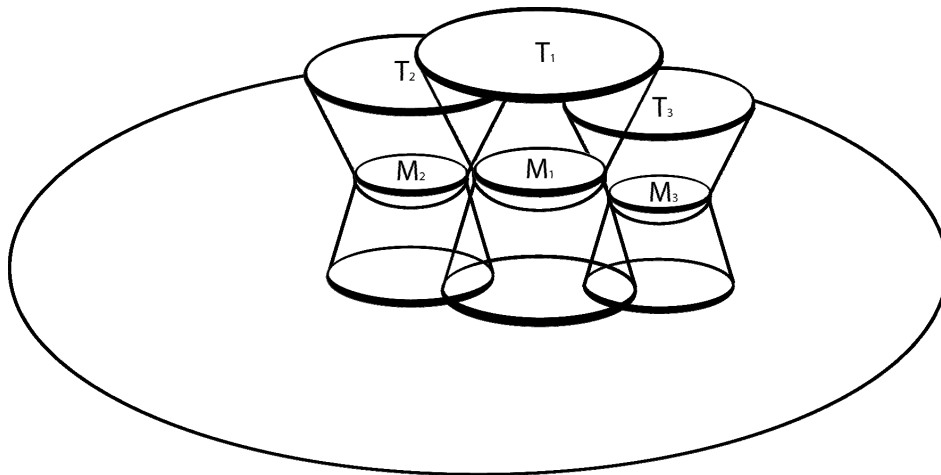

Figure 2.3 - An illustration of the semantic perspective on scientific discourse. Different theories and narrative tradition are not merely differences in perspective or meaning, but rely on different ways of idealising and defining the target object.

It appears obvious, once pointed out, that design theory relies on such idealised models, and that these models have an impact on the understanding of design. Design researchers frequently make use of both explicit and implicit models to represent design practice (figure 2.4). If researchers choose to base their inquiries on common and much-used conceptions of design such as *phased process, design as form-generation, or design as collaborative inquiry*, these models will shape hypotheses and theory-generation. The models will decide how observations are to be understood and made sense of, and the central and important elements to consider in design practice. Such models decide primacy of elements, focus, and the general framing that design inquiries receive.
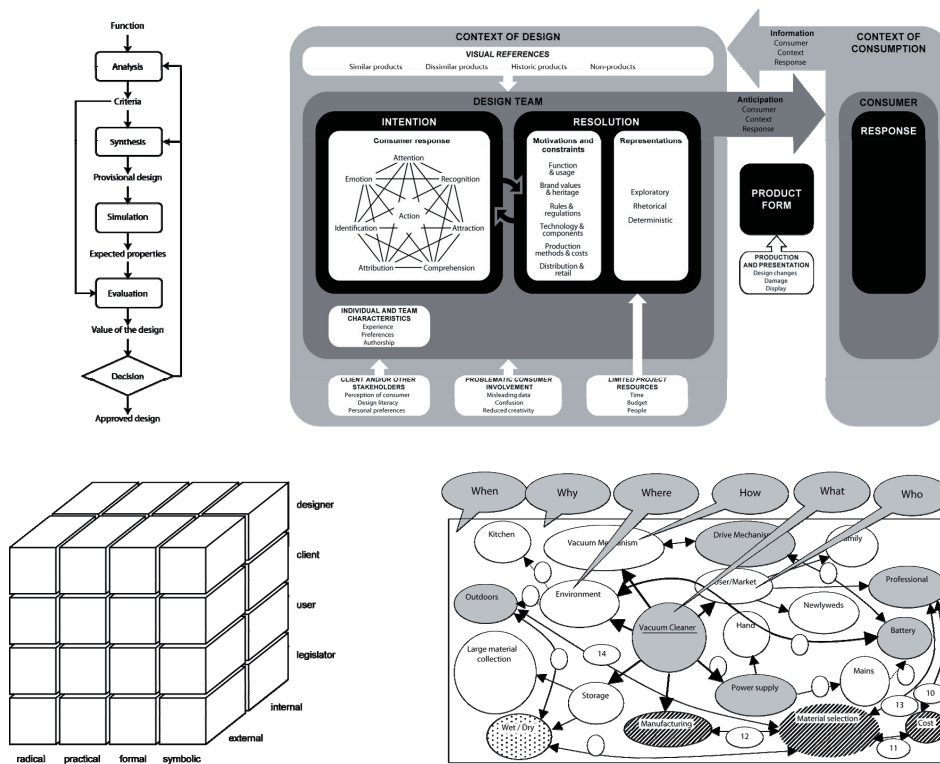

Figure 2.4 - Examples of models in design theory. Clockwise from top left: The basic design cycle (Roozenburg and Eekels 1995), a framework for how customer response influence form (Crilly et al. 2009), a mind-map of functions and components (Kokotovich 2008), and a subdivision of the many design problems in a process (Lawson 1997)

If these models are put to use as assumptions underlying inquiries, they will provide much of the rationale for theory-production. The scientific view for instance, espouses a program where design theory should aim for empirically grounded "rules" for

designers, the social view will opt for understanding the design process as a dialogue, whereas the conversation-model may indicate a hermeneutic research program. A more detailed understanding of these models may therefore display some of the characteristics of the theoretical traditions in design theory, and thereby aid readers in navigating the many traditions existing.

Thus, the general view of design theory argued here is that it contains several traditions that rely on different idealised models of 'design'. Idealised models reference design practice, establish common understandings of the how's and what's of design, and serve as idealised depictions of the design activity. The promise of the semantic view of theories is that it provides an analytic framework and some operative constructs for understanding the role that such models have for the development of theories, and thereby an important element in the larger project of development of design competence.

2.5 Research question

Among the many models that can be argued to underlie the narratives in design theory, the focus here is how these traditions have abstracted and idealised the professional inference of design work: Implicit with existing theories are different conceptions of how designers reason and reflect while designing; an assumption that will impact how one understands design by idealising this practice in a specific manner, and ultimately lay trajectories for how design theory develops.

These models are, however, different in nature. Some of them are explicit models of designers, whereas others are more implicit or hidden reflections. The examples displayed in the first chapter illustrates that the presumption on professional reasoning hold great influence over how theories in the design domain will be embodied.

The precedence for *decision-making* inquiries in design theory, in the vein exemplified by Ulrich & Eppinger (2007), associates design practice with a rational-choice paradigm, influenced by cognitive theories (Simon 1996). Under this view, design processes are designated in terms of problem structuring, problem spaces, decisions, and others. This terminology is derived from an assumption that professional reasoning in design can be seen as a problem of optimal choice and associated with the research practices of this tradition. The implicit rationale for theoretical inquiries in the design field will be to provide aid and support to the designer in making optimal choices by providing heuristics and methods.

With Schön's reflective account (Schön 1995) the reasoning process in design is seen as a problem of *understanding*. Under such a program, researchers make use of alternate concepts such as frames, reflection-in-action, and restructuring to describe design projects. The ontology is based on a constructivist premise; by including how designers use experiments to test and restructure their understanding, the account implicitly endorses research efforts that challenge frames-of-understanding, common professional practices, and aims to disclose designer's habits and understandings rather than how they decide in typical situations.

The social model sees design as primarily a social process. Reasoning in design is something that involves negotiating and bridging the different *object worlds* of the participants (Bucciarelli 2003). The underlying assumption is that in an industrial context, no single person will have a complete oversight and understanding of the design problem and that several competencies (and stakeholders) will have to be involved in the design process. Design work will demand facilitation and cooperative innovation, and research theories should thereby aim to support these social challenges to design work.

The hypothesis here is that if one could identify central models of professional reasoning existing in design theory, it should be possible to point out the central stances and assumptions inherent with individual narratives. If so, one may potentially both show some of the practical and theoretical benefits of certain models, as well as some implicit limitations with individual models.

Furthermore, it is assumed that the models of professional reasoning hold such a central role within narratives that their identification could be used to demarcate between different narrative traditions. Such a study would be cross-sectional in its approach; it would show different models across the spectrum of design theory, rendering available the narrative traditions which these idealized conceptions have emerged from.

This leads to the research questions:

1. *Which are the central idealised models of professional reasoning in the parts of design theory relevant to product design?*

2. *How, characteristically, will the ontology of these models constrain and influence theory production in product design?*

Addressing the first question, a method for reviewing, and sampling models from design theory is presented in the next chapter. The second question on the "influence" these models exert on theoretical production is more complex and elusive. It will here be approached both through the analytic studies - how the conceptual structure of these models will highlight and emphasise some aspects of designing while black-boxing others, but also by taking up the discourse that has taken place between rival camps; i.e. the politicized discussion that has accompanied the use of these models in design theory. These investigations lead to a comparative section, where the transfer-models implicit with these traditions are deduced, and the trajectories these perspectives lay for design research are sketched out.

2.6 Methods

In general, the models of professional reasoning will be approached from several angles, aiming for an interpretative examination of design theory. The research is inspired by Lakatos' perspective that research should be merited by the insights it provides on a topic, and by the potential questions it opens for (Lakatos 1977). The research design is intended to extract idealised models from the existing discourse in design theory and subject these to analysis with a focus on their ontology and premises. The ensuing chapters present the methods followed.

A substantial portion of the challenge with this thesis was finding a method which could be used to sample and document the models existing in design theory. Therefore, chapters 2.6.1 to 2.6.3 present the methods underlying the review presented in chapter 3, whereas the subsequent chapters present the methods for analysis.

In chapter 2.6.1 the perceived methodical challenges with this type of review work are presented. The main challenge was seen as uneven dispersion of ideal models throughout the literature, leading to the practical problem of having to go through a very large data-set with roughly the same content, to cover the relevant models in design theory.

In 2.6.2 the operative understanding of idealised models is presented and, after having identified these positions, how the documentation and analysis the models of professional reasoning were carried out. In order to identify the models, a broad data-set was extracted, mapping the main positions and assumptions of different authors. This approach recorded the larger framework by which 'design' was understood and depicted.

In 2.6.3 the procedural review approach, designed to overcome the problems presented in (2.6.1), is presented. The main idea is to sample idealised models from design theory by using well-known conflicts in this discourse. From these one can map different central positions in design theory, effectively indicating different narrative traditions in the material.

In 2.6.4, it is explicated how a terminological approach has been used to compare the conceptual structures of three of the models. The argument underlying this examination is that for research inquiries, the conceptual structure of different idealised models will highlight some aspects of design practice at the cost of others. The text shows and exemplifies such effects through comparative analysis.

In 2.6.5 the more political question of *correspondence* is addressed. Any research community has implicit drivers for conservatism in how problems are depicted and pursued as objects of study. The conflicts that arise between researchers regarding the

appropriate modelling of design practice are political in nature and cannot be "solved" analytically. But the proposal here is that disputes stemming from these conflicts may be a source for reflection and insights. By structuring the critiques surrounding the problem-solving model, the goal is to render, firstly, areas that have been problematic in the common project of design theory, and secondly, that the criticism introduces other ways of approaching and regarding these "problem areas".

The last section, 2.6.6, discusses the methodological approach, taking up the problems of representativity, and the robustness of the research design.

2.6.1 Reviewing design theory.

To identify and assess different models of professional reasoning in design theory, it was necessary to review and analyse large sections of design theory. Defining and delimiting relevant literature proved to be a surprisingly large obstacle, due to the varieties and idiosyncrasies of design theory. The main conceptual challenges perceived are therefore listed as they motivated the form that the sampling and reviewing would eventually receive.

Delimiting the relevant theory

Historically, there exists precedence for defining a common field of design, from which most design professions can be regarded as sub-sets (Chapter 2.3). Since there are few formal demarcations in design theory, the scope of theories forming the bulk of a literary review or analysis may potentially grow very large. The problem is illustrated by a review of design research published by the Rhode Island School of Design (Poggenpohl 2002). The publications that this review deemed important and relevant to design research belonged to a large array of theoretical traditions, including management literature, canonical philosophers, cognitive science, rhetoric, network theory, consumer research, sociology, systems theory and others. Since the reading of any text will require some background knowledge of the context for the text, one may question the realism of presuming that it is possible to cognitively cope with such a vast and diverse set of theories, with few disciplinary borders. The insight this challenge led to, was that while this text was originally written from the perspective of product design, it seemed necessary to retain an openness regarding relevant literature, as design theorists have argued by drawing on a large number of theoretical thinkers and traditions.

Self-referential clusters

This review approaches a subject that is unevenly dispersed throughout the design literature. Since texts that answer to specific institutions (e.g. a journal or a conference) usually share the same basic assumptions, there is a risk that a large number of texts could contain the same models on professional reasoning, and that such "schools"

would form self-referential clusters with respect to the ideal models contained. The methodological challenge with this was that if the review were limited to certain institutions, one would have to go through a potentially large body of texts with essentially the same relevant content.

Lack of review tradition in design theory

The format and standard of a review is usually given implicitly by the tacit traditions in a research community. For design research, however, review articles are quite rare. There exists no dedicated review journal, as one can find in other disciplines, and there are few reviews in existing journals. For instance, Design Studies, one of the few international science citation indexed design journals, contained 14 dedicated theoretical reviews from its first publication in 1979. Due to this lack of conventions, the reviewing phase was somewhat tentative and exploratory in form.

2.6.2 Identifying and sampling models

As the main characteristic of ideal models is their social usage and the agreement as a conventional reference on a topic (Teller 2001, quoted in chapter 2.4), the question is how such an understanding can be translated into an operative definition. The examples we have on use of the semantic perspective on theories are taken from research traditions such as geology, economics, and physics, and translating their operative approach to the design field requires some consideration.

The identification of "models of professional reasoning" is circumstantial. The model is understood here as roughly akin to the various conceptions of 'the designer' that can be found in the literature; i.e. the idealised and general depiction of 'the designer' which underlies theories. Since this model seldom is stated explicitly in texts, it appeared necessary to collect the stances and definitions which indicated 'the designerly inference'.

A review was carried out to find the stances and definitions which indicated the models. The review recorded the key concepts which referenced authors' implicit model of professional reasoning. For general understanding, points that indicated the larger structure of authors' theories on design were also included. These points were recorded in a concept-matrix (Webster and Watson 2002) and the entities that were mapped at the time were:

- Research paradigm
- Definition of design
- Prototypical problems
- Ontology of design theory
- Key audience (if stated)

- Model of structuring
- Key terms
- Types of evidence
- Main criticisms (if available)

The method follows Hart (2005) in its approach and mapping of key concepts, with the general perspective that one *needs to elicit from the literature the ways in which core ideas, concepts and methodologies have been employed in argument and how they have been operationalized for empirical work* (p. 142). For analysis, the literature was therefore structured according to a set of mapping techniques discussed by Hart[8]. Some risks are associated with this approach as one makes use of extracts of a larger material, particularly there is a risk that one construe authors' positions. Hart, for instance, warns against attributing motives and methodological assumptions without clear evidence. Another common bias, that Webster and Watson (2002) warn against, is that reviews are structured around persons, rather than concepts.

From this mapping process, six models of professional reasoning were identified. These models were categorized on basis of their ontology; i.e. the elements that authors' held important and central when considering design reasoning. The models contain different perspectives on design, and on the challenges that designers face in work. Table 2.1 shows the models that were identified and their key concepts, and these are discussed and elaborated in chapter 3.

In terms of contribution to the wider research community, one should note that this is an original methical approach to theoretical assessment of design theory. Hart observes that quality criteria for reviews will rely on subjective judgments such as 'appropriate' breadth and depth, 'rigour' and 'consistency', 'clarity', 'brevity', and 'effective' analysis and synthesis. But there are few other reviews to compare and judge this review against. It is therefore uncertain to what extent the models here presented are new to the research community, or whether they can be expected to be common knowledge in this field. A claim is, however, that the review presents a way of understanding design theory that provides the a broad view of the idealized models of professional reasoning that have been employed in design theory, and therefore also new, coherent, insights on the issue.

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[8] Chris Hart, *Doing a Literature Review: Releasing the Social Science Research Imagination* (London: SAGE Publications, 2005). Chapter 6

Model	Typical works	Argument and main models	Model of professional reason	Key terms
Problem solving	Herbert A. Simon: 1. *the Sciences of the Artificial 2. The Structure of Ill-structured Problems*	Design is a type of problem-solving activity. Problem-solving is a core topic for cognitive science.	Ideally: Designers span out a problem-space, then systematically searches within this. In practice: decomposition into solvable sub-problems.	Design problem, problem structuring, problem-space, ill-structured problems, satisficing
Reflective practice	Donald A. Schön: *The Reflective Practitioner*	Design is a professional practice - the designer's competence is shaped by the materials and contexts of practice.	A *double design* process - Designers establish a design world and by a reflective conversation with the materials of the situation elaborate physical structures with reference to this. Problematic situatins may lead to restructuring of the product as well as the design world.	Reflective practice, problem setting, design worlds, framing
Normative	Classical: Vitruvius: *the Ten Books on Architecture*	Designers must assure that design solutions are fitted to certain standards, values or conventions in accordance with their role and responsibility.	Designers structure the professional task in accordance with one or several categorical systems. Joining and unifying the perspectives of these will be a muddled process.	Design for X
Hermeneutic	Hillier, Musgrove et al: *Knowledge and Design*	At the outset of a design process the potential opportunities and the choices that designers face are practically infinite. The designer must reduce this variety by establishing a directed understanding that reduce the variety and provide some guidance.	Designers search for simplified prestructures that are simpler and fewer than the constraints of the process. The solutions that are generated are subsequently evaluated against these constraints.	The primary generator
Social	Walter G. Vincenti: *What Engineers Know and How They Know It,* Louis L. Bucciarelli: *Engineering Philosophy*	Design activities are enabled by the social community in which they are situated; resources, competence, and formal bodies interact to establish a body of knowledge as common wisdom.	The social perspective treats reason indirectly – professional reason is not a personal competence, but based on the collective wisdom of a community of practitioners.	Object worlds, technological frame
Participatory	Rittel & Webber: *Dilemmas in a General Theory of Planning*	Designers pursue their own perception and understanding of design problems. It is therefore important to include the perspectives of the stakeholders in this process.	Designers must mend the gap between designers and users. This is a process of interpretation, information-gathering and facilitation.	Wicked problems

Table 2.1 – An overview of different perspectives on design collected in the review.

2.6.3 Review; using discourse to demarcate theoretical traditions

In the process of identifying literature, different conceptions of designing were actively sought out, while their quantitative influence (i.e. number of citations) were regarded as secondary. For this purpose, the review takes as its departure point a series of central theoretical disputes existing in design theory.

It could have been feasible to restrict the review to particular journals, e.g. the peer-reviewed Design Studies, or it could have been restricted geographically, e.g. Scandinavian textbooks on product design. But the assumption at the time was that restricting the review to a particular journal would have led to an unwarranted bias. The journal Design Studies was, for instance, perceived to favour a systematic and cognitive orientation, whereas the scope of Scandinavian textbooks was perceived to be quite small.

Instead, the review seeks to broaden the scope by focusing on canonical disputes in the domain of design theory. Over the history of design research, different authors have proposed and argued for different conceptual perspectives on design. The review makes use of these disputes to extract conceptually different conceptions of design. The procedure for this was, firstly, to start with conflicts that were deemed central, and record the idealised model or perspective on design that authors argued for.

After this, citation-mapping was used to identify the origins of those theoretical positions. 'Origins' were at this point understood rather loosely, as either adherence to the same concepts - case in point being the proposal that design is "wicked" problem-solving - or adherence to the same diagnosis of design - e.g. design is a social process. The citation-mapping was carried out in an explorative manner to identify and elaborate the models, or conceptions, of professional reasoning that underlie the positions of the various authors, and the procedure follows Small in what is termed "a snowball approach" to mapping science (Small 2003).

The process lead to the identification of some works that were perceived as canonical, in that they have provided central models and perspectives for how 'design' can (and allegedly should) be understood as a field of study. I.e. they are "schools" for design theory in that they have provided central models, concepts, and premises.

Conflicts in the design discourse

The disputes that were the outset for this review can be seen as different variants of the positivism-dispute. In different guises, they concern how theory for design credibly can and should be produced. Three variants of this dispute were identified. Either, these are theoretical disputes over how a theoretical field should be embodied; should it aim for design research being a cumulative science, or in another form? There are also conflicts over the process-model much used in design theory; i.e. should design be

described in the context of discovery and justification, or in another form? And finally, there are the disputes whether a design theory should be assumed to hold a deductive structure. (Cf. points 3, 8, and 6 respectively, Hacking's table, section 2.3.4.)

The first perceived conflict was the one that concerned the extent to which systems theory could serve as meta-theory for design theory. The debate, at heart, concerns how and whether 'design' can be formalised as a cumulative science (through logical or numerical means), and thereby has obvious percussions for how a design theory should be embodied. Central positions in this debate were perceived to be Simon (1969, 1st edition), who asserted that design problems have a formal structure, whereas Rittel and Webber (1973), argued that real-life problem-solving could not possibly follow such a technical pattern, as it would affect the lives and habits of real people with inherently conflicting interests. They termed design problems are "wicked", a notion that has raised considerable interest throughout the design community.

Although the theoretical dispute concerning the role of systems theory in a theory of design is an old one, it resurfaces in discourse at intermittent intervals, although under different guises. Among the protagonists for a systems view of design one find Jones (1970), who wrote one of the earliest textbooks on design methods, leaning heavily on Simon's ideas of structured problem-solving. Friedman (2003) uses Simon's ideas of "a process of goal-directed problem-solving" as departure point for an entire classification of design theory. And from interaction design, Carroll (2006) sees Simon's model as a beneficial framework for the inclusion of users in design processes (sic). In the opposing stance, one find Liddament (1999), who argues that the assumptions underlying the "computationalist" paradigm are outdated and flawed. Goel (1995), argue from a position inside cognitive science, Simon's original domain, that the Simon's theory is ineffective. And from interaction design, Kyng (1995) takes the opposite position of Carroll, arguing that the problem with system theories is that they exclude perspectives and interests of users.

Similarly, there have been disputes concerning the process-models of design; the variations over seeing design as a process of analysis-synthesis-evaluation. Kroes (2002), for instance, argues against "the process perspective" he sees as dominant in design theory. Earlier, Darke (1979), drawing on Hillier et al (1972), had argued for an alternative process understanding of design. This view is summarized by Bamford (2002) comparing what he terms "the two principal modes of design", analysis-synthesis and conjecture – analysis. The latter model has as its central feature that designers bring conjectures to the design task that shape the form in which solutions are produced. From the perspective of cognitive science, Gedenryd (1998), has also raised criticism of this model, arguing that it relies on a flawed cognitive metaphor.
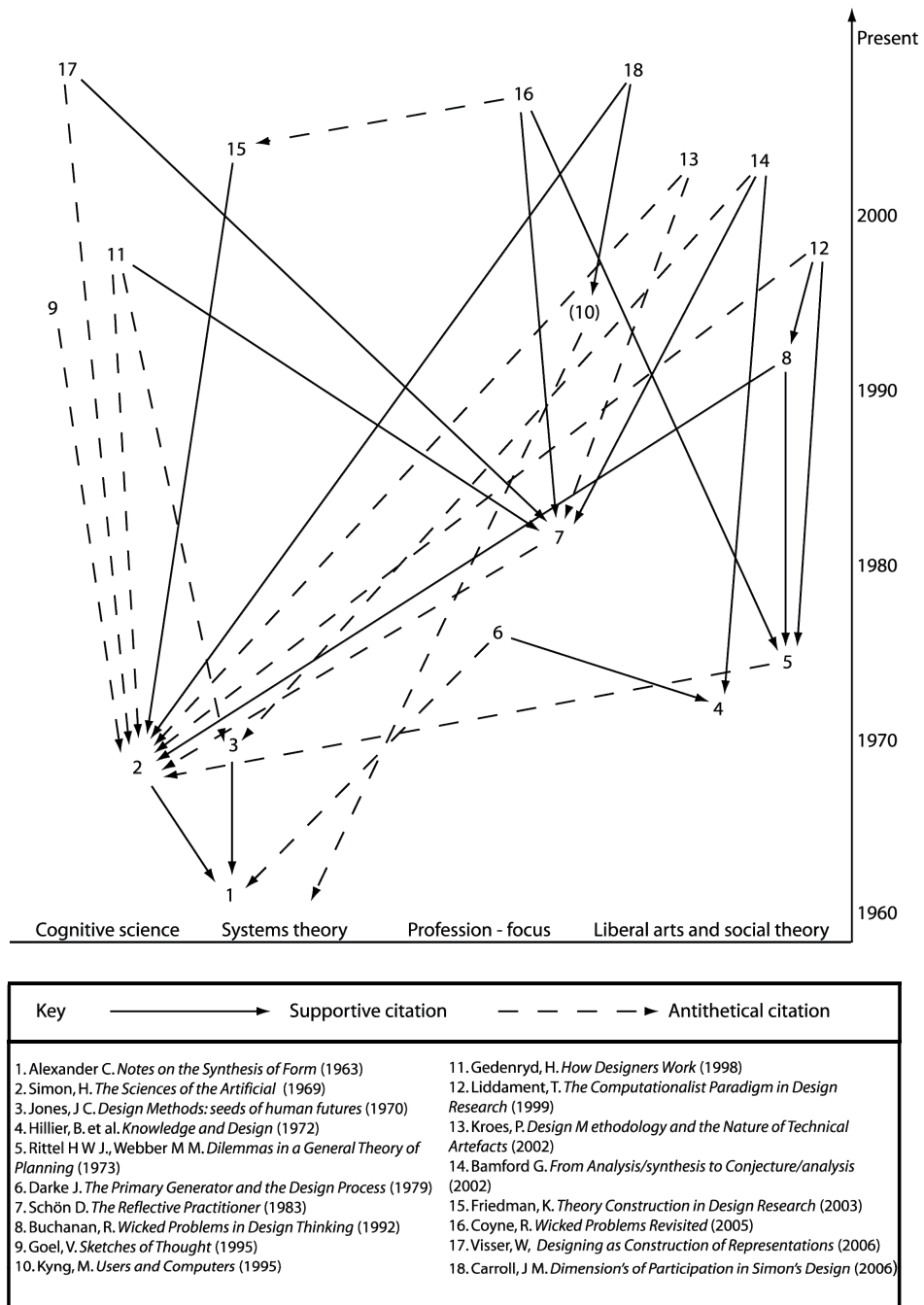
Present

2000

1990

1980

1970

1960

| Cognitive science | Systems theory | Profession - focus | Liberal arts and social theory |

Key ⎯⎯⎯⎯⎯► Supportive citation   — — — — ► Antithetical citation

1. Alexander C. *Notes on the Synthesis of Form* (1963)
2. Simon, H. *The Sciences of the Artificial* (1969)
3. Jones, J C. *Design Methods: seeds of human futures* (1970)
4. Hillier, B. et al. *Knowledge and Design* (1972)
5. Rittel H W J., Webber M M. *Dilemmas in a General Theory of Planning* (1973)
6. Darke J. *The Primary Generator and the Design Process* (1979)
7. Schön D. *The Reflective Practitioner* (1983)
8. Buchanan, R. *Wicked Problems in Design Thinking* (1992)
9. Goel, V. *Sketches of Thought* (1995)
10. Kyng, M. *Users and Computers* (1995)

11. Gedenryd, H. *How Designers Work* (1998)
12. Liddament, T. *The Computationalist Paradigm in Design Research* (1999)
13. Kroes, P. *Design M ethodology and the Nature of Technical Artefacts* (2002)
14. Bamford G. *From Analysis/synthesis to Conjecture/analysis* (2002)
15. Friedman, K. *Theory Construction in Design Research* (2003)
16. Coyne, R. *Wicked Problems Revisited* (2005)
17. Visser, W, *Designing as Construction of Representations* (2006)
18. Carroll, J M. *Dimension's of Participation in Simon's Design* (2006)

Figure 2.5 - A systematic perspective of conflicts in design theory

The last dispute which served as starting point concerns the relationship between design practice and design research. The argument is often raised that theorisers are out of step with the realities of design practice. This implies a dispute whether design theorists should frame this practice from the (assumedly deductive) design theoretical field, or whether they should frame it in the language and concepts of practitioners themselves. Schön (1983, 1st edition) proposed reflective practice as an alternative to "technical rationality", and Coyne (2005), sees a conflict between the theoretical "systemizers" and alternative conceptions of professionalism.

The review-material was generated by firstly, documenting various positions that had been central in these disputes and then trace the sources and references that authors in these disputes based their arguments on. By this approach, authors' conceptual positions on design reasoning could be visualized in a map.

Figure 2.5 displays these conflicts as a tool to arrange and visualize the reviewed material. The figure includes the timeline at which works were published, the theoretical domain that authors can be associated with, and the arrows indicate protagonist or antagonist stances.

2.6.4 Conceptual structure and black-boxing in design models.

After having identified these ideal models, the fourth chapter presents an examination of conceptual structures, i.e. the ontology, with three of the models. For exemplary purposes, the text compares the conceptual structures with three of the models and suggests how these influence the formation and development of theory.

The argument underlying the analysis is that the different models of design have as a fundamental trait conceptual structures which emphasise and highlight certain aspects of real-life design practice, while black-boxing others. The ontology of the model contains a terminology that provides parameters and invariants for inquiries, suggesting that observations and hypotheses will be coloured by the worldview inherent. The practical importance translate to situations such as when researchers choose to designate aspects of design work as e.g. either "structuring", or the establishment of "generative metaphors". The use of any given conceptual structure will skew inquiries, a fact of which awareness is needed in situations of inquiry and research.

For this research, a terminological procedure was followed (Cabré 1999). It consisted in extracting and documenting the significant terms with the models and identifying what kind of concepts and conceptual structures that were postulated for design. The terms used by authors in different traditions were registered and grouped according to the concepts they designated.

In this work, the prior identification of models is important, because terminological methodology requires that one identifies the 'conceptual structure' of a written corpus before one can extract terms or concepts from it. This is because the conceptual structure serves as a principle for interpretation; it is the conceptual structure that enables differentiation between terms that belong to a particular conceptual structure, and terms that are just elements in the larger language (Cabré 1999, pp. 132-136). The assumption was that these models of professional reasoning corresponded to what is terminologically understood as a conceptual structure.

This approach may be understood also as a general hermeneutic principle: When one extract terms from a large written corpus, the derivation of a structure will allow one to consider terms in relation to the overall intention of the corpus: One interprets the central concepts and elements in the theories by first assuming that the models in question are similar to the conceptual structure.

2.6.5 'Correspondence' - Discourse and criticism of the problem-solving model

The text in chapter five takes up under what premises idealised models will have its fair and proper application in research inquiries, i.e. the assumed correspondence between models and concrete design practice.

Given the nature of this practice, one could ideally expect design researchers to hold a repertoire of methods and approaches to design, and be familiar with advantages and limitations to different approaches, and the situations for which they applied. This implies ability to recognise concrete problems with a suitable framework, e.g. associating problems of cooperation with social models, associating problems of organisation with e.g. cognitive models and so on.

While working with this thesis, a striking feature was that real-life research rarely exhibits these rational characteristics. On the contrary, disputes in design theory often turn into as-is discussions on the nature of design; fierce discussions on the one correct way to depict and designate design practice.

As an afterthought, this is hardly surprising. The way researchers choose to idealise design is closely intertwined with their general perspective on the world, and their research orientation. One can assume that researchers have vested interests with promoting certain ways of idealising design because it is related to their self-identity as researchers, and the commitment that follows from gaining merit within certain research traditions. The obvious danger with this practice is that models are propagated throughout the research community on basis of habit and convention, rather than consideration of the problem at hand.

The general problem is that any research community has implicit drivers for conservatism in how problems are approached. The conflicts that arise from different worldviews and ideal models being argued are political in nature and cannot be "solved" analytically.

But these disputes in design theory over how practice should be understood and modelled provide access to many of the practical concerns that has arisen historically when researchers attempt to model design practice. The discourses can thereby present arguments and caveats that have been raised in the history of design theory, and be a source for more pragmatic reflections on the topic.

One such historical dispute concerns the proper role for and understanding of problem-solving models of design. This model of design has exerted much influence on design theory, possibly bordering dominance. The model in question can be traced to the cognitive information-processing programme of Newell and Simon (1972), and essentially regards design as a type of cognitive process.

In order to provide reflection over issues of modelling of practice, or choice between existing models, the aim here is to draw on the historical wisdom of the research community. The means is to display and structure the disagreements that have been prominent, and thereby provide insight on the practical problematic areas with idealising design. The problem of model choice is here approached in an exemplary manner. It is structured around the criticisms of one of the models, the problem-solving model, in a way that is intended to open reflection over how models can be judged and assessed also in general.

A problem in this regard is that the stances from which researchers have argued are uneven in their focus and understanding of design; the individual disputes don't address the same aspects with the problem-solving model. Rittel and Webber (1973) for instance, hold that the attempt to "scientise" design in itself is flawed and elaborate their criticism to a series of points with a technical conception of design that the authors find problematic. For Schön (1995), the criticism is indirect: it is the inherent positivism of the model that is problematic, but Schön's alternative is another scientific paradigm: pragmatism. Coyne (2005) on the other hand criticizes what he sees as a flawed conception of professionalism with systematic design methods in general. Since these discourses hold different foci, it has been necessary to equalise the arguments of these authors.

The approach has been to extract central stances, i.e. premises, from the problem-solving model and subject these to the historical criticisms of the design community. The critiques of these tenets were then structured as a series of arguments pro et contra this model to render this discourse transparent.

2.6.6 Discussion of the method

The research questions aim for the identification of "central models" in design theory. An important question is therefore whether the method undertaken here is likely to yield an overview of the most central models of professional reasoning; i.e. can the method yield an overview which is *representative* for design theory?

The answer relies very much with the conflict approach, and the postulate that the referenced works points to the central conception in design theory. Undoubtedly, this diagnosis relies with the author, and is shaped by this writer's horizon and understanding of the field.

Throughout the work, as one's understanding evolves, and knowledge grows, one discovers that there are more and even more models that could have deserved scrutiny, and which substantial groups of design researchers hold as idealisations for inquiries.

A case in point is the semantic tradition in design theory, exemplified with Krippendorff's "the semantic turn" (2006). The view with this tradition is largely that one should differentiate between "technology-centred" and "human-centred" design, and that design work implies the ability to negotiate products' meaning; meaning in use, meaning in language, and meaning in an "ecology of artefacts".

The reader will see that I in the succeeding text have treated this tradition as one of several "doctrinaire" positions. The tradition implicitly presents a normative framework for the issues and responsibilities that designers should undertake in the course of professional work, a perspective on design knowledge that can be traced to ancient texts as (Vitruvius 1914). But this is *my* interpretation and categorisation. Other readers may categorise the field differently, and read the semantic model as a holistic view of design activities.

Thus, the problem with choosing an adequate perspective and a system of classification for the models encountered is one that will impact the degree to which this text can be trusted and received by readers. The methodical challenge with any text of this kind is that examining a large and diverse theoretical tradition to a question of models is a project that requires making concessions.

The knowledge claim associated with the research questions should therefore be qualified: This thesis attempts to identify and examine idealised models of reasoning that are much used and referenced in design theory, but it is only one of several (and equally valid) perspectives on this body of theories.

A second potential problem with this method is the assumption of a static view of theory and theoretical meaning. The perspective underlying e.g. discourse analysis in

social theory is that meanings change over time as a discourse unfolds. Meanings and intentions in statements evolve as participants reframe and elaborate their argument.

An example is the cognitive model of design, derived from Newell and Simon's theory of information-processing which by this point has been argued to be a much used reference in parts of design theory. Goldschmidt, one of the central figures in cognitive design research, speculates that many of these references are not based on a deep examination of Simon's theories, but that they are rather referenced because such references provide access to the academic discourse (Goldschmidt 2008).

The implicit argument is that the way in which such theoretical frameworks are appropriated in design theory is not only a matter of 'design theory' appropriating models from 'science', but that several parallel discourses exist; Both the way in which cognitive scientists understand the problem-solving model, and the way in which design researchers understand the problem-solving model. A question that could have been raised is therefore how the theoretical models taken up here are used on a daily basis, and how they have their implicit meaning has changed over the history of design research.

Thus, the static understanding of 'theory' and 'model' assumed with this thesis risk petrifying stances which are somewhat different from everyday usage in parts of the design discourse.

While this point probably is important to keep in mind for the reader, the scope of such an examination would have been too large to pursue within this thesis. The view here is simply that overview of these models is beneficial, but notably, it is the *historical* and *original* meaning that is the focus of attention

A procedural risk with the method also needs mentioning; the operative definition of 'ideal models' is vague, opening for subjective interpretation of authors' standpoints. The interpretation of theoretical perspectives and positions will give simplified depictions of the assumptions that authors have employed in inquiries on of concrete design issues. It can therefore be argued that the positions presented in this thesis are stereotypes; positions that few writers in reality ascribe to, and which are qualified by the concrete problems and concerns of individual writers. It has been necessary to do so, however, to render the points in this thesis explicit.

Lastly, the reader should be aware that employing the semantic view of theories in the manner here might leave the impression that this perspective is philosophically uncontroversial. The reality is far from it. In the current discourse there is much debate over the correct understanding and depiction of models, and associated issues such as whether the relation between models and the target phenomenon can be characterized as *isomorph* or *similar* (Teller 2001)*,* whether the model view leads to *relativist* accounts

of science (Giere 2004), the unclear role that language have in models (Frigg 2006) and even over the most fitting or correct depiction of semantic models themselves (Suppe 1977). What remains uncontroversial, however, is the general claim that scientific inquiry relies on idealised models of its target subject.

3 - Models of design as professional reasoning

The review in this chapter identifies six models of professional reasoning. It takes up the background and context for these models, the characteristics to the models, and discusses how these conceptions will influence theory-production in the design domain.

Motivating the inquiry is a central problem in the endeavour of documenting insights and producing theories in the design domain. How does one "observe" and generally theorise 'design'? It is not self-evident how insights from one particular design project can prove anything for another design project. Premises of any project will vary and the contingencies of individual design projects are significant, so a common-sense argument is that one must be cautious about inferring across such a large and eclectic body of practices.

A key element in the domain is therefore the assumptions laid down on the nature of this practice: Which tasks it typically consists in, the context in which this practice takes place, and the elements and behaviour postulated for this practice. Assuming theoretical coherence for the domain is a necessary step in rendering it homogeneous and comprehensible, so that insights can be transferred from individual projects to the knowledge of the larger domain (See e.g. Hendricks et al. 2000).

One way to understand such pre-theoretical assumptions is to hold with the semantic view of theories the view that any theorising significantly relies on models. I.e. by postulating an abstract and ideal entity of the real-world phenomenon, theories can be judged as true or false with reference to this ideal model.

Here, model-theory is used to explain a group of such models; the models of professional reasoning that underlie design theory. 'Professional reasoning' is here understood as the implicit depiction of the reasoning process typical to design practice.

In existing design theory, many such depictions exist. Some authors have assumed that the design process is a hypothetic-deductive process akin to scientific reasoning. Others have held that the reasoning that characterise design is a social process, where several stakeholders or groups interact, whereas others have seen reasoning as a

reflective conversation with materials. If these models are used as assumptions underlying inquiries, they will provide much of the rationale for theory-production. A more detailed understanding of these models may therefore display important characteristics of the theoretical traditions in design theory, and thereby aid readers in navigating the many traditions existing.

This chapter presents and elaborates these models. The focus for this presentation is how these models depict professional reasoning, the central stances with these models. The cultural context; tradition or research program, from which these models have emerged are presented, and the ways in which they constrain design theory are sketched out.

3.1 The problem solving model

Large parts of what is often termed systematic design theory, for instance the Design Methods Movement, are based on the problem solving model of design**.** The model has its background in the information-processing theories of cognitive science associated with Newell and Simon (1972). Particularly Simon's contributions to design theory (Simon 1973, 1996) can be considered seminal, as they have an explicit design focus and are much referenced (Gedenryd 1998).

The historical background for the problem solving model is complex and its emergence appears to have been part of a historical trend: Many practically motivated works on design from the same time also describes design by the same depiction as Newell and Simon: as a goal-oriented, tractable process, moulded in the tradition of decision-theory and systems theory (e.g. Asimow 1962).

Understanding the problem solving model may require a recapitulation of the scientific discourse at the time of its conception. In the 1950's, behaviourism was a leading psychological paradigm (Rowe 1987, p. 44). Behaviourism had emerged as a reaction to mentalism, i.e. it rejected all attempts to study inner mental processes on the account that these were unobservable, and therefore unreliable as a subject of any scientific study. For studies of problem-solving and creativity, the stance caused obvious problems, as behaviour in these areas to an undefined extent will rely on the thought processes of the problem solver.

From the perspective of cognitive science, Newell, Shaw and Simon proposed a solution to this gordic knot in the paper "Elements of a Theory of Human Problem Solving" (Newell et al. 1958). They proposed to understand problem-solving behaviour by way of basic information processes, holding that explanations of human behaviour in this respect can be given by the "program" that underlies this behaviour. They thereby reasserted the primacy of cognitive processes, although in a cautious manner as they maintained an analogy between thought and the physical processes of a computer; the computer's processes having the clear benefit, in this regard, of being observable[9].

As a framework for design, the problem-solving model was introduced to design theory through several routes. On one hand, Simon argued vocally that design was a natural sub-field in a theory of problem solving (Simon 1996). Simon argued for *a science of design;* a science of the contingent, which could embrace the professions of engineering, medicine, business, architecture, and painting.

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[9] See e.g. Herbert A. Simon, *The Sciences of the Artificial* (3rd edn.; Cambridge, Mass.: MIT Press, 1996) XIV, 231 s., p. 21

Many practically focused design theorists have picked up the perspective of problem solving, presumably because it provides scientific authority and credence to their theories (e.g. Jones 1970; Pahl et al. 1996). The problem-solving program has also been furthered as a particular branch of study in design theory (e.g. Akin 1986).

Recapitulating the stances of this program is rather extensive, as the positions have been the backbone of fields such as cognitive science and artificial intelligence. But the central positions are: Design is a kind of problem-solving. It can be understood as a problem space (P), which is a set of elements or potential choices. Within (P), there is a sub-set of solutions (S) that the problem solver seeks to find, i.e. the solutions that provide a satisfactory outcome. An illustration that the authors use is to think of the problem-space as a crossword. P is then all the possible words in the English alphabet, whereas the subset S is *those combinations in which all consecutive linear horizontal and vertical sequences are words that satisfy specified conditions* (Newell et al. 1959, p. 11).

Central in Simon's view of design is that it is a process that seeks to attain goals by adapting the inner environments (of products) with its outer environment; mapping the structure of the product with its function. The mental process for finding solutions consist in two types of processes: One is the solution-generating processes, e.g. trial-and-error searches. Another is the verifying processes which evaluate the merit of a tested solution, through means-end analysis (Simon 1996, pp. 128-129).

A central stance is that a product, understood widely, has a structure; it represents a hierarchy which allows the designer to decompose the design problem into smaller sub-problems which can be solved individually. Using architecture as example, Simon argued in *The structure of ill-structured problems* (Simon 1973):

> *The problem space is not defined in any meaningful way, for a definition would have to encompass all kinds of structures the architect might at some point consider, all considerable materials, all design processes, and organizations of design processes (pp. 187-188).*

Instead, the designer *decomposes* the design problem into smaller sub-problems. By moving down in the hierarchy of functions, the architect will discover sub-sets of problems that are amenable to structured problem solving:

> *Applying the same linguistic metaphor to house design, "house" might transform to "general floor plan plus structure", "structure" to "support plus roofing plus sheathing plus utilities", "utilities" to "plumbing plus heating system plus electrical system", and so on (p. 190).*

The reason that a design problem presents a challenge has to do with the limits to human reasoning, the *bounded rationality* of humans. Simon does not regard design problems as problems of understanding or interpretation, but as problems of processing,

i.e. the cognitive capacities for information-processing. Humans are seen as quite simple *behaving systems*:

> *The most striking limits of subjects' capacities to employ efficient strategies arise from the very small capacity of the short-term memory structure (seven chunks) and from the relatively long time (eight seconds) required to transfer a chunk of information from the short term to long-term memory" (Simon 1996, p. 81).*

As a model of the professional inference of design practice, the problem-solving model suggests three points: One is that 'design' is a matter of matching solution structures to the requirements of the situation. It is a process where solutions are evoked or generated from memory, and tested, to see whether their application is conforming to requirements. Secondly, the judging of appropriateness takes the form of a means-end analysis, which Simon termed *satisficing:* The designer seeks solutions that are "good enough", not optimum ones, as it is practically unfeasible to believe that one can find such an optimum solution. Thirdly, due to the complexities of real-life, design problems need to be structured: Design problems are decomposed into smaller problems that can be solved in a nearly individual manner before being put together to an overall solution.

What consequences does this model hold for the production of theories and hypotheses in the design domain? First of all, Simon promotes a *Science of design;* a cumulative and falsifiable theoretical field of designing. The aim was to elevate the status of designers by producing an empirically testable theory of the issues relevant to the design professions (Simon 1996, p. 114).

The main challenge in design practices, as Simon saw it, was the limited cognitive capabilities of humans. Correspondingly, he argued for theories that could aid the problem-solving involved in design: General strategies that can be employed across a large range of projects and which includes *evaluation, formal logic, heuristics for search, a theory of structure, and a theory for representation. (Simon 1996, p. 134).*

One thing that should be particularly noted with this model is that it excludes what we normally think of as knowledge. Simon emphasised that his theory of design was *complementary* to basic knowledge of solutions (Simon 1996, p. 135). So the repertoire that the designer draws from when generating solutions is simply assumed to "be there". Designers must turn to other sources if they are to acquire solutions and techniques that are to be reapplied in new projects.

The impact this model has had on design theory is huge. Many writers ascribe a central historical role for the problem-solving model in design theory, arguing that it was one of the first that abstracted the design process from the product, and dared to do so in a systematic way. It has even been argued that it serves as a "default model" of

design in design theory (Coyne 2005; Dorst 2006). It has thereby provided stances and ways of thinking about design that has moved into the general discourse; *problem-solving, structuring, decomposition,* are examples of concepts that can be traced to this model.

The problem-solving model's influence on design theory can be witnessed in e.g. how the topic of *representation* is a dedicated topic of study in design theory (Porter and Goldschmidt 2004; Visser 2006).It can be found with developments of formal models of design, e.g. the F-B-S model (Gero 1990). It can be found with research that develops Simon's model and tests the boundaries of it (Goel 1995). Applications developed for the purpose of easing or aiding the cognitive problems with designing (Restrepo 2004). And it can be found with the tradition for relying design research with laboratory, or protocol-studies of design (Dorst et al. 1996). Furthermore, the conception of design as a goal-oriented decision process, is a often used as a basic model in textbooks on design, e.g. (Jones 1992; Roozenburg and Eekels 1995).

3.2 Reflective practice

The model of design as reflective practice is characterised by a constructivist understanding of knowledge and therefore posits a central role for tools, media, and the social contexts in which design takes place. The underlying perspective is that if there is such a thing as "designerly reasoning", then the sketches and models that designers normally use must be considered elements in this process. This perspective on design is commonly associated with Donald Schön, who relied on Dewey's theory of inquiry when the theories on design were formulated (Schön 1992, 1995).

Schön's theories on reflective practice extend to all of professional practice. But a substantial part of these theories concern design practice specifically, typically architects, industrial designers and engineers. Central for these theories is a diagnosis and warning that far too often, professional practice is conceived as a form of applied science; i.e. that professional work is the mere "execution" of a master science. Typical instances of this are when engineering is understood as merely a subset of mathematical and physical science, or medicine a subset of biology (Schön 1992, p. 119).

Rather, Schön argues, knowledge emerges from the context of practice. By interaction with the tools and materials that are common to the practitioner, and by dialogue with clients, practitioners establish knowledge that is particular to the practice they carry out. In the view of Schön, practitioners have their own esoteric knowledge codes woven into practice, and he is concerned with how these ontological differences in our ways of seeing the world will shape and influence our professional work, hence the constructivist underpinnings of this theory.

In Schön's view, design is an instance of Dewey's *transactional inquiry* (Schön 1992, p. 127); a kind of inquiry *shaping and then shaped by a problematic situation.* Thus, design is not seen primarily as solving a problem, but about making sense of the design task: *In order to convert a problematic situation to a problem, a practitioner must do a certain kind of work. He must make sense of an uncertain situation that makes no sense* (Schön 1995, p. 40). The inquiry of the designer depend in a significant way on the context of practice, its tools media and clients: *The inquirer does not stand outside the problematic situation like a spectator; he is in it and in transaction with it* (Schön 1992, p. 122).

Concerning the professional reasoning in design, Schön depicts this as a *double* design process. On the one hand, designers construct, from a given technical universe, a (wholly mental) *design world* and within this world, the particular structure, or product, is built (Schön 1992, p. 129). On the other hand, this object world is put to the test by the moves and experiments that designers carry out in the real-world, particularly with the materials of the situation.

To begin with, the designer establishes a design world[10]- or frame – on basis of the prestructures and appreciations that the designer holds. Establishing the design world is "problem setting", i.e. the designer decides the meaningful framework for understanding the design problem. This framework includes such items as: names of elements, features, relations, actions, and of norms used to evaluate problems. A design world is not necessarily an objectively true description of the design problem, in the way a problem-space is taken to be in cognitive theories, but is a subjective perception of the design problem. It relies also on the preferences and appreciative judgments of the designer.

The design world serves for the designer as a frame-of-reference for thinking about the design problem. But the elaboration of new solutions is not solely a cognitive effort. The designer elaborates the understanding of the design problem through a *conversation-like transaction with the materials at hand* (Schön 1992, p. 125). By various forms of interaction, the designer manipulates the design worlds and the designed object, testing own understanding of the design problem as much as testing the particular structure. By this interaction the designer arrives at new and more certain insights. This in turn could lead to either the elaboration of certain proposals or it could lead to the designer realising he is holding a limited or flawed understanding of the design problem. In such instances, the designer must reconsider his initial understandings and reset the design problem. The situation "backtalks" to the designer and the backtalking is a central element in professional reflection.

The fluency and ease with which designers alternate between design worlds thus is a central parameter in good design practice. Schön uses an anecdotal example from product development to explain this argument:

> *Some years ago, a group of product-development researchers was considering how to improve the performance of a new paintbrush made with synthetic bristles. Compared to the old natural-bristle brush, the new one delivered paint to a surface in a discontinuous, "gloppy" way. The researchers had tried a number of different improvements. They had noticed, for example, that natural bristles had split ends, whereas the synthetic bristles did not, and they tried (without significant improvement resulting) to split the ends of the synthetic bristles. They experimented with bristles of different diameters. Nothing seemed to help. Then someone observed, "You know, a paintbrush is a kind of pump!" He pointed out that when a paintbrush is pressed against a surface, paint is forced through the spaces between bristles onto the surface (Schön 1995, p. 184).*

The argument being, that the appropriate reframing of the design problem leads to the elaboration of new and better solutions.

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[10] Throughout the writings, Schön uses several terms for mentalist concepts, many of which appear interchangeable. A synonymous term for 'design world' is 'frame'.

The view of knowledge and learning that Schön establishes with this model breaks with the positivist conception of applied science that underlies e.g. Simon's theories on design. Instead, they see design practice as a context for *generating* knowledge, and not for *applying* knowledge:

> *In this sense, designing serves as preparation for further designing – both within and across the boundaries of a local design episode. We speculate that designers are able to store the discoveries that result from past projects, carrying them over to new design situations that trigger them, on the basis of features perceived as similar. So designers may acquire the ability to operate simultaneously in multiple domains, spin out complex design scenarios, and think about larger and more complex move experiments (Schön and Wiggins 1992, p. 155).*

Therefore, Schön argues that important theories, concepts and categories are formed by designers in their work, and that this knowledge is possible to generalise also for other design projects. But Schön also holds that while design is learnable, it is not didactively or discursively teachable: design relies upon the ability to recognise desirable and undesirable qualities of the discovered world. But novice students do not possess this ability, and it cannot be conveyed to them by verbal descriptions. Hence, it must be learned through apprenticeship in a novice-expert relation. Schön does concede also a role also for more traditional forms of research, suggesting that these may be of four types (Schön 1995, pp. 307-325):

- Frame analysis – the study of the ways in which practitioners frame problems and roles.
- Repertoire-building research – accumulating and describing exemplars.
- Research on fundamental methods of inquiry and overarching theories.
- Research on the process of reflection-in-action.

In the same way that the problem-solving model excludes basic knowledge, the reflective model is also somewhat silent on these matters. Waks (2001) raises a question on where the appreciations and "prestructures" that designers use can possibly originate. And he continues to ask where designers can learn acquaintance with the many tools and materials that they are presumed to master under Schön's model. The apparent answer is that such general knowledge, as well as skills with tools, is learnt through general education, which is the very kind of education that Schön can be read as defining out of a design curriculum.

Schön's theories for understanding design have influenced and shaped design research in many ways. The model of reflective practice thus provides rationale and

focus for subjects that have resonated with many design researchers. The view that designers have their own distinct culture, shaped by the profession is also something that has gained resonance in the discourse. Cross argues that Schön is fundamental in understanding the underlying forms of knowledge particular to the designer – the designerly ways of knowing:

> *Following Schön and others, many researchers in the design world have realized that design practice does indeed have its own strong and appropriate intellectual culture, and that we must avoid swamping our design research with different cultures imported either from the sciences or the arts (Cross 2001, p. 55)*

Schön's model for example allows for a focus on how materials "talk back" to the designer during the design process, where an applied example is (Dearden 2006), and it allows for inquiries into how designer set problems and impose meaningful frameworks to design, an applied example being (Adams et al. 2003).

3.3 Doctrinaire models

In design literature one will often find explicitly normative perspectives providing doctrines and categorical systems for how design work should be organised and carried out. These works present statements of values and thus of priorities to be aspired toward in design practice. This is a traditional way of formulating theories in the design domain, with e.g. Vitruvius' Ten Books on Architecture, as the classical example (Vitruvius 1914). The example categorically states that architecture must aspire towards the qualities of firmitas (strength), utilitas (utility), and venustas (beauty), as these are seen as the ethos and responsibility of the architect, which illustrates the general characteristic to the doctrinaire model: That a particular set of knowledge, or doctrines, are prescribed as the framework by which designers should approach and treat a design problem.

The doctrinaire perspectives can be witnessed in the many Design for X publications, both of instrumental and more affective nature: Design for a better world, (Papanek 1984), Design for production (Boothroyd et al. 2002), or Design for product understanding (Monö 1997), to mention a few.

The doctrinaire model covers a wide and varied practice, and contains the largest sub-set of publications of the models presented here. When categorised in this manner, the doctrinaire model includes, for instance, publications on ecology (holding that designers should take responsibility for sustainable aspects of products), semantics (holding that how products communicate is a responsibility of designers), or ergonomics (holding that physiology and cognition are central elements in design work)

To understand the underlying perspective on design in such works, this text relies on an account given by Rowe (1987). In a discussion of architectural theories, he holds that doctrinaire theories are characteristic to the field. These formulate the ways in which a design task should be approached, and the normative stances the designer should uphold when undertaking such tasks. They provide organising principles for design work, and thus are a central element in the intellectual structure of the profession:

> *To achieve an adjudication of merit that transcends personal likes and dislikes would also seem to require inspection, discussion, and debate about the perspectives through which organizing principles and constraints are supplied. Otherwise, important issues of applicability, appropriateness, opportunity and real enhancement of a problem cannot very well be broached. Therefore, it is to the normative perspectives that supply and shape organising principles that we should turn in order to develop a more thoroughgoing account of inquiry in architecture and urban design. (Rowe 1987, p. 113).*

These "normative perspectives" come in many forms in design theory. They range from doctrinaire positions, which are guiding principles for design work, via prescriptions of those elements that should be given primacy in a design process, to categorical systems, which are frameworks that elaborates, connects, and sustain norms and categories for separating the important from the unimportant.

As a general characteristic, Rowe suggests that the basis for doctrinaire theories is the assessment of an unfavourable practice within the profession:

> *These normative perspectives can generally be found to include the following elements: 1) The location and identification of a problem or pertinent issues under contention, 2) an unfavourable assessment of prevailing practice and an enumeration of untapped opportunities, and 3) a counterproposal with its rationale (Rowe 1987, p. 113).*

Doctrinaire theories thus provide designers with a theoretical basis for structuring and organising the design task, based on a preceding diagnosis of the design profession's role and poor or unwarranted practice. They conceive design as a form of professional expertise, which implies a specific professional responsibility and a social role. The implicit normative stances thus aim to influence this practice by steering clear of unfavourable practices, and encouraging beneficial ones conveying for instance, historical traditions, professional conventions or more technical standards.

Among the examples of normative perspectives, most designers will be familiar with the presence of doctrines for design work such as "form follows function" from their studies and the general discourse. They will also be acquainted with more elaborate categorical systems such as the mentioned Design for X approaches. These are important elements for the development of design competence and ability, as they provide metaphorical understanding of design work and its challenges, canons in the profession's history, central exemplars and common professional principles.

The implicit model of professional reasoning with this tradition is that a design task involves reflection against several kinds of standards and conventions, beyond the particular constraints given in a design project. It is not only the requirements of the task that, in a "technical" manner will provide the normative grounding for design decisions, but a large range of standards and conventions that follow the responsibility of the design profession. In order to organise and structure the many potential decisions the design process presents to the designer, he/she will negotiate a number of normative frameworks, ranging from simple doctrines to more elaborate and substantial categorical systems. So, reasoning in design can be considered as navigating between rival frames of reference that impose different standards for the project to be designed.

However, the many normative perspectives present the designer with a new problem of choice. He/she must decide which of the many known normative perspectives that are fitting for the concrete design task and he must make priorities between the perspectives that are relevant. One of the pressing problems, once categories have been defined, *is the assignment of priorities among the aspects that are to be considered good and proper (Rowe 1987, p. 145).*

In practical terms, this implies that the designer may at some point in the design process find himself in a trade-off situation, where the requirements of the many standards and conventions will need reconciliation. With a caricature, such a trade-off situation will occur when the technical requirements of production are found to conflict with more functional criteria, or conception of "desirability". How should one go about to assign priorities in such a situation? There are no clear stances on how such priorities should be made, but Rowe suggests tentatively that designers may structure such choices by drawing on moral philosophy.

The general view on theoretical production in the design domain is one that markedly differs from a scientific conception of cumulative growth in knowledge. The normative perspectives emerge from a *diagnosis* of some unfavourable practice in design. This means that they are founded in an understanding of design's role and potential in the society or in practices in the community of designers. For instance, Design for X, follows this depiction, where, with the mentioned examples, Papanek grounds his views with a diagnosis that designers contribute to the unfavourable effects of the consumer society. Monö, on the other hand, diagnosed that designers needed better knowledge on communication theory, whereas Boothroyd et al sensed the need for better knowledge on production practices. Even though the knowledge in these individual domains may develop according to strict epistemic standards, the underlying diagnoses are political and ideological, rather than scientific ones. They cannot be logically argued as their credibility resides with the authors' ability to sense real and pressing problems that are current to groups of, or all, designers.

3.4 The hermeneutic model

A hermeneutic model of design has been proposed on several occasions in design theory (Bamford 2002; Coyne and Snodgrass 1992; Darke 1979; Hillier et al. 1972). A unifying characteristic of these proposed models is a concern for how design practice is experienced by design professionals, and a focus on the processes of understanding during design work. Coyne and Snodgrass argue that the aim of design models should be to understand and describe how the designer works:

> *This involves a close examination of: the part interpretation plays in the design process; how preconceptions function in the process of selection and evaluation; how preconceptions lead to prefigurations of the design product; and how tacit experience and skills enter the situation (Coyne and Snodgrass 1992, p. 74).*

From a hermeneutic perspective, the central challenge of design work is to gain an understanding of the designed product; its contexts, its values, and its functions. At the outset of a design process the potential solutions and the choices that designers face are practically infinite. The designer must reduce this variety by establishing a directed understanding that reduce the variety and provide some guidance. The process of gaining such understanding is gradual. The designer will move from an initial vague, or fuzzy, understanding of the design problem to some core ideas about the design which then are gradually tested and developed. Throughout this process, the preconceptions and the strategies of interpretation that the designer employs will be determinants that shape the course of the design process.

The hermeneutic perspective was proposed out of discontent with the much used *analysis-synthesis-evaluation* model of design work, i.e. a traditional process model, and the model has a partial precursor in Popper's model of scientific discovery (Bamford 2002) (Hillier et al. 1972).

If one follows Darke's conception of the hermeneutic model (Darke 1979), the reasoning of the designer does not begin with a list of requirements or a brief. The designer begins the reflection in the design process with a prestructure; an idea or a group of related concepts that Darke terms *primary generators*. These prestructures are, as Darke holds a designer-imposed constraint that functions as: *A way in to the problem* (p. 38). They are needed to reduce the large number of potential solutions that designer would otherwise need to consider: *Only by prestructuring any problem, either explicitly or implicitly, can we make it tractable, to rational analysis or empirical investigation* (p. 38).

The primary generators, together with the broad requirements of the task are used in arriving at an initial conjecture or concept. Once the initial concept has been generated, it is tested against the requirements and modified if necessary. This process is spiral or iterative in character. Hence, the design process is seen as a process of *generator – conjecture – test*, and not the traditional model *analysis – synthesis – evaluation.*

The underlying perspective on design is that designers use considerable resources on establishing simple prestructures that guide subsequent designing. These prestructures are the designer's way of understanding the design problem itself and will significantly shape the design process. This view contrasts with e.g. problem-solving, which does not differentiate between ways of seeing the design problem, and regards understanding processes as secondary to a design theory.

As a general model of design processes, the hermeneutic model will influence inquiries and theories, by a more articulate concern for the processes of understanding and interpretation. This influence may be somewhat paradoxical however. Darke used the hermeneutic model to call for the *revaluation of subjectivity* (Darke 1979, p. 336) in design theory. The hermeneutic model implicitly posits the designer's personal experience of the design process as a central element. But this raises a methodical problem: How can a general program of subjectivity be pursued? If the design process relies significantly on the personal and the intuitive, it may seem to render the design process as entirely personal; one can say little more about design practice than noting that some people are more creative than others.

An answer to such a methodical challenge may be given by Lawson. Design in Mind (Lawson 1994) presents a series of interviews with designers. Lawson used the theories on the primary generator as underlying model for interviewing these designers on how they understood and approached the design process. As such, the research was in the form of qualitative interviews, but Darke's model was the underlying explanatory framework of the process. This could suggest that as a research program, the hermeneutic model implicitly calls for interpretative research on designer's ways of establishing structures and understandings for the design process.

As a general perspective for design, the hermeneutic model provides a focus on how designers think about their projects. The hermeneutic model has therefore a natural affinity with vision-models from the management literature, and there are many hybrid-models from this literature that resemble the hermeneutic model (e.g. Lerdahl 2001). The hermeneutic model is also akin in principle to the Vision in Product Design model (Snoek and Hekkert 1999), by focusing on the way designers establish goals and contexts in their design projects, and the impact that these have for the design process.

The impact of the hermeneutic model in design theory appears paradoxical. For a long time, Darke's paper was the most quoted one in the journal Design Studies. But

Darke's model positions itself in a humanist tradition in design research by its concern for understanding and its use of mentalist concepts. But at the same time, the model is based in the scientific and systematic tradition of design theory, through its inclusion of basic process-models, its conception by means of falsifiable scientific methods, and its use of the concepts in this tradition. Few would deny the general soundness of the hermeneutic model, but it may be suggested that the hermeneutic model has served mostly as a corrective to the scientific models of design by pointing out the inherent limitations and qualifications in these approaches, rather than as a full-fledged tradition for research.

3.5 The social model

A social model of design is proposed by authors who in different ways argue that the community of design practitioners can be considered as a social field that holds their own norms and kinds of knowledge. Designers belong to a social group which has its own stances, knowledge and models which allows for efficient and proper solving of design problems. The membership in a professional group thus is a strong influence on how individual designers perceive and deal with professional problems.

This perspective on design is rooted in social theory, and has been argued in design theory by, among others, Vincenti, who argues that technology must be considered an autonomous form of knowledge (Vincenti 1990), and Bucciarelli, who introduced the term *object worlds* to denote how different designers "see" their object differently, depending on the communities they belong to (Bucciarelli 2003). The account here relies on these authors, in addition to the tradition in social theory called Social Construction of Technology (SCOT) (Bijker et al. 1987).

With the view of the social model designers will, as a group, institutionalise certain ways of understanding and solving problems that are typical to the professions dealings. The knowledge that goes into solving typical problems can be termed a technological frame (Bijker 1995). A technological frame is not knowledge in the sense of an objective, scientific theory, but is more like the disciplinary matrix of Kuhn; knowledge of product conventions, catalogues of examples of similar artefacts, typical problems that are faced in design work and strategies for solving them, as well as tacit knowledge. It includes abstractions, heuristics, generic conceptual tools and other "tools for thinking" on the design problem. As Bijker states:

> *Technological frames provide the goals, the ideas, and the tools needed for action. They guide thinking and interaction. A technological frame offers both the central problems and the related strategies for solving them (Bijker 1995, p. 192).*

The repertoire of a technological frame consists in knowledge in several forms: abstractions, metaphors, common problems, exemplars, product conventions and others. Bijker proposes that the elements in a technological frame can only be tentatively listed, because the important elements will change from group to group. The tentative proposal is that a frame may consist in: *Goals, Key problems, Problem-solving strategies, Requirements to be met by problem solutions, Current theories, Tacit knowledge, Testing procedures, Design methods and criteria, User's practice, Perceived substitution function, and Exemplary artefacts* (Bijker 1995, p. 123).

Central to the evolution of a technological frame for a professional group are the typical problems that said group encounters in their work. The frame is institutionalised

in the community of practitioners as beneficial ways of thinking and reflecting on common design problems. The concrete and practical problems that designers encounter in their work are taken to hold reoccurring and general characteristics. Such reoccurring characteristics can be, for instance, the deep and detailed knowledge that designers develop when they work on the same product group or product type, another is when designers work for the same company or particular business, a third is when designers gain experience over time with particular technologies, materials or functions.

The community of practitioners is therefore central with this model. For one, the professional community is a beholder of professional knowledge; the relevant professional knowledge covers a wide range of knowledge-items, from rules-of-thumbs to formalised knowledge. Secondly, it is in the community, on the job, that relevant knowledge is established and propagated, and thirdly, the community id the main source from which such knowledge can be learnt.

According to this account, the process of reasoning that a designer undergoes when solving professional problems will be twofold. It firstly involves the identification and categorisation from a professional task the sub-problems that can be considered typical from those problems that are new and require trial-and-error. Typical problems can be solved nearly automatic drawing on existing knowledge, whereas trial and error approaches will require a more cumbersome working process. (Vincenti 1990, p. 45).

Since professional problems in the design profession will hold some similar characteristics, there will be an impetus to develop professional knowledge that may ease judgement and reflection on the particular kind of problem. Central for effective professional practice is therefore the membership in a profession, where designers can learn "the tricks of the trade", i.e. the technological frame.

What this model implicitly says about knowledge and learning in design is that for design practice, the social communities, and the ways knowledge is established and codified in these communities is important.

For one, it holds a very open understanding of what "knowledge" is. It gives attention to varied forms of knowledge, that often fall out from more formal scientific models of design practice: It includes tools to think with, product conventions, fundamental exemplars, and the many simplified models and theories that designers make use of. This also implies that the documentation of such elements may be valid and useful outcomes of design research itself.

Secondly, the social model assigns a central role to the social field that a community of design practitioners is and the institutions of these fields such as schools, chartered societies, and government organisations because they have a central role in codifying and formalising this professional knowledge. Vincenti for instance, studied the

evolution of engineering knowledge across the aviation industry in the 20th century, and showed an array of interactions between schools, practitioners, and government bodies, which led to the codification of what one today considers formal knowledge in this area (Vincenti 1990).

A general heuristic that emerges from this model of design work is a memento to look beyond internal accounts, and consider the competence and strategies of the design group or community; the "groupthink" that a set of designers employ on a set of tasks. It also encourages comparing strategies between groups of designers or between other professionals and to base such comparison on a wider understanding of knowledge than a positivist account of scientific knowledge.

3.6 The participatory model

The participatory model of design implicitly sees the designer as a facilitator; understanding users and their interactions with a product as a complex task that requires from the designer both an empathic perspective as well as a set of tools and knowledge for understanding users. The background of the participatory model can be traced to the critical theory that emerged in the 60's and 70's. In conjunction with the general perspectives at the time, design theory saw the emergence of conferences that explicitly focused on participation (Cross 1972), contributions that questioned the theoretical foundations of means-end reasoning that systematic design methods were based on (Rittel and Webber 1973), as well as an increased sense of social responsibility and community consciousness (Sanoff 2007).

Participatory design has had a marked influence in computer science (e.g. Kyng 1995), and environmental design, (e.g. Sanoff 1999). Participatory approaches in other disciplines, such as product design, extensively rely on and reference these traditions. Some examples with a focus on product design are scenario building (Fulton and Marsh 2000) and context mapping (Stappers and Sleeswijk Visser 2007).

Attempting to ring in participatory design illustrates the fuzzy disciplinary edges in design theory. To some people, participatory design is a movement that is well-developed with its own conferences, journals, and textbooks. To others, participatory design is a sub-discipline in a broad design theory, which merely signals the design professions' traditional concern with and focus on user-centred design.

An underlying diagnosis of design practice that is shared by participatory approaches however, is the perception of a *gap* between the designer and the user of the designed product. The designer's conception of the design problem will be coloured by own preferences and values, and throughout the design process it is therefore necessary to correct this conception with improved understanding of the real needs and goals of the users. Bridging this gap between the designers' conception of the design problem and the user's problems and real needs is therefore one, if not the, central challenge in a design process.

Minding, or mending, this gap can follow several strategies. One traditional approach to participatory design is where designers have involved users as a source of information and in post-hoc evaluations of product concepts, e.g. user testing of early product concepts. Later approaches, often in conjunction with marketing techniques, include ways of eliciting a need, or a social diagnosis, that can be used to develop new products. Etnomethodological approaches and e.g. *probes* exemplify such approaches. A third approach advocates the partnering with users in the creation of product

concepts. This can be done for instance through workshops or games, exemplified by Sanders and Stappers (2007).

Professional reasoning in design can under this model generally be regarded as the attempt to bridge the gap between designers and users. The main "problem" in this regard, is that designers will have an incomplete preconception of the product's functions and uses. Designers can not possibly foresee all the potential consequences that may arise from use, neither can they foresee all the aspirations and desires that users lay on a product. Correspondingly, a pronounced risk is that designers project their own preferences and fallible understanding when designing the product.

Because of this, organising a design process requires that one challenges the designer's preconceptions, and ensure that aspirations and wishes of the user are included in the design and development of the product. This is, however, a complex epistemic project, and one therefore need strategies and knowledge in order to bridge the gap. This takes place as a form of dialogue that will prevent designers from inadvertently promoting their own views and preferences during a design process.

There is no single way in which design processes should be structured to facilitate the inclusion of users. The issues that the designer needs to understand will depend on the characteristics of the concrete design problem. It may imply attaining an understanding of the user's preferences and personality, it may imply gaining an understanding of the product's technical characteristics and the user's physical characteristics; e.g. in questions of ergonomics, or it may require identifying the user's cognitive frame of understanding for the interaction with the product.

Concerning learning and knowledge, a participatory view of design will influence theory-construction primarily by including the users in the general theories on design. As the general challenge of designing is seen as the designers "incomplete" preconceptions, the design process will require the externalisation and testing of the designers' beliefs, preferences, and models of the product.

Thus, within the participatory tradition there has been an influx of particular techniques for involving users; interviews, workshops, games, user-testing a.o. But he tradition has also seen the introduction of formal research methods to the design field. This is because such methods provide valid and credible ways of testing hypotheses.

Sanders and Stappers suggest that this implies a more research-intensive role for designers, because the design process will become more knowledge-intensive: *The landscapes of design and design research will continue to change as design and research blur together.* (Sanders and Stappers 2007, p. 15). They also suggest that means for cross-cultural communication should gain a more central importance in

design theory, because of the gap that exists between the different frames of understanding that the participants in a design process holds:

> *For example, one of the major challenges in the planning and architectural practices today is the communication gap between the design team, the various levels of 'user groups' and the wide array of specialised consultants to the process. In the future, the new co-design languages that support and facilitate the many varieties of cross-cultural communication will become highly valued (p. 16).*

As general advice, the participatory model function as a memento that requirements and briefs are only tentative in their definition of the designed product, and this participatory approach suggests a wealth of strategies to mend the gap that exists between designers and users.

Assessing the impact that the participatory approach has had on design theory, it is obvious that the participatory perspective always has been an explicit part of design theory, and many would probably argue that an implicit concern for user-orientation has always been a strong undercurrent in design theory. But to many authors, the future promise of the participatory perspective goes beyond that of being a sub-set in a design discipline; it indicates the future of designers' professional roles: *We find it promising that whatever the future role of a designer will be, it seems that it will be a role of participation rather than one of command and control.* (Binder et al. 2008, p. 3)

3.7 Concluding remarks

The examination shows that, historically, design practice has been defined by a large range of variant conceptions in theory: Design as a goal-oriented process of information-processing and problem solving is perhaps the classical, scientific view of design practice. Design as reflective practice emphasises the constructionism in designers' reasoning and reflection as well as the iterative nature of interpretation in design processes. Doctrinaire models of design provide categorical systems that designers use to claim jurisdiction and responsibility for tasks in design processes. The hermeneutic model emphasises the important role of preconceptions, or prestructures, in design work. The social model points out that much of the knowledge that designers rely on in their work reside with the social communities of practice, and particularly the typical problems of this practice. Lastly, the many participatory approaches to design diagnose the challenge of design practice as the gap in understanding and imagination that exist between designers and the users of their products.

The differences that can be found with these models relate mainly to which aspects of the design process they see as central. This is probably due to the paradigmatically different understandings of science and research that underlie these models. The problem solving tradition for instance, associates design theory with a program of empirical science, concentrating on designers' behaviour, rather than speculation on the mental processes that underlie this behaviour. While this gives the so designated design theory the credibility and authority of science, it is, as will be discussed in chapter five, an approach that has been criticised for being reductionist in nature. The reflective practice of Donald Schön focuses on the artful and creative aspects of design practice, and in doing so, it influences design theory to look for personal and cognitive characteristics in design work. It is little concerned with characteristics of "the outside world", e.g. how the design professions have changed over time due to changes in roles and responsibilities, but regards design as a relationship primarily between designers and materials, in the confinements of "the design studio". The doctrinaire models are categorical systems that implicitly argue diagnoses of roles and responsibilities inherent with design work, thus providing theories with a strong normative impact. The hermeneutic models emphasise the personal and cognitive processes in designing, and as such propagate introspective inquiries of designers' processes of reasoning and reflection. The social models direct attention to the communities in which designers work, and the participatory approaches have an explicit focus with the users of products and the means to include these in the design process.

In line with these different premises, the underlying conceptions of professional reasoning in design stands out: The problem-solving approach regards design as a process of sub-optimising decision-making. Reflective practice sees the same as a fluid

process intertwined with materials and established practices. The doctrinaire models suggest that design is carried out by negotiating many different kinds of standards and conventions and adapting these to the concrete design problem. The hermeneutic model sees prestructuring and interpretation as essential to this process. The social model sees design reflection as constrained by the social communities in which they take place, and participatory design sees it as an information-intensive process of facilitation and collaborative creativity.

The question this raises is how these premises will impact the production of theories and knowledge in the design domain. For purposes of containing the research, the assumption with this thesis is that the ontology; i.e. concepts and their relations, will be a central in constraining theories. But the reader should note that this is a somewhat "mechanical" assumption.

When design is explained, in the form of empirical inquiry or proposal of hypothetical models and theories, the association of one's research with an idealised model will also imply the association with different theoretical and disciplinary perspectives; i.e. a wider research program. And the association with particular programs will not only provide technical concepts, but probably also a given understanding of purpose and aims with research activities.

The problem solving model suggests that design theory should be built in a cumulative fashion in the vein of a classical positivist conception of science. It should focus on the development of context-free tools and heuristics that designers can guide and aid designers' actions in the supposedly complex context of design. The reflective account on the other hand, focus on experience and skills of the designer, the materials that are used to work with, and therefore makes use of mentalist concepts as *design worlds* and *repertoire-building* in this project. As a scientific project, it suggests an interpretative, i.e. reflective approach to the accumulation of theory in the design domain. The normative perspectives implicitly suggest that design theory is mostly complementary to the practices that are at any time current. They provide categorical systems that guide the structuring of design tasks and are based in a political diagnosis of designers' roles in society. The hermeneutic model suggests quite an inward-reaching kind of research, as it is concerned with understanding, interpretation, and inner conceptions. Therefore, monographs and case-reflections over the ways in which skilled designers think are valued. The social models emphasise the role of communities and how these formalise the practical wisdom that emerges from practice. As such, they suggest a social program for design research. And, lastly, the participatory model suggests the inclusion of users and stakeholders in any design theory, thereby suggesting a variety of programs for design research, all with an emphasis on mending the gap between designers and users.

The different models thereby lay trajectories that will guide research, in a wide sense. These trajectories are not restricted to the ontology of models, but also implicit stances which shape the focus of inquiries, the conventions and standards to which inquiries should adhere, or the definition and thereby the delimitation of design practices.

But the diversity of idealisations that this review has showed provokes a question: What does this multitude of perspectives say of design research as a common project? How should design researchers make use of, and relate their findings to, previous inquiries, given that the underlying perceptions of "design" that one may encounter deviate so significantly from each other? The review suggests that readers of design theory will find strict disciplinary demarcations in design theory, because of the strong differences in the basic assumptions on design.

The reality is not so, however. In design theory, one will find that these different models are used interchangeably in the same journals and conferences. Concepts and models are used rather freely, leaving one wondering about the operative meanings that these conceptions have in design theory. For instance, one can find that the problem solving models and even the cognitive theories of Simon are read as arguments for a constructivist conception of design theory (Carroll 2006; Chua Soo Meng 2009). Conversely, one can find that the constructivist concepts and models of Schön subjected to protocol studies to identify exact cognitive definitions of the "weltanschauungen" concept *frames* (Stumpf and McDonnell 2002). Design researchers appear to use and reuse ideal models in original ways to serve their inquiries.

What does this interchangeable use of models say about design research practices? How should design researchers make use of, and relate their findings to, previous inquiries, given that the underlying perceptions of "design" that one may encounter in design theory appear to deviate so significantly? Researchers are faced with the problem that design research builds on ontologically different perspectives, and it is not clear how such different perspectives can be reconciled and support each other in inquiries given their differences in perspective and idealisation of design as a research object.

It seems unclear, for instance, how the different mentalist concepts of Schön can support or contribute to problem solving based design research. If one takes the scientific orientation of the problem solving program seriously, there is no natural place for mentalist conceptions. One cannot include mentalist concepts in laboratory and protocol-studies of design without violating the premises of the original model. The criteria for scientific inquiries in one of the programs identified with this review will simply render insights from alternative programs invalid. If design researchers aim for theoretically informed inquiries, they must expect to spend great resources translating and qualifying previous findings.

4 - Concepts and parameters in design models

An open-ended question after the review in the previous chapter is whether the diversity of models in design theory has any significant consequences for the understanding of design practice, and ultimately, the development of theories in the domain. In the preceding section it was argued that this influence will be complex. The variety in models indicates that the field has been influenced by paradigmatically different orientations, different personal preferences, as well as different perceptions of the important elements in this practice. The different perspectives thus may influence the understanding of the field in myriad ways. One instance where the models' influence is marked and traceable, however, is in the conceptual structure of design that the model postulates; i.e. the ontology of the model. This chapter examines the conceptual structure with three of the models. By examining this, one may see how these models frame professional reasoning in design practice and it provides insight into different historical stances on how inquiry into design practice might be carried out.

When researchers or practitioners inquire into elements of design practice, a tacit element of this activity is the association of a concrete situation with an ideal model. The conceptual structure of the model provides concepts and key relations defining how activities and working phases should be understood. The conceptual structure will emphasise some aspects of design work, while black-boxing others. In more formal wording: the ontology of the model decides the parameters by which design practice is understood and inquired.

For instance, if a design researcher for a specific research purpose assumes that design can be considered as a form of 'problem solving', then the inquiry will also be committed his to a conceptual structure where design is seen as the search in a 'problem-space' and the activity described in terms of 'problems', 'goals', 'requirements', 'representation', 'decisions', 'information' and others. This conceptual structure will be the terminology for coding observations, and it will be the language by which hypotheses and theories ultimately will be deemed true or false.

The example is not coincidental. The problem-solving tradition in design research is large, bordering a dominating role in the field. Many authors have argued that the common convention in design literature is to idealise design practice as a form of problem solving process (Bousbaci 2008; 2006; Gedenryd 1998; Hey and Agogino 2007). This implies that common research practice is to frame design in a problem-solution dichotomy, in a way that sees design as a cognitive process of reasoning from function to form.

A cause for concern in this respect is that the problem-solving model black-boxes central issues on designers' knowledge. It is, by its own definition, concerned with procedural aspects of knowledge; it contains a (behavioural) focus on decisions, but is not particularly concerned with the knowledge and understanding that underlying those decisions.

The problem-solving model excludes issues which many would consider central elements in "practical" or "professional" knowledge; the nature and characteristics of the mental entities by which designers structure and reflect over design problems. Examples are 'frames' postulated by Schön, 'primary generators' with Darke, and social models of design, which claim that a professional community gives rise to certain ways of thinking about and dealing with professional problems.

For the community of researchers and practitioners, a risk with an alleged dominance of the problem-solving model is a monotonous understanding of knowledge in the design domain. If professional design practice, as a default model, is explained through a problem-solving model from cognitive roots, then this may spill over to an impoverished understanding of common sense concepts of knowledge and experience, and awareness over their role in practice.

The chapter therefore takes up three of the previous models, identifies their conceptual structure and displays how they provide different perspectives on the act of reasoning while designing and the corresponding perspectives on the development of professional knowledge in design practice.

4.1 Approach

For reasons of scope, this section does not detail all the models the previous chapter. The goal here is firstly, to highlight how the central concepts with these models emphasise and black-box aspects of designing, and secondly to test a principled perspective of idealised models in design theory. The main unit of analysis in this chapter is 'conceptual structure', a term taken from the field of terminology (Cabré 1999). With the words of Cabré a terminology is "the set of terms of a particular special subject"; i.e. the specialized vocabulary of a subject field.

As a first observation, a terminology is not a reflection of the world, but an idealized version of it. Employing a given terminology will imply associating real-world phenomena, in this case design practice, with a set of concepts, categories and implicit principles. The terminology of a subject field provides the terms and categories that are used to understand and make sense of the field. Correspondingly, the terminology of design theory will set constraints for how design practice is understood by establishing an ontology of design practice:

> *In order to communicate concepts and their supporting propositions, speakers use written or linguistic signs made up of a term or groups of terms, or some other type of symbols. What they express, however, is not the real world as it is, but rather how the individual and the community have internalized it."* (p.42)

Conceptual structure' points to the fact that terms in a terminology are not isolated units, but stand in a relation to each other, forming a coherent whole.

> *As speakers become more familiar with a special segment of the real world, they turn their knowledge into conceptual structures in which each concept occupies a specific place and acquires a functional value (p.43).*

Methodically, the similarity between the idealised models from chapters 3 and 'conceptual structures' was seen to allow following a terminological procedure to examine the central concepts with these models. The assumption is that the concepts that go into the different idealized models from the review can be understood as largely equivalent to conceptual structures. And that the internal logic of the idealised model allows for identifying concepts in the same way as conceptual structures would.

The identification of models is methodically significant, because terminological methodology requires us to identify the 'conceptual structure' of a written corpus before one can extract terms or concepts from it. This is because the conceptual structure serves as a principle for interpretation: it is the totality of a conceptual structure which enables us to differentiate between terms that belong to a particular conceptual

structure, and terms that are just elements in the larger language (Cabré 1999, pp. 132-136). This approach may be understood as a hermeneutic principle: When one extract terms from a large written corpus, it is the overall structure of the corpus which allows the identification of meaning with individual terms.

The procedure for analysis consisted in extracting from the written material the terms that were deemed as central to explain design reasoning. These terms were registered and grouped according to the concepts they designated. This work led to tables of the significant concepts within each group being drawn.

This approach is qualified on some accounts. The approach here presumes a restricted understanding of language. In natural language, words have several uses and functions, such as performative functions, expressive purposes, communicative functions, and others. With this approach, however, the focus is on the referential aspects of language; i.e. what real-life equivalents the concepts denote. Consequentially, the categorization of authors into models and conceptual structures is a generalization that may leave out the nuances and subtler points of the authors included.

The models that will be analysed in the following are the hermeneutic, the reflective and the social models of design. The text briefly explains how these models differ from the problem-solving model on knowledge in design, before moving on to the central concepts with these models, and what these models implicitly suggest for knowledge-transfer in the design field.

4.2 Concepts in the reflective model

The reflective model of design was also originally put forth as an antithesis to what was perceived as the prevailing paradigm at the time; *technical rationality*. The model proposes that knowledge in professional practices, including design, is interwoven with practice. The use of tools and materials, and the cooperation and interaction with clients should be integrated in any reflection over professional knowledge. These items were something which previous models of professional knowledge (i.e. the problem-solving perspective) had found it hard to include, as technical rationality relied on a positivist doctrine of knowledge:

> *...Practical knowledge was to be construed as knowledge of the relationship of means to ends. Given agreement about ends, the question, "how I ought to act?" could be reduced to a merely instrumental question about the means best suited to achieve one's ends. From the perspective of technical rationality, professional practice is a process of problem solving. Problems of choice or decision are solved through the selection, from available means, of the one best suited to establish ends. But with this emphasis on problem solving, we ignore problem setting, the process by which we define the decision to be made, the ends to be achieved, the means which may be chosen. In real-life practice, problems do not present themselves to the practitioner as givens. They must be constructed from the materials of problematic situations which are puzzling, troubling, and uncertain. (Schön 1995, pp. 39-40).*

The reflective model suggests a different depiction of the way and the means by which solutions are proposed and reflected over during the process. The problem-solving model holds centrally that human cognition is a *symbol processing system.* Design processes are correspondingly understood as a cognitive endeavour; 'data' and 'information' are processed in the brain in the same way as a computer uses symbols and algorithms. When proposing solutions, designers use a form of means-end analysis to calculate its benefit, and then simply discard or accept it, in a process of *satisficing.*

The reflective model provides a depiction of this process which associates design with the different philosophical tradition of constructivism. In Schön's view, professional knowledge emerges from everyday practice; through this practice, the designer develops a rich repertoire of mental models, prototypes, ways of seeing things, and different templates. When engaged in a design task, the designer draws on these items to structure the design problem. Schön explicitly proposed this perspective as an alternative to Simon's:

> *All of the above negates a widely accepted theory, held by Simon, among others, according to which designing consists in heuristic search within an initially given "search space". According to this view, designing is an information-*

processing task that begins with objective "inputs". In contrast, the parable of designing sketched above highlights that designer's active role in constructing, prior to what are usually considered design inputs, a personal design world. It emphasises the construction of coherence to play and appreciative judgment. (1992, p. 131)

Thus the design process is a dual process. On the one hand, designers tentatively test concepts and product solutions, but on the other hand, they also constantly test their own (incomplete) understanding of the design problem. This process takes place as an inquiry; a dialogue with the situation; and among its characteristics are firstly, that it is transactional and social, secondly, that physical materials are important, and thirdly, that the process leads to new insights.

> *The inquirer does not stand outside the problematic situation like a spectator, he is in it and in transaction with it (Schön 1992, p. 122). ... an inquirer, in transaction with the materials of a situation, encounters a surprise in the form of "back-talk", that momentarily interrupts action, evoking uncertainty. [...]The term conversation is, in this usage, metaphorical. It does not refer to a literal conversation about the situation but an inquirer's conversation-like transaction with the materials at hand (p. 125).*

In this dialogue, the materials that designers work with occupy a central role. Throughout the design process, designers work with a large range of representations such as models, sketches, diagrams, and plans. The interaction with these items is a complex process of reflection, experimentation with materials and reframing of the designer's tentative understandings:

> *A designer makes things. Sometimes he makes the final product; more often, he makes a representation – a plan, a program, or an image – of an artifact to be constructed by others. He works in particular situations, uses particular materials, and employs a distinctive medium and language. Typically, his making process is complex. There are more variables – kinds of possible moves, norms and interrelationships of these – than can be represented in a finite model. Because of this complexity, the designer's moves tend, happily or unhappily, to produce consequences other than those intended. When this happens, the designer may take account of the unintended changes he has made in the situation by forming new appreciations and understandings and by making new moves. He shapes the situation, in accordance with his initial appreciation of it. The situation "talks back," and he responds to the situation's back-talk* (Schön 1995, pp. 78-79).

The impact of this perspective in design theory (e.g. Cross 2007), may be traced to its congruency with traditional hands-on focus in design practice and education. The central role of models and materials has always been considered a central characteristic

of design work and Schön's model posits a central role for these items. Other authors have attempted to ring in design in light of these same characteristics. Archer (1979) attempted, in the very first issue of Design Studies, to define design theory as the 'language of modelling". Goldschmidt (2003) has published extensively on the role of sketching and models, and argue that "sketches are extensions of mental imagery", and reveal "unforeseen configurations and relationships". Buur and Andreasen (1989) elaborate a framework for the several functions that models have in design work.

Turning to the model itself, a fundamental element in Schön's model is that any given design process is shaped by the *problem setting* that the designer lays down; how the design problem is to be understood, and what to treat as the "things" of the situation. By setting a design problem in a certain perspective, the designer chooses how to *frame* the design problem; the designer regards the design problem from a perspective that includes elements, features, relations, and actions, and of norms used to evaluate problems, and tests this perspective and the ensuing hypotheses by experimentation with materials, or *representations*. These interactions are termed *design moves*. From these experiments and conversations with the materials, designers arrive at new ways of understanding the design problem, and potentially restructure their initial frames and ways of understanding the problem.

The concepts that are central in the model of reflective practice are here taken from four of Schön's publications (Schön 1988; Schön and Wiggins 1992; 1992, 1995):

Problem setting	When addressing new or unique problems, problem setting is the selection of what to treat as the "things" of the situation. The designer sets boundaries and imposes coherence on the design situation by naming the things to attend to, and frame the context in which they will be attended. (1995, p. 40).
Representations	Designers use many kinds of representations in their work: plans, sketches, images, and models. These representations are "virtual worlds" where the designer can experiment rigorously, or "things to think with" in that assumptions and hypotheses can tested (1992, p. 124)
Frames	Designers frame design problems from a personal perspective connected to the appreciative system of the designer. Frames include names of elements, features, relations, and actions, and of norms used to evaluate problems. Frames can be considered a limited perspective of design problems, and the concept has family resemblance to 'prototypes' and 'exemplars' (1998)

	Synonyms: *Design worlds (1992), normative domains (1995), types (1988)*
Design moves	Designers manipulate and change their representations through experiments to explore, test consequences of moves, or as hypothesis-testing. These are moves by which one tries to effect a desired change in the situation (1995, pp. 151-153).
	Design moves extend the designers thinking because, due to limited cognitive information processing capacity, one cannot, in advance of making a particular move, consider all the consequences and qualities we may eventually consider relevant to its evaluation." (Schön & Wiggins, 1992, p. 143)
Conversation	The interaction with materials takes form as a transactional inquiry. Design moves are carried out on the material, and the results *backtalk* to the designer who reflects over these. Such reflection leads to frame experiments or further developments along the same line of reasoning.
	This is carried out in a fluid conversation-like manner where doing extends thinking in the tests, moves, and probes of experimental action, and reflection feeds on doing and its result. (1995, p. 280)
Frame experiments	When the phenomenon at hand eludes the ordinary categories of knowledge-in-practice, presenting itself as unique or unstable, the practitioner may surface and criticize his initial understanding of the phenomenon, construct a new description of it, and test the new description by an on-the-spot experiment. When the designer finds himself stuck in a problematic situation which he cannot readily convert to a manageable problem, he may construct a new way of setting the problem – a new frame which he tries to impose on the situation. This is a frame experiment (1995, pp. 62-63).
	Synonym: *Problem resetting (1995)*

Table 4.1 - Central concepts in the model: Design as reflective practice

The conceptual structure which Schön proposes is troublesome if regarded with a positivist lens. It includes (unobservable) mental concepts. But even with a positively instilled reading, there are problems with identifying the real-world equivalents of Schön's concepts.

The 'frames', for instance, which denotes the personal understanding that decides how designers perceive and think of a given professional problem, have been denoted by a range of interchangeable concepts throughout Schön's writings. Schön used terms such as 'normative domains', 'generative metaphors', 'worlds', and 'types', and even aligned these terms with 'prototypes', 'precedents', and Kuhnian 'exemplars'. The content of 'frames', i.e. the definition of these mental structures which underlie problem setting is a vague. The paintbrush-example in the preceding section, where a different analogy induced during product design facilitated new and improved solutions (chapter 3.2) suggests that frames can be understood as some form of analogy, something which Schön termed both 'seeing-as' and 'generative metaphor' (Schön 1993). Other examples in Schön's writings suggest that 'frames' could be understood as normative domains; i.e. different kinds of programs for the spatial and physical organisation of designed products (Schön 1995, p. 96) or, that frames could be understood as the personal, and appreciative system of designers, similar to Polanyi's tacit knowledge (Schön 1992).

The ambiguity in Schön's writing is problematic from a scientific perspective aiming for cumulative research, where one seeks precise definitions of the concepts that go into theoretical inquiry. But from a sympathetic reading, one may argue that Schön's contribution is to instil a certain attitude towards how the processes of design should be perceived. The social theorist Blumer operates with the term *sensitising concepts;* concepts, ideas or notions that guide observations and data collection. If Schön's conceptual structure is understood as such one, it may be seen as a memento; it focuses on the prestructures that designers bring to the process and the breadth of perspectives and beliefs that such prestructures consist in.

The historical contribution may arguably be that in a cultural climate where complex mental processes had been reduced to simple physical processes, Schön simply reopened the question of these mental structures, and illustrated the complexity.

As a model of design practice, it is necessary to stress a premise with Schön's model; the reference point for any development of professional knowledge is not the "blank slate" that the problem-solving model departs from. For professional knowledge, one does not build a cumulative body of theories in the way a scientific discipline can be assumed to build upon first premises. For Schön, knowledge is interwoven with practice; it is something that emerges from everyday interaction with professional problems, and internalised through this practice, in the same way that we learn walking, and bicycling (Schön 1992, p. 124). Any learning, reflection, and development of knowledge must take the existing professional practices into consideration.

If one sees research and reflection over design practice as a question of parameters and constants for this practice, a characteristic of Schön's model is that it regards the

role framing and the repertoire of designers as constants. In their everyday practice, designers work by techniques and perspectives that are "natural" elements in their practice, and may appear as more or less self-evident to the practitioner. Schön's project is to question these ingrained behaviours, and propose that practice is an opportunity to reflect over these tacit practices, and also to question their limits and their proper application; i.e. *reflection-in-action.*

From this perspective, there are at least three ways in which this model (and Schön's writings) suggests that inquiries should be framed, i.e. what is significant to transfer across individual design projects. For one, it argues that knowledge-transfer is an automatic outcome of experience and practice, secondly, it argues the value of a critical attitude to how this knowledge develops, and thirdly, it assigns a role for physical materials in our understanding of practice.

Elaborating these stances, one can first note that design can be seen as learning by itself. The "frames" or "design worlds" that designers use to structure the task are many things; analogues, templates, normative domains and many others. Design projects provide a way of testing these mental prestructures, and thus, through practice, designers gain a feel for what works:

> *In this sense, designing serves as preparation for further designing – both within and across the boundaries of a local design episode. We speculate that designers are able to store the discoveries that result from past projects, carrying them over to new design situations that trigger them, on the basis of features perceived as similar. So designers may acquire the ability to operate simultaneously in multiple domains, spin out complex design scenarios, and think about larger and more complex move experiments (Schön and Wiggins 1992, p. 155).*

Secondly, the reflective model argues that practice is an opportunity to reflect on the more or less automatic ways of framing design situations and practices that designers bring to design problems. Schön argues that the instances where designers experience breakdowns of their understanding of the design problem are opportunities to reflect over one's own repertoire, as such situations reveal limitations in ones repertoire. These limitations are not particularly beneficial per se, but an opportunity to seek out new approaches and practices. Such reflection on one's own repertoire was termed *frame analysis* by Schön:

> *When practitioners are unaware of their frames for roles or problems, they do not experience the need to choose among them. They do not attend to the ways in which they construct the reality in which they function; for them, it is simply the given reality… When a practitioner becomes aware of his frames, he also becomes aware of the possibility of alternative ways of framing the reality*

of his practice. He takes note of the values and norms to which he has given priority, and those he has given less importance or left out of account altogether (Schön 1995, p. 310).

Thirdly: one unintended way in which the reflective model has impacted design theory is as a grounding theory for the complex issues that takes place when designers use physical materials. It has proven to hold the potential to reflect over own tools and materials that designers use in practice. By its focus on *backtalk* and conversation, the reflective model has grounded many examinations of merits and potentials associated with different tools and techniques. Examples of such inquiries can be found with for instance (Dearden 2006), and (Dorta et al. 2008).

In general, when compared with the problem-solving framework, the conceptual model of design that that Schön introduced, invites reflection on the personal perspectives and understandings that designers bring to the design process, and the role that models and materials have in the development of this understanding. It singles out the backtalk that emerges from this interaction as a decisive factor in design processes, and distinguishes the interaction with materials that is part of everyday design practice.

4.3 Concepts in the hermeneutic model

The hermeneutic model is also explicitly antagonistic, or alternative, to the problem-solving model. The model was proposed as an alternative to scientific, behavioural research practices which restricted the empirical material to observations of designers and the outcome of their work. As a consequence of this stance, the hermeneutic model proposes a concept for the mental structures of designers; primary generators. This implies a focus on the mental models that designers carry, the way in which design problems are interpreted, and the role of personal preferences and perspectives in design processes:

> *Some rather unfruitful attempts were made to observe designers at work but it seems to the present author that the research material necessary to understand the design process is not a set of sketches, but a knowledge of the mental process the designer goes through. Observation of sketched and written output is a curious way of obtaining such material. Asking designers to recall their own processes would seem prima facie to get closer to the truth about such processes, albeit in a less verifiable form (Darke 1979, p. 37).*

Contrasting the problem-solving model's focus on functional reasoning, the hermeneutic model on the other hand introduces a personal and mentalist concept which is seen as significant in understanding how a designed product comes about. The premise for this depiction is that design problems are regarded as *unique*, singular problems. The central challenge in design work is that there are infinite ways of understanding the design problem, and an infinite number of potential solutions to it. To overcome this, designers *prestructure* the design problems in a way so that solutions can be discriminated. Design is thus a process of 'variety reduction': *with the very large number of potential solutions reduced by external constraints and by the designer's own cognitive structures* (Darke 1979, p. 329). The prestructures that designers impose on a design problem are decisive for the design performance:

> *…only by prestructuring any problem, either explicitly or implicitly, can we make it tractable, to rational analysis or empirical investigation… design is essentially a matter of prestructuring problems either by a knowledge of solution types or by a knowledge of the latencies of the instrumental set in relation to solution types (Darke 1979, p. 38).*

The prestructures serve as a 'way in' to the design problem. When designers create solutions to design problems, they do not rely on instrumental means-end analysis only. The generation of solutions is characterised by a 'rationality gap'. It is not a logical or

instrumental process, but the subjective perspectives by which designers render the design problem in a certain light that are the basis for the generation of solutions.

The *primary generators* can be a particular objective or small group of objectives, that are strongly valued and self-imposed, that give rise to solution concepts. They may be fussy or metaphorical in nature, and they implicitly render some solutions as better than others:

> *The concept or objective that generates a solution is here called 'the primary generator'. It can in fact be a group rather than a single idea. These objectives form a starting point for the architect, a way in to the problem; he does not start by listing all the constraints. Any particular primary generator may be capable of justification on rational grounds, but at the point where it enters the design process it is usually more of an article of faith on the part of the architect, a designer-imposed constraint, not necessarily explicit. (p. 38)*

The primary generator induces designers to propose conjectures, i.e. approximate, partial solutions to the design problem. It includes only some of the characteristics of the design object. In other words, the solution is not generated by a means-end analysis, but is shaped by the personal perspective that the designer impose on the design situation.

From these conjectures, the design solution is refined in an iterative manner. Designers compare or evaluate the conjectures against the requirements of the design process, but the requirements enter the design process at varying level of details. This means that the designer constantly interprets the approximate values of the requirements throughout the design process. If the conjecture fits the requirements in an adequate way, it is kept and refined, if it doesn't meet the requirements, the conjecture is discarded and new conjectures are elaborated:

> *The designer has been aware all along that there are several detailed requirements to be met by the design, but performances on these parameters are not specified in advance. Once the initial concept has been generated it is tested against these various requirements and modified if necessary; the performance levels with respect to particular requirements are decided interactively, in the light of the effect on the emerging concept and on other parameters (Darke 1979, p. 38).*

Where problem-solving models are largely silent about the nature of the cognitive processes that generate ideas in his generator-test cycle, Darke is including the nature of these cognitive elements in her account of design: It is seen as a process where primary generators give rise to conjectures, which are subsequently analysed against the

requirements and constraints of the process at varying level of precision. The definitions in the following are taken from Darke (1979).

Prestructuring	For purposes of variety reduction, designers construct a problem setting story. This involves a knowledge of solution types or by a knowledge of the latencies of the instrumental set in relation to solution types (p. 38*).*
Primary generators	To guide the generation of solutions, designers fix on a particular objective or small group of objectives, which are strongly valued and self-imposed. These serve as a way in to the design problem and give rise to proposed solutions or conjecture. This generation of solutions is characterised by a *rationality gap*, it is not dictated by prior analysis, but by designers' own cognitive structures (p. 38).
Conjectures	Concepts and solutions in a design process are first presented as conjectures. The conjecture is a partial solution to the design problem. It includes characteristics of the design object, as well as the personalised, metaphorical understanding of these characteristics (p 37).
Analysis and Refinement	Conjectures are evaluated against the requirements at various levels of detail and iteration. Once the initial concept has been generated it is tested against these various requirements and modified if necessary; the performance levels with respect to particular requirements are decided interactively, in the light of the effect on the emerging concept and on other parameters. If there is a glaring mismatch between the conjecture and the detailed requirements, then the conjecture is discarded (p. 38).

Table 4.2 - Central concepts in the model: Design as hermeneutic search

Turning to the nature of primary generators, the model holds a conceptual problem: Darke's argument that early design methods approaches had concentrated on a series of boxes "rather than with how designers filled the boxes with concepts" (p. 43), will probably resound with readers acquainted with those boxes. But it remains a depiction vague on the nature of these generators and a definition of what primary generators really are. Are they ideas? Concepts? Elements? Furthermore: If designers' subjective understanding of a problem holds such central role for professional behaviour, then it

still is an open question whether such subjective primary generators can be documented and communicated to others.

From interviews with architects, Darke exemplifies primary generators with subjective and qualitative items such as 'expressing the unique quality of the site', 'provide private open space', 'a traditional relationship to a communal space', and others. This mirrors Darke's disciplinary background in architecture, and provides a glimpse of what primary generators can be.

For product design, one can speculate that one can find similar references to abstract concepts that may function as conceptual anchors in a design process, with common terms such as "affordances", "usability", "intuitive use", "high-end", "flexibility" and others. One may speculate that such metaphors, or generators, hold a central role in design practice, functioning as personal stances on what products should be; their purpose and meaning. And thus serve to discriminate design solutions based on personal and professional inclinations, rather than through the sequestered framework of goals and purposes that the problem-solving model suggests.

For learning and knowledge transfer in design, primary generators have a central role. The development of a "stock" of primary generators is the difference between students (novices) and the professionals (experts).

> *Probably the main difference between the practising architect and the student is that the former has the experience of solution types required for a realistic conjecture. A frequent problem in a school of architecture is the student who has a limited stock of generating ideas which he attempts to apply to every problem without considering whether they are appropriate (Darke 1979, p. 38).*

The question then is how students can learn and acquire a "stock" of primary generators? If the ability to structure one' projects is so important for professional capability, then the development of one's own stock seems to be a central question.

One suggestion is that the hermeneutic model singles out the cognitive structures that serve as "ways into the problem" for designers, and in doing so it proposes a principled understanding for the fussy part of design processes where designers structure and shape the design problem. The conceptual structure of the hermeneutic model invites reflection on the metaphorical and conceptual ideas that designers bring to the design process; it indicates the role of conjectures in this process, and it argues that evaluation of solutions against requirements take place as mediation between the personal generators and the objective requirements of the situation.

By this perspective, the hermeneutic model opens up for questioning the practices in establishing conjectures, and maybe the biases with which one approaches design

problems. Compared with the problem-solving model's assumption that design solutions are considered by reference to goals or requirements, the perspective that designers attend to partial and different facts when engaged in design, may be a focus that allow questioning which characteristics that are attended to in a given design process, and by what (fussy) understanding they are approached.

But it is also an account that argues strongly that this is a process of interpretation. If one are to approach the "subjective" understandings that designers lay down in design processes, these are only available through designers' retroactive accounts of what they were thinking and how they were thinking of the design problem.

Using the hermeneutic model as a model of design practice emphasises introspective considerations of the cognitive structures that designers bring to design projects. It explains design practice as a task environment where designers through experience gradually build a repertoire of subjective generators and metaphors, and that these have a central role in design performance. In general, the hermeneutic model posits a central role for examples, metaphors, ways of thinking, and subjective practices, and how these will shape the design process. Concepts and a principled perspective for the vague ideas, metaphors, and subjective factors that go into the fussy front-end of designing are provided.

4.4 Concepts in the social model

In the same way as the reflective model, the social model sees design as a professional practice. But unlike the reflective model's emphasis on designer's interaction with materials in situ, the social model sees the professional community as central for holding and educating in the mental structures that designers use to frame professional problems. Typical professional problems give rise to a wide range of solution-structures, such as rules-of-thumbs, models, examples and others. These solution-structures will decide how problems are understood, and lay trajectories for the effectiveness and ease with which professional problems are approached and solved. Thus, designers can be said to work within *technological frames* (Bijker 1995), or alternatively, that they hold different *object worlds* (Bucciarelli 2003).

This view stands in contrast to the functional reasoning of the problem-solving model; the view that design problems are reasoning from is to ought where designers evaluate the outcome in the form of objective means-end analysis.

Three stances are central with the social model. One is the view that professional design tasks in many respects are similar, or at least have generic traits, and that these generic traits give rise to general professional knowledge. The problems that designers face are seldom entirely novel, but require familiar kinds of judgements from problem to problem. Problems of structural design, for instance, involve recurrent judgements on issues such as stress, tension or constructive principles. Problems of function and ergonomics require recurrent judgements on human behaviour and physiognomy. And it is possible to argue that it also extends to aesthetics, as such problems require recurrent judgements on form composition, shape, colour, and materials. Knowledge in the sense of the social model emerges as knowledge on structures or analytical procedures that have proven useful in solving such recurrent problems.

Secondly, the professional knowledge that designers employ is not a set of scientific facts. Faced with a concrete design problem, designers assess whether the problem can be solved drawing on existing knowledge, or whether one must recourse to the more cumbersome process of trial-and-error experiments. Trial-and-error approaches require more in terms of time and manpower, and there is thus "a premium" in the professional community for knowledge that will contribute to the fast and certain resolution of professional problems (Vincenti 1990, p. 45). Knowledge, in the sense here, therefore goes beyond "scientific facts" and includes structures, abstractions, facts and others that a more certain resolution of typical design problems. Designerly knowledge is not primarily academic or applied knowledge, but emerges simply to "solve problems" that

are common and generic to design practice[11]. This knowledge may be of many kinds and types. Vincenti suggests a taxonomy of knowledge items that hold roles in a design process and specifies: *Fundamental design concepts*; i.e. the operative principle of the product in question; *criteria and specifications*, *theoretical tools, quantitative data, practical considerations, and design instrumentalities (Vincenti 1990, p. 208)*. Bucciarelli provides a similar taxonomy: *Worlds of technical specializations, with their own dialects, systems of symbols, metaphors and models, instruments and craft sensitivities* (Bucciarelli 1988, p. 162). In other words, the view here is that the knowledge-structures of designers resemble Kuhn's technical matrix (Kuhn 1977), as an overarching system of examples and common references.

Thirdly, the community of practitioners is where knowledge "resides". As a social field, practitioners share the same kinds of problems, and develop strategies for their effective resolution. The community thus has "a historic memory" for how problems should be resolved. The concept of knowledge in the model is thus more akin to social field theory (e.g. Bourdieu, 1977), than the positivist conception of falsifiable facts. The social model views knowledge as residing in the community.

Vincenti proposes an evolutionary model to explain how designerly knowledge emerges: Campbell's model of *blind variation – selective retention* (Campbell 1960). The claim is that knowledge grows through extension of the limits of what can be foreseen or predicted. Vincenti illustrates this with an historical example from aeronautics engineering. In the first attempts to build aircrafts around 1900, one simply did not know how to make an airplane. One was devoid of theoretical principles, of technological configurations, and of functioning examples. But by proposing solutions, testing their feasibility by direct trials, and by systemising these findings, aeronautics emerged as a theoretical field with a repertoire of design principles and functioning examples[12]. This evolutionary process led the community of practitioners to accumulate knowledge of configurations that worked as well as configurations that did not work. This is the general principle of the evolutionary model, and Vincenti argues that the fundamental variation-selection idea is typical to the emergence of knowledge in all design fields, including the crafts (Vincenti 1990, p. 256).

In principle, the emergence of designerly knowledge has a form where first, the designer or design group introduces solutions that "might" work – i.e. introduces "blind

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[11] The perspective is argued at length in chapter 7 of Walter G. Vincenti, *What Engineers Know and How They Know It* (Baltimore: Johns Hopkins University Press, 1990)..

[12] While Vincenti's empirical material is from the theoretical engineering field of aeronautical engineering, the model is taken to be valid for most accounts of professional creative making, including the crafts. It is argued here that the model also fits nicely with the emergence of many, if not most domains of designerly knowledge. An example is ergonomics, which first started out as a set of rules-of-thumbs, before evolving into a set of principles and analytical procedures e.g. Henry Dreyfuss, *The Measure of Man: Human Factors in Design* (New York: Whitney, 1967) 20 s., 30 pl. i mappe..

variation". Secondly, by trial-and-error, the solutions that are tested and proven useful will "survive", as they become standards for solving given problems of such kinds. Thirdly, there must be mechanisms in the professional community for *preserving and propagating* the different variations, or solution-structures, if the larger community is to make use of the feasible and useful solution-types. This last aspect typically takes place through journals, handbooks, textbooks, teaching, design traditions, word of mouth and so forth.

The outcome of the design community's growth in knowledge of techniques and analytical procedures serves one important function. This knowledge enables designers to make judgements that would otherwise require trial-and-error by *vicarious trials*. By instituting knowledge of exemplary solutions and analytical procedures in the professional community, designers are enabled to perform common and recurrent judgements early in the process without having to resort to trial-and-error. Thus, the design practices and the practical testing of solutions and procedures are a way of *reducing blindness* in practitioners' knowledge. The designer tests the limits to and the proper application of certain knowledge-structures, so that these may be taken up and applied with greater degree of certainty in subsequent design processes.

The role of the professional design community for individuals' execution of design work is therefore twofold: On the one hand, the community documents and institutes useful practical knowledge, by *propagating* solution strategies for common problems. On the other hand, the design community is a source of education, as it is also a social field with knowledge codes which equips budding practitioners with strategies for solving common problems.

In the social model, design is still seen as a problem solving process, but one that is a somewhat predictable and foreseeable product of the social knowledge that resides in the design community. Prior knowledge, preconceptions, and professional cultures influence the quality and performance of design work, and the ensuing picture of design is one where this practice is seen essentially as the development and application of different knowledge-structures. The central elements in this account are taken from Vincenti (1990), unless indicated otherwise:

Designers	Designers are part of a professional community, and have varying experience and knowledge of solutions that work and analytical procedures.
Typicality of problems	Professional design problems range from typical problems to entirely unknown problems. Typical problems can be expected to reoccur throughout practice, and there is thus a premium on knowledge of such problems. Unfamiliar problems will require the

	more cumbersome process of trial-and-error (p. 45).
Repertoire	The repertoire of the designer, involve many kinds of instrumental knowledge, ranging from examples to scientific facts.
	Vincenti proposes that knowledge is of six kinds: *Fundamental design concepts; Criteria and specifications; Theoretical tools; Quantitative data; Practical considerations; and Design instrumentalities* (p. 208)
	Near synonyms: *object worlds* (Bucciarelli 1988), *technological frame* (Bijker 1995)
Mapping	Faced with a concrete problem, designers identify the problems that can be dealt with through known approaches and problems that must be resorted through trial-and-error. (p. 45)
Problem-solving behaviour	In design problem solving, designers strive for vicarious trials, i.e. simple methods to evaluate solutions as early as possible in the process, with the least amount of resources being used.
Vicarious Trials	By practical trial-and-error, the repertoire of experimental and analytical techniques grows. As these techniques are propagated and instituted in the professional community, common judgements can be performed by vicarious trial (i.e. a simplified analysis) at earlier stages in the process (p. 247).
Institutionalisation	The incentive towards vicarious trials lead to increasingly sophisticated experimental and analytical techniques (248). These techniques are instituted in the community through journals, handbooks, textbooks, engineering-school teaching, design traditions, word of mouth and so forth. (pp. 242-247)
	Synonym: *Propagation*

Table 4.3 - Central concepts in the social model of design

For reflection over design practice, the relevance of this model for understanding design projects is firstly that it assumes that professional knowledge, in the form of strategies for solving problems, is constrained by the problems that are typical and reoccurring. One can illustrate this phenomenon by stating that if a group of designers typically hold the professional responsibility for form giving in a group of products, they will develop generic approaches which allow them to treat questions of form

throughout their work. Similarly, responsibility for structure, interaction, or other areas will lead to the evolution of generic approaches, allowing designers to reflect over, and discriminate between alternative solutions.

As a general model of development of professional competence in design, it holds that professional knowledge is constrained by the social context. Whereas the problem-solving model frames design as a work-type seeking objective evaluations, the social model, sees design reflection as constrained by the knowledge and models residing in a particular community. This knowledge is characterised by being applicable across a continuum of typical problems, and consequentially, there will be important differences in designers' knowledge with respect to the particular industry they work in or the geographical or social context for their work.

As a general, principled perspective on design practice, the social model distinguishes the concepts underlying knowledge in the design process, and the role that the professional community has for the establishment of this knowledge. It argues that this knowledge is founded in the desire to perform typical judgements by vicarious trial rather than trial-and-error. As such the terminology of the social model invites reflection on design practice as the appropriation and employment of professional knowledge codes. Practice is an opportunity to apply and test the limits of these knowledge codes. For the design community, design practice is an opportunity to "reduce the blindness" with the community's repertoire. The social model therefore implicitly argues that it is important to consider these knowledge structures as common practices and standards in the practical community.

Different from the problem solving model, the questions that may be posed in inquiries in design from this model are questions such "What kinds of tools and models do the community use to solve design problems? In what ways are design problems similar? And for what kinds of problems are particular models applicable?"

4.5 Concluding remarks

The conceptual structures presented here define ontologies of design where mental structures and knowledge are included and given a designation as central elements in design practice. They provide different frameworks for understanding and reflecting over design work, by idealising different depictions of how understanding develops in a concrete project, and how the more enduring professional knowledge evolves as a consequence of professional experience with projects and through participation in professional communities.

The importance of these conceptual structures is that they open for reflection on how the designer's understanding will shape outcome in a design project: How designers reflect over a problem, how solutions are generated, and how solutions are discriminated and judged. In doing so, the models indicate some of the many underlying processes that lead to the development of this knowledge: the personal element in understanding, the transactional nature of design work, and the role of professional communities for developing and constraining such knowledge.

Cognitive scientist Hoff once noted that designers very seldom are aware that they actually *have* an implicit theory of the products they make. The observation, he argued, is as trivial, really, as to say that a designer of a hat has a theory the size of a head (Hoff 2003, p. 27). He argued that the implicit theories that designers hold is something they should be aware of, because the potential for errors and misconceptions is potentially limitless. The first step in such a project, he notes, is to make designers' theories explicit, and step two is to put those theories under close scrutiny.

The conceptual structures here provide frameworks for such reflection. Rather than assuming the stances in the problem-solving model, that design projects are contextually insensitive, and a form of symbolical means-end optimisation, they provide depictions of the causes and elements that partake in the forming of designers' implicit theories (to follow the terminology). It also goes beyond noting that designers hold implicit theories, and propose the processes and practices that go into the formation of these theories.

To elaborate Hoff's rhetorical example, it is obvious that one need a theory of a head for the making of a hat. From the reflective model, it could be argued that designers make hats in a transactional nature; prototypes, experiments and samples reshape their initial theories, and develop templates by which also other design problems are approached. From the hermeneutic perspective, it could even be argued that designers draw on "stocks" of theories; of heads, of purposes, appreciations, and likings, and that these will contribute to structure the design problem. Consequentially, reflection and inquiry on design should acknowledge and identify the repertoire of such generating

theories. And finally, from the social model it could be argued that the theories held by designers are not positive, scientific theories, but a wide range of knowledge-items, which evolves from the community of practitioners as they gain experience with solving similar problems over time.

The conceptual structures presented here provide means to reflect over such aspects in inquiries, and they do so by opening up aspects to design work which were black-boxed and defined out by the problem-solving model.

5 - The problem-solving model; limits and fair uses

Of the models presented, the problem-solving model has been argued to stand out as something of a "default model" in design theory. Originally emerging from Newell and Simon's research on human problem-solving (Newell and Simon 1972), the model has occupied a pivotal role in design research and in many respects define design as an area of systematic study. The model is much referenced, its central concepts and terminology are widely employed, also by those not working within an explicit cognitive tradition, and the pervasive use of protocol- and laboratory studies in design research can arguably be traced to the research program that Newell and Simon instigated.

The mere observation of such historical "trends" in the design literature point to an important aspect of research practices: Abstractions and idealisations in the literature are not normally the outcome of a conscious mapping between a concrete problem at hand and the characteristics of an ideal model. Rather, common models are *inherited* as metaphysical stances on what design "is", and how the field should be understood. As such individual schools of thoughts are internalised by researchers, they gradually gain status as proper ways of understanding and idealising the research topic. If one follows (Lakatos 1977), one could hold that researchers within a community will belong to different programs. The central element in these programs is a theoretical core; communally agreed theories, postulates, and assumptions, as well as a "protective belt" of auxiliary hypotheses that serve to protect this hard core.

A similar perspective, but from a different point of view, was observed by Schön; in professional communities, different schools of thought will be formed, and the debate between the protagonists between these schools can be harsh:

> *Traditionally, the discussion of alternative frames, values, and approaches to practice tends to appear in professional communities in the mode of debate among representatives of the contending schools of thought. There is a great deal of polemical writing, in this vein, in the literatures of such fields as architecture, psychiatry, planning, social work, and divinity. There is also a literature of debate in such fields as law, engineering, and medicine between*

practitioners of the establishment and their radical critics. In this sort of writing, the style of communication is primarily ideological. The protagonists of the various points of view do not reflect on their frames but act from them, seeking to defend their own positions and attack the positions of their opponents. The readers of these literatures may be helped to become aware of alternative points of view, but they are not much helped to reflect on the different frames that underlie them (Schön 1995, p. 312).

Against this general background, the problem-solving model can be seen as exemplifying a core element in such a program; by many researchers, the model has been understood as a, if not the, way to abstract design problems and practices. But despite, or maybe because, of its central position in design theory, several critiques of the model and of the general research program associated with it, have been raised. These critics argue that the models diagnosis of design is flawed, that the empirical data the model is based on are irrelevant for design practice; that it builds on an outdated conception of the mind; and others.

If one gives credence to this line of critique, awareness of premises and characteristics with the model is called for. Inawareness of the characteristics with this model may lead to conceptual problems resurfacing in research practices. As Dorst states: *Some of the problems inherent in Simon's theory are inherited by the people using the conceptual framework that he introduced* (Dorst 2006, p. 16). If it is so, as Dorst suggests, that problems are inherited by the tendency for conservatism in a research community, then a general understanding of how different ways of framing design practice will impact inquiries and reflection appears a sensible remedy.

The situation calls the ability to reflect over abstractions in design theory on a general level. Asking for instance, what are the characteristics to certain ways of depicting design, and what are the limits to these depictions? Any such reflection is, however, confronted by a conceptual problem. As it ultimately raises the question of *correspondence* between an ideal model and design practice, one cannot presume to find an ulterior objective point of reference, i.e. objective criteria, against which different abstractions of design can be compared as more fitting, or truer, depictions of design work (Morgan and Morrison 1999b). Any reflection over the correspondence between abstractions of design practice, and a concrete problem at hand will be pre-theoretical in that it is an article of faith just as much as it will be a rational reflection over the characteristics of the model and its subject. There is nothing "truer" in asserting design to be a cognitive entity, such as Simon does, than asserting it to be of any other kind, be it social, reflective, hermeneutic, or another one.

But reflection and awareness is still necessary. For every instance where design researchers or design practitioners seek to reflect and inquire into practice, they must

choose between and navigate the large range of narratives that can be found in design theory.

The suggestion here is that one can turn to the history of design research for acquiring such awareness. By aiming to learn from insights others have arrived at, to gain awareness with important caveats in the field, and to steer clear of the most blatant errors, one may enhance ones knowledge and awareness.

The approach in this chapter is to make use of the historical discourse in the design research community as a means to reflect over the characteristics and limits with the problem-solving model. Although one cannot base this reflection on objective ground, one can make use of "the common wisdom" that field of design theory represents and document the limits that have been identified with the model.

The historical criticism of the problem-solving model that can be found in the literature is here structured and presented in order to provide a reflection over the ways in which the problem-solving model shape inquiries when it is employed as an underlying abstraction of design work. The text is exemplary, in that it demonstrates a principled way of understanding design theory. It is as such an approach that could have been levelled also at other abstractions in design theory, and is not primarily concerned with debunking the problem-solving program. The underlying conviction here is that the problem-solving model is simply one of several ways of abstracting design practice, and as such has both instances of fair use, as well as limitations in the situations it applies to.

5.1 Approach

In this chapter, the problem-solving model is examined by firstly presenting the background for the model; its role in design theory, the greater program it grew out from, as well as restating some of its central positions.

Beginning in chapter 5.3, five central tenets with the model, and the critique these tenets have generated, are taken up and discussed. The reason for this structure is that comparing the criticisms requires an element of glossing. The criticisms of the problem-solving model have emerged from a variety of perspectives and take on different aspects of the model. They include vague references to the model, such as when Darke argues against the tendency to "a sequence of boxes bearing particular labels, rather than the way particular designers filled the boxes with concepts" (Darke 1979), or when Rittel and Webber argue against the "zeitgeist" of systemising at the time (Rittel and Webber 1973). But there are also concretely directed criticisms, such as when Schön explicitly argue against Simon's conception of design as problem solving (Schön 1992, p. 131), or when Dorst argues it is based on a false distinction between kinds of problems (Dorst 2006), or when Coyne argue that the inherent view of professionalism is simply flawed (Coyne 2005).

The examination of the discourse suggests that the cognitive purpose of the problem-solving model may have been overlooked in design theory and that this negligence may be a source for problems. The problem-solving model is structured around *cognitive invariants* which is different from design research's traditional focus on real-world invariants. If this characteristic is not acknowledged, problems for research may occur.

The discussion of design is here constrained to a general and typical level. The assumption is that 'design' denotes the kind of project work where designers act from an incomplete brief or information to make a product concept or solution, and that this takes place in an industrial context. The problem solving model is thus understood as a model, or framework, for describing design. It is an analytical tool for understanding this practice, and the model will potentially influence inquiries by providing a set of terms (e.g. problem space, structuring, decision-making), a general model (design as a process of consecutive steps to optimise decisions), and an implicit diagnosis of the challenges in design (the limited capacity for information-processing in humans).

5.2 Design theory and the problem solving model

Before examining the tenets of the model, this section sketches out the problem-solving model's impact on design theory, some central positions with the model, and the scientific context from which it emerged.

5.2.1 The problem solving model in design theory

The problem solving model of design has influenced design theory in many ways. Most obviously, it has grounded cognitive and computational studies in design. It has provided a framework for describing design, and it may have served, in many instances, as a general blueprint for what design research should be, as *a body of intellectually tough, analytic, partly formalizable, partly empirical, teachable doctrine about the design process* (Cross 2007). Dorst argues that the problem solving framework is simply the lingua franca of design research:

> *The rational problem-solving paradigm, based on the conceptual framework that Simon introduced, is still a dominant paradigm in the field, and that the conceptual framework of rational problem solving has become the normal "language" of thinking and talking about design (Dorst 2006, p. 4).*

A similar argument is raised by Gedenryd, who holds that the problem solving model shares with design theory an *underlying pattern that is a general model of rationality and rational action* (Gedenryd 1998, p. 55). Bousbaci argues that the problem solving model has had a transitional role in design theory. When developing from the early, entirely rationalist, models of design, to the now dominant reflective paradigm in design theory, he proposes that the bounded rationality of the problem solving model served as an intermediate conception of the designer's rationality (Bousbaci 2008). The assertion that the problem solving model is outdated may be premature however. Hey and Agogino (2007) analysed the conceptual design chapters of engineering and product development textbooks and found *a largely consistent Western approach to design* (p. 9): namely that design was commonly explained in terms of *ideas, problems and solutions.*

Apart from the direct references, one may also trace the influences of the problem solving model with the research practices in design theory. The Design Methods Movement, for instance, was susceptible to the formal models and the schematic conception of design. Computational approaches, e.g. CAD-research, also shared many of the same basic assumptions and principles in their models (e.g. Gero 1990; Jones 1970). Furthermore, common terms such as "solution space" and "problem-space" can be traced to the problem-solving model, and the common practice of laboratory and

protocol studies of design is also one that is derived from the heritage of Newell and Simon (e.g. Dorst et al. 1996).

The influence that the problem-solving model has exerted on design theory is thus large, albeit difficult to define. The problem-solving model appears to be understood both as a scientific paradigm, and as a more general program of rationality in design theory. While the problem solving model provides a systematic view of design practice as a scientific object, it is also a model of design that can be read metaphorically. Several researchers apply to the perspective that the problem solving model should be understood as a general way of understanding design and thereby merely a principled view in thinking about design (Carroll 2006). There is merit to the claim that one may read Simon openly, and that its main contribution is a systematic way of thinking about design. But either way, it may be argued that this way of thinking about design has influenced design theory and laid important trajectories for the development of the design theory as a knowledge domain.

5.2.2 The problem solving model

The problem-solving model of design can be traced to The Sciences of the Artificial (Simon 1996), where Simon establishes a research program for design. The book's first edition appeared in 1969, and was one of the first instances where 'design' was conceived as both an independent and scientific domain of study. Simon saw 'design' as a cross-disciplinary topic aimed at improving and strengthening the knowledge at professional schools. The curricula in these schools were, according to Simon, struggling to meet the conflicting demands of scientific credibility, as well as practically relevance:

> *The professional schools can reassume their professional responsibilities just to the degree that they discover and teach a science of design, a body of intellectually tough, analytic, partly formalizable, partly empirical, teachable doctrine about the design process (p. 113)*

The principled view of the new topic of 'design' was a particular kind of problem solving; a purposeful, rational process of decision making. 'Design' was understood as bringing about desired situations and artefacts states from given ends. Since Simon was intellectually engaged with the communities of cognitive science and artificial intelligence, and thereby the current scientific practices of these disciplines, a particular conception with this model is the view that the inference, or professional reasoning, that took place when moving from *is* to *ought*, could be represented by logical symbols. I.e. the human mind was for all practical purposes analogous to that of the computer. This logical model of design required that one defined the current state of affairs as well as "the goal state", so that any design move could be judged against how it contributed

towards reaching the final goal state (Simon 1973). In practical terms, this laid the foundation for seeing design as the cognitive process of reasoning from a set of requirements to a solution to those requirements.

The kind of reasoning that designers undergo when designing is to span out a "problem space", which consists in all the possible choices that the designer can make to reach the goal state. Notably, the actions that the designer can make are seen as decisions; choices between alternatives. In the cases where the full consequences of these choices cannot be foreseen by the designer, Simon's contention is that the design problem should be broken down further into sub-problems, and sub-sub-problems, i.e. a hierarchical decomposition of design problems:

> *Applying the same linguistic metaphor to house design, "house" might transform to "general floor plan plus structure", "structure" to "support plus roofing plus sheathing plus utilities", "utilities" to "plumbing plus heating system plus electrical system and so on."* (Simon 1973, p. 190)

5.2.3 The problem solving research program

The reason that design is depicted in this particular way is that the problem solving model of design grew out of a larger cognitive research project on information processing. This research project was concerned with the formal modelling of human reasoning and thought with the aim of improving our knowledge both on cognition and computers. The project was large and involved many scholars with a variety of backgrounds, such as linguistics, mathematics, artificial intelligence and management (Gardner 1986).

Herbert Simon was a central person in this project, and also the author that were to be the most central contributor to design theory. Simon was an interdisciplinary scientist who primarily worked on decision making by combining fields such as economics, mathematics, psychology, and management. The time span of Simon's active career stretched from his PhD on administrative behaviour in 1942, through a Nobel Prize in economics in 1978, until his death in 2001.

According to Simon's biographer Crowther-Heyck (2005), an overriding concern in Simon's project was to explain rationality in decision making. Rationality, implying how humans can make ethical, or good, choices, is, according to Simon, limited by the human bounds of reason: the human species' limited capacity for cognitive processing. This is what he termed "bounded rationality", the theoretical complex for which he would eventually receive the Nobel Prize in 1976. Simon's view of decisions, however, is a particular one: From the American psychologist Tolman he took the idea that rationality depends upon the existence of purpose – rationality is displayed by learning to adapt means to ends. From Carnap, the logical positivist, he took the view that a

decision is like a logical proof in that it is based upon the application of logical rules to given premises. The union of these ideas is the view that purpose is inherent in premises of a decision, and reason in the degree to which those decisions achieve purposes.

Another central point in Simon's scientific outlook was that he saw the entire world as a system. The economy, the family, the cell; all were complex, hierarchically structured systems. Truth, in the form of theories that could explain the world to us, would lay in identifying structure from chaos, in deducing the structure of the topic at hand.

The goal of this new science of decision-making was the construction of formal models of human thought and reasoning, as it was believed that such models would aid practical decision making. Simon's preferred method was to develop programs that would enable one complex system – such as the computer – to simulate the behaviour of another - such as the human mind. The empirical data that went into these models were for the most part derived from examinations of how laymen and experts behaved when they solved simple tasks like puzzles, mazes and chess-games.

The central point of this is that the problem solving model emerged from attempts to systemise and explain human behaviour in a scientific frame. In practice, this has implied the association of real-life design practice with an ideal model based in a program of decision-making and systems theory.

5.3 Tenets in the problem solving model

The tenets discussed in the following are extracted from Simon's book The Sciences of the Artificial (Simon 1996), and the paper The Structure of Ill-structured Problems (Simon 1973). The criticisms presented are taken from design theory, and can be considered "classic" to the field. The principle behind selecting these criticisms was their *practical focus.* I.e. they are criticisms that have been levelled at the model for being incorrect or deficient in its depiction of practice. These criticisms are in the following structured and confronted with the tenets of the problem solving model.

5.3.1 Design is problem solving

The first and central assumption with Simon's model of design is the view that 'design' itself can be made the object of scientific study, and that it is a domain that transcends many known disciplinary borders. Simon saw design as a discipline of making that encompasses all of man-made making:

> *Engineers are not the only professional designers. Everyone designs who devises courses of action aimed at changing existing situations into preferred ones. The intellectual activity that produces material artefacts is no different fundamentally from the one that prescribes remedies for a sick patient or the one that devises a new sales plan for a company or a social welfare policy for a state. Design, so construed, is the core of all professional training: it is the principal mark that distinguishes the professions from the sciences (Simon 1996, p. 111).*

Simon thus defines design as an instrumental activity, of which the general purpose is to adapt means to ends. This includes considerable human activity. Simon also indicated the theoretical structure of this new scientific domain. It was the way in which design processes were similar and thereby objects of generalisation that were valuable in the new approach to design science:

> *Few engineers and composers, whether deaf, ignorant, or not can carry on a mutually rewarding conversation about the content of each other's professional work. What I am suggesting, is that they can carry on such a conversation about design, can begin to perceive the common creative activity in which they are both engaged, can begin to share their experiences of the creative, professional design process (p. 137).*

The proposal to see design as a scientific domain that is concerned with the general and common aspects of design may seem common sense. But it is also a view that

generated criticism. Rittel and Webber pointed out in a classical critique that it implicitly depicts the designer as an efficiency expert: the designer is seen as diagnosing a problem and then solving it while reducing the resource inputs (Rittel and Webber 1973). Rittel and Webber argued instead that since there are social issues at stake, there is always more than one good answer, and more than one singular perspective on any problem that is presented to the designer. Design problems are understood differently from the "tame problems" of the scientist they argue. Instead, design problems should be understood as essentially unique and coined design problems to be "wicked".

> *by 'essentially unique' we mean that, despite long lists of similarities between a current problem and a previous one, there might always be an additional distinguishing property that is of overriding importance (Rittel and Webber 1973, p. 164).*

Their argument indicates the danger of reductionism with the problem-solving model. The example that is stated will in itself open a question: Is it so that engineers and musicians can converse *meaningfully* about the design of anything. The counter-argument that also Schön later introduced to design theory is that designers of any profession will develop esoteric knowledge codes by which they think about the design problem. Schön held that one should be cautious with Simon's perspective of design, simply because it reduces the focus and the parameters by which design is understood:

> *Herbert Simon and others have suggested that all occupations engaged in converting actual to preferred situations are concerned with design. Increasingly there has been a tendency to think of policies, institutions, and behaviour itself as objects of design. It is questionable how far we ought to go. We risk ignoring or underestimating significant differences in media, contexts, goals, and bodies of knowledge specific to the professions (Schön 1995, p. 77).*

A general criticism of the problem solving model is therefore the extent to which design problems have the general and recurring features that Simon postulated. Can one ignore the particular and contingent characteristics of a design task, without reducing the value and usability of the theory? Arguments have been raised that the specialised knowledge and the perspectives and languages of design participants will significantly shape the design situation, and that the problem solving model therefore is rather coarse in its depiction of design.

5.3.2 A goal-directed process

A second characteristic of the problem solving model is that it sees design as a process of decision-making. In essence, the reasoning process in design can be

understood as a decision-tree, where, for every node in the tree, designers generate a move – and then evaluate this move against the end-goals of the task. The design task is thus seen as a consecutive set of choices between alternatives.

The counter-argument to this depiction is that designers use considerable resources in making sense of a design task. The design process seldom presents itself to designers as a set of alternatives where designers simply reflect over alternatives and move along.

Simon concedes that there are some problems with this conception of design. In The Sciences of the Artificial, he elaborates the theory to account also for such situations as when alternatives are unknown to the designer and when the end-goals are unknown to the designer and others. But the underlying conception of design as decision-making is retained also in these depictions of design.

There is general agreement that while designing, the conversion of a real-life problem into a structured and ideal problem space will require a form of interpretation and abstraction on part of the designer. For Simon however, these processes of interpretation are merely secondary. On discussing the difference between well-structured problems (i.e. problems that have known solution procedures) and ill-structured problems (i.e. problems where the solution procedure is unknown), Simon holds that all real-life problems are ill-structured problems, but that the process of converting them to well-structured (i.e. solvable) problems is rather mundane, or secondary:

> *A standard posture in artificial intelligence work, and in the theorising in this field, has been to consider only the idealized problems, and to leave the quality of the approximation, and the processes for formulating that approximation to informal discussion outside the scopes both of the theory and of the problem solving programs. This is a defensible strategy, common to many fields of intellectual inquiry; but it encourages allegations that the "real" problem solving activity occurs while providing a problem with structure, and not after the problem has been formulated as a WSP[13]. As Newell and I have observed elsewhere […], these allegations are refuted simple by observing that "if [they] were correct, and tasks from the same environment were presented sequentially to a subject, only the first of them would present him with a problem, since he would not need to determine a new problem space and program for subsequent tasks". Nevertheless, there is merit to the claim that much of the problem solving effort is directed at structuring problems, and only a fraction of it at solving problems once they are structured (Simon 1973, pp. 186-187).*

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[13] WSP is shorthand for a 'well-structured problem'; i.e. a problem that is naturally decomposable.

From these writings, it is clear that Simon acknowledges that the construction of the problem-space is a difficult step in real-life design situations. He does hold, however, that this is only of secondary interest to theories on design. The "problem" of establishing a problem space falls outside the responsibility and interest of a design theory.

In this way, Simon met up with a central criticism of the model. Many design researchers hold that what may be termed "the construction of the problem space" is a central topic for design theory, and argue against the realism of this conception.

Dorst and Cross (2001) use a hermeneutical argument that implicitly counters Simon's conception. They argue that the "problem" and the "solution" to the problem co-evolve:

> It seems that creative design is not a matter of first fixing the problem and then searching for a satisfactory solution concept. Creative design seems more to be a matter of developing and refining together both the formulation of a problem and ideas for a solution, with constant iteration of analysis, synthesis and evaluation processes between the two notional design 'spaces'—problem space and solution space (p. 434). Their focus is more on moments of surprise and discovery, which leads to new conceptions of the design problem, than on the reasoning that is confined within a problem space.

Schön also argued that in many instances, *how* designers structured their problems is more important to understand than the reasoning once the problem is set:

> But with this emphasis on problem solving, we ignore problem setting, the process by which we define the decisions to be made, the ends to be achieved, the means which may be chosen. In real-world practice, problems do not present themselves to the practitioner as givens. They must be constructed from the materials of problematic situations which are puzzling, troubling, and uncertain (Schön 1995, p. 40).

The view that a design theory should be based in a conception where designers structure problems into problem spaces and that a design theory could provide general heuristics for structurally similar problem spaces thus has generated many counterarguments. The gist of these arguments is that the construction of the problem space is not secondary at all, as Simon contended, but a central topic for a design theory. In other words, the process of interpreting the design problem into an operative understanding is something that design researchers should be aware of as both troublesome and worthy of attention.

5.3.3 Hierarchy and decomposition in design

The problem solving model also presents the reader with a particular worldview; that any object can be regarded as a hierarchic system, where simpler sub-systems are embedded in larger ones. This is a central position in Simon's worldview, even the conclusive point in The Sciences of the Artificial:

> *My thesis has been that one path to the construction of a nontrivial theory of complex systems is by way of a theory of hierarchy. Empirically a large proportion of the complex systems we observe in nature exhibit hierarchic structure. On theoretical grounds we could expect complex systems to be hierarchies in a world in which complexity had to evolve from simplicity. In their dynamics hierarchies have a property, near decomposability, that greatly simplifies their behaviour. Near decomposability also simplifies the description of a complex system and makes it easier to understand how the information needed for the development or reproduction of the system can be stored in reasonable compass (Simon 1996, p. 216).*

"Near decomposability" is a concept that is central. By and large, the view is, any design task can be expected to exhibit a given structure, and the task of the designer is largely to discover this structure. Design problems are sub-sets of problems embedded in larger problems, and the design process can be understood as attending to the smaller problems individually, before recombining them to solve the larger design problem. A previous quote illustrates this view:

> *Applying the same linguistic metaphor to house design, "house" might transform to "general floor plan plus structure", "structure" to "support plus roofing plus sheathing plus utilities", "utilities" to "plumbing plus heating system plus electrical system and so on." (Simon 1973, p. 190)*

Simon concedes that there may be problems in that the individual sub-systems in a design process are not entirely independent of each other, so that solutions in one sub-space may influence other sub-spaces. But Simon does not hold this to be a problem with the model. Rather, he provides a normative stance towards the proper decomposition of design problems: *a good procedure will divide the task into components that are as nearly "self-contained" as possible".* (Simon 1973, p. 191) Simon grounds the argument for this normative view with Alexander's seminal work in design methodology, Notes on the Synthesis of Form (Alexander 1964) where Alexander argues for such a systematic approach to designing.

The normative basis for this tenet is problematic. The author in question, Alexander, has later famously disowned the theory, calling it an entirely unrealistic approach to how designers design (Alexander 1971).

As Bousbaci notes, Simon's worldview is essentially Cartesian (Bousbaci 2008). It prescribes an attitude towards problems where, for solving them, they should be decomposed into their constituent elements, the sub-problems then solved individually, and subsequently recombined again into a solved problem.

The criticism of this tenet does not concern hierarchy itself, but rather how and with what purpose designers assign hierarchy to design problems. Simon's normative position, that designers should aim to establish near-independence between issues, is a stance that has caused disputes.

First, this tenet has generated qualifiers from researchers who have followed explicitly in the path that Simon laid out. If one solves design problems by way of individually isolated sub-problems, one will have great problems recombining these solutions into a solved design problem (Reich 1995). Consider for instance, the design of a car: If the electrical engineer, the mechanical engineer, and the stylist were to solve their task individually, there would be obvious problems of recombining the solutions within the given set of constraints. Solving design sub-problems in individual manner is known to cause problems.

The conception of hierarchy in design problems that Simon proposes is problematic because it suggests that there is an optimum, or near natural, way of decomposing design problems. But a centrepiece in much design discourse is the view that there are practically infinite ways of decomposing a professional problem and assigning hierarchy to the tasks that need attention. Assigning a hierarchy to a design problem is a normative decision, i.e. the designer *decides* to see the design problem as being of a certain type or belonging to a certain class. Making the assumption that this normative stance is "naturally given" runs contrary to much design theory where it is argued that the decision on how to characterise the design problem is a central part of solving the design problem, and not something that is objectively "given" (Coyne 2005).

As a general model of how designers decompose design problems, the assumption that there exists a natural hierarchy for any object will need attention and probably modification if it is to be applied in design inquiries. The assumption that design problems are hierarchic and should be decomposed into independent sub-problems is a claim with little empirical backing.

5.3.4 Bounded rationality

A fourth tenet of the problem solving model concerns Simon's general conception of the mind, and thereby the implicit view of how designers understand and reflect over design problems. With the problem solving model, Simon lays down a conception of human understanding termed "bounded rationality" which has consequences for how design knowledge is understood.

Bounded rationality is a centrepiece in Simon's writings. Originally, bounded rationality was a concept that addressed why people were "irrational" in their decision making behaviour. On the one hand, theories on decision making that explained human behaviour as entirely rational, e.g. Bayesian models, were obviously flawed; on the other hand, theories that explained irrationality in terms of passion or the unconscious are obviously problematic in a scientific context. Rather, Simon held, limited capacities for information processing were the underlying factor of irrationality. When faced with a complex world, humans construct simplified models of their environment in order to deal with it, and people act and reflect on the basis of these simplified models.

Given this view of human understanding, Simon held that the larger goal of the new science was the construction of formal models of human behaviour, and its method was to develop programs that would enable one complex system to simulate the behaviour of another, such as the human mind. Thus, the problem solving program equalised understanding with an algorithm; different (numerical) heuristics that could be applied in situations of complexity, such as design.

This general view of human understanding as rule-based reasoning is included in a science of design. In The Sciences of the Artificial (Simon 1996, p. 134), Simon indicates and delimits the topics in a theory of design. These are, notably, in the form of rules and algorithms that are believed to be central in a design process:

1. Theory of evaluation; utility theory, statistical decision theory
2. Computational methods
   a. Algorithms for choosing optimal alternatives
   b. Algorithms and heuristics for choosing satisfactory alternatives
3. The formal logic of design: imperative and declarative logics
4. Heuristic search: factorization and means-end analysis
5. Allocation of resources for search
6. Theory of structure and design organization: hierarchic systems
7. Representation of design problems

The depiction has generated criticisms that one cannot meaningfully develop a scientific program aiming for "rules" for design. To render the gist of this criticism, one may observe that when designers face a design problem, their understanding of the design problem will decide how they approach and attempt to solve that problem. For the problem solving model, the scientific commitment to the behaviourist tradition, renders it virtually impossible to deal with a concept such as 'understanding' because it is a mentalist concept.

But in normal language and much of design theory, mentalist concepts such as "frames" are entirely unproblematic. They denote more or less the worldview or specific understanding that a designer approaches a given task with. The exact nature of

"understanding" is, however, something of a riddle as it is more varied and generally more difficult to define than the mere existence of rules.

Other design researchers have argued that the reasoning process in design is vitally depending on mental prestructures that designers make use of to impose coherence and meaning onto the design problem. These authors hold that designers' moves and judgements in the design process are evaluated by simple and vague mental structures, and not evaluated against the end-goal of the process (Darke 1979; Hillier et al. 1972; Schön 1992).

In design theory, such mentalist conceptions have been a prominent part of the discussion in design theory; tacit knowledge, experience, practical knowledge, values, i.e. the entire background of the designer will contribute to how designers solve their tasks. Schön for instance, notably proposed "frames" as a way of depicting the understanding that designers approach design problems with (Schön 1995). Another conception of understanding is proposed by Vincenti (Vincenti 1990). He sees the understanding that designers make use of in design problems as being a spectrum of different knowledge types: Fundamental design concepts, theoretical tools, rules-of-thumbs, quantitative data, procedural knowledge, and many others (p. 208). One may also consider Dorst's introduction of Dreyfus' general conception of competence to design theory (Dorst 2003); that understanding develops with experience and familiarity with certain kinds of problems.

In summary, one should be aware that Simon's programmatic commitments hinders the problem solving model from dealing with mentalist conceptions, and that many design researchers have found the idea of rules underlying design behaviour as greatly deficient concerning their explanatory and predictive value for a design context.

5.3.5 A scientifically objective design theory

The final tenet with the problem solving model taken up here is the view that a design theory can and should be pursued by scientific means in the mould of positivism. As has been argued, one of the central concerns in Simon's theories was the view that computers and human minds were similar:

> *As we succeed in broadening and deepening our knowledge – theoretical and empirical – about computers, we discover that in large part their behaviour is governed by simple general laws, that what appeared as complexity in the computer program was to a considerable extent complexity of the environment to which the program was seeking to adapt its behaviour. This relation of program to environment opened up an exceedingly important role for computer simulation as a tool for achieving a deeper understanding of human behaviour. For if it is the organisation of components, and not their physical properties,*

> *that largely determines behaviour, and computers are organised somewhat in*
> *the image of man, then the computer becomes an obvious device for exploring*
> *the consequences of alternative organisational assumptions for human*
> *behaviour (Simon 1996, p. 21).*

This quote shows some of the labours that one had to go through to establish a research field, in psychology, that was concerned with how people reason at the time. One obviously had great difficulties in allocating a role to mental concepts because of the behaviourist heritage that influenced the model.

Instead of approaching human faculties directly, Simon had to establish a physical object (the computer) and argue its analogy to the human mind. By way of this approach, one could argue that mentalist conceptions were "physical", in that they were symbols (akin to the computers signals). This allowed for an empirical science on problem solving, by way of careful analogising: One could simulate and compare human mental processes, by arguing that they were the same as one found inside a computer.

The two central elements in this account are the inner environment of humans, and the outer environment. Human cognition is regarded as discreet "symbol systems" that adapts to different environments, and can be programmed to deal with different "task environments" by careful scientific scrutiny.

"The science of design" thus is a cognitive science aiming for better knowledge of *cognitive* invariants, but where issues of understanding and interpretation; i.e. participation in the real world; are regarded as secondary. So the view here is that by examining "design behaviour" it is possible, by scientific means, to establish rules that guide design behaviour in different "task environments". So, the outer environment is, quite simply, of secondary interest.

A problem with this conception is therefore that it is largely unconcerned with the characteristics of the outer world. This "outer environment" has a role for any design process that is much more important, and much more complex than merely "providing goals". In any design process, designers must seek to understand various interests and trade-off situations. Rittel and Webber, for instance, termed design problems "wicked": since there are social issues at stake, there is always more than one good answer, and more than one singular perspective on any problem that is presented to the designer. Design problems are understood differently from the "tame problems" of the scientist (Rittel and Webber 1973). It is difficult to see how these wicked problems can be categorised into "task environments"

A similar argument has been raised by Hatchuel, who argues that Simon overlooked the social interactions that contribute in driving the design process forward (Hatchuel

2001). Common sense supports the claim that design does not take place in a vacuum. In the industrial context there are always many stakeholders involved: clients, suppliers, customers, not to mention the many kinds of professionals that are involved in development. A design process is always dependent on the information provided by the client, and for many inquiries it may seem strange to isolate these and generalise them into task environments, as they may be factors that are decisive for the course of the design process. It is therefore open what a cognitive, empirical theory on design can tell us about such situations.

5.4 Discussion

Given the objections that have been raised in the preceding, the historical impact of the problem-solving model seems to be somewhat of a puzzle. Why does the model hold such a central role in design theory, when so many vocal counter-arguments have been raised against it?

One answer probably has to do with Simon's authority. As a nobel-laureated academic, central in research communities spanning cognitive science and academic research, his recognition surpassed any other academic who has held an interest in design. The general credibility of the model may have been deemed high by merit of this status alone, and thereby provided an alluring reference for authors seeking respectability.

But apart from external factors, the criticisms suggest that the problem solving model causes problems regarding its practical application, as its explanatory value of design is contested on several grounds. Why then, is the model so much used, and what are the reasons it causes these problems when applied in research?

A tentative explanation for how the problem-solving model causes problems when applied in a design context is that it might be common to overlook the extent to which the problem-solving model has a cognitive focus and purpose. If one considers the research culture that Simon worked within, one will note that it is rooted in behavioural research, and was primarily concerned with cognitive research, artificial intelligence, as well as other fields related to decision-making (Crowther-Heyck 2005; Gardner 1986) The problem-solving model was an attempt to formalise human reasoning both to understand it better and to be able to model it (in computer form). This is, quite simply, a different motivation than design researchers are likely to hold. If one assumes that design researchers hold an interest in design because they seek to learn across design projects, i.e. how insights and learning in one context can be transformed to another context, then the consequences that the problem-solving model will have for research will be difficult to spot, but they will also be significant and determine important qualifiers.

A characteristic to the problem-solving model is that it regards design in a very general manner. It is based on the conception that 'design' includes all of man-made making. But any design researcher searching further clarification and elaboration of the characteristics to different "task environments" will find that Simon's theories are consistently vague in describing the entities that are general and reoccurring in this large set. From a design perspective, one could expect some form of classification in Simon's model; a discussion of the ways in which different design disciplines differ from each other for instance; how engineering is different from architecture, how graphic design is

different from product design, to mention some typical examples. In the absence of these, one could at least expect some discussion of the characteristic differences between different types of problems in the real world. Such an explication would be important for understanding transfer in design, i.e. how designers of different kinds transfer experiences from one context to another, and the way in which different design tasks are similar.

But going through Simon's texts, one will find no such explication of the differences between different problem-solving contexts. Rather, Simon's empirical material is restricted to chess-playing, ants moving on a beach, and theorem-finding computer programs, where the intention is more to show that such contexts are similar (at heart simple processes) than to reflect over how these differ. Simon simply blurs the topic of how different real-world "task environments" differ from each other, something other authors have noted:

> *In Newell and Simon's early work on problem solving (1963), the environment is reduced to the discrete series of choices that it presents in the course of solving a given problem. The phrase "task environment" came to refer to the formal structure of the search space of choices and outcomes. This is clearly a good way of modelling tasks such as logical theorem-proving and chess, in which the objects being manipulated are purely formal. For tasks that involve activities in the physical world, however, the picture is more complex. In such cases, the problem solving model analyzes the world in a distinctive way. Their theory does not treat the world and the agent as separate constructs. Instead, the world shows up, so to speak, phenomenologically: in terms of the differences that make a difference for this agent, given its particular representations, actions, and goals. Agents with different perceptual capabilities and action repertoires, for example, will inhabit different task environments, even though their physical surroundings and goals might be identical* (Agre and Horswill 1997, p. 113).

Why this peculiar construct? The answer is that the real focus of this model is the cognitive processes, not the design process per se. The problem-solving model glosses over the way in which different contexts are different, and focuses instead on the *cognitive invariants* of design; i.e. that which will be reoccurring every time a human individual confronts a design situation. If such cognitive invariants could be established, Simon would have opened a new avenue for scientific inquiry into a particular branch of the human mind.

The implications for transfer considerations in the design field are that one may learn from observing designers, through e.g. protocol-study, how limits to their cognitive capacity are overcome. But there is little to none consideration of how different tasks will, and should, trigger different behaviour. If design researchers are to

learn from one project to another, the model contains neither terminology nor means to identify differences in premises or similarity between different real-world projects.

This focus can be interpreted as a flat out deficiency, given design research's historical concerns and focus. If one holds the view that research in the design field has the purpose of documenting and communicating insights that are valuable and useful across a range of design projects, then one is implicitly looking for real-world invariance, not cognitive ones. Vincenti's social model of design, for instance defines the invariance underlying design as the "typicality" of professional problems (Vincenti 1990). Groups of designers will encounter problems that have generic traits; it is from this kind of generality that insights can be derived and transferred across the field. Not, importantly, through the invariance that is psychologically common to all people.

The qualifier that can be derived is that if the problem-solving model is used for more traditional design research, researchers must, on their own initiative, consider and reflect over how different real-world design projects are similar. If one relies on the implicit stances of the problem-solving model, there is a risk of reductionism in that all kinds of design activities are deflated into one simple entity.

The percussions of the cognitive and symbolic nature of the problem-solving model extend to the other criticisms taken up here. The second tenet criticised; that for design activities, problem setting and co-development of problems and solutions is central; is a topic of great practical interest. In education, and in practice, ways of understanding design problems appears to be at the heart of research and reflection over design activity. But in the problem-solving model, these issues are actively deemphasised because they violate the definition of design; that it is a form of reasoning from function to form. Accepting the view that problem setting and understanding in design is contingent and depending on the problem at hand would make it endlessly difficult to formalise the cognitive problem-solving process in a form that could be programmed in a computer. Thus, the qualifier to the problem-solving model is that it defines out problem setting as an element in design. In other words; designers should be aware that any form of problem interpretation is defined out from the model. The model ignores how designers establish a problem-space, potentially leading to the belief that designers retain an unchanged view of the design problem throughout the process.

The same extends to the third tenet. Why should one assume that there exists a hierarchy in all kinds of design problems; a Cartesian world-view, philosophically dubious, against which a range of objections have been raised? A plausible answer is that it fits nicely with Simon's programmatic view: The belief that computers would, eventually, solve every kind of problem required that one postulated the decomposition of complex problems into simpler ones. If it hadn't been done, Simon would have had to postulate a form of computing unknown at the time. The qualifier is that one must be

careful with taking up the normative view that designers should decompose the design task into independent entities, or that there exists such a thing as a natural hierarchy in design problems. Observing any given design process under the view that there exists and "optimum" way of decomposing it, researchers will risk projecting their own conceptions, and their own preferences with the design task under the assumption that they present a natural hierarchy of the design problem.

The fourth criticism touches on more philosophical problems of Simon's model: To see mental reasoning as a form of 'symbol-processing' is a depiction with obvious analogies to computers. Against this way of seeing human reasoning, there are vocal counter-arguments, many of which from design theory. Darke's primary generators and Schön's frames are just some examples. From a design perspective, researchers should be aware that the problem-solving model is a conception that excludes concepts of mind and understanding, such as frames (the problem space *is* the frame), and that the model aims at documenting only observable behaviour.

Finally, the scientific framework may appear incredible today. It is a requirement mostly necessary for discourse in the cognitive domains, artificial intelligence and so on where establishing the status of science is important. For design research, one may debate whether scientific status of this kind is necessary, or even plausible. If one is concerned with how designers think, for instance, why not simply go ahead and interview them? The option is open to design researchers, but the answers they receive are likely to be couched in other terms than 'heuristics', 'problem-spaces, and 'representations'.

5.5 Concluding remarks

The discussion here has concentrated on the problem-solving model as it has been formulated by Herbert Simon. One may question how relevant this discussion is for design research today. Is it so that the problems mentioned here have been sorted out by researchers; have they moved on to remedy the flaws that were inherent in Simon's model?

It appears that the discussion is still relevant. Examining the latest issue of Design Studies at the time of writing (March 2011), one will find the article *The effects of physical prototyping and group work on the reduction of design fixation* (Youmans 2011). The article displays every characteristic of Simon's model: It is based on protocol-studies of 120 designers. The premise for the article is that fixation is a major problem in design, and the hypothesis is that physical prototyping will yield fewer fixations. The conclusion from the experiment is that:

> *Results showed that designs were better and contained fewer fixations to the example tool when designed in the physical prototyping environment, but that groups designed better tools than individuals or nominal groups when no physical prototyping was available. These results underscore the importance of physical prototyping in design.*

With other words: After having set up variables and environment for protocol studies of 120 students, documented experiments, subjected empirical studies to blind review of dependent variables, and run statistical correlation and regression tests, Youmans concludes that for designers, using models is a better form of practice than not using models. Few will disagree with him. Except perhaps, Herbert Simon himself, on the grounds that he arrived at the same conclusion in 1969 (Simon 1996, p. 132). So, the problem-solving model appears to be alive and well, and knowledge of its characteristics is still required background knowledge for anyone engaged in design theory.

The argument that the problem-solving model should be used with caution is not a devaluation of its value or its historical contribution to design theory. In inventing these theories and models Simon did several contributions: He formulated a program research, discussed the contents of such a program with unprecedented level of detail, suggested a systems view of design problems, and invented a terminology for the field. In short, Simon provided theoretical structure to an otherwise very fussy field of inquiry. It is difficult to imagine a design theory at all, without the contributions of Herbert Simon, and his postulate that design can be considered a valuable domain of

inquiry. And judging from the quantity of researchers that have followed in his footsteps, it is a contribution that many have found valuable.

But for any real-life application of this model, one should keep in mind that it comes with a string of qualifiers attached: 1) It contains a reductive depiction of the many contexts and environments designers work in; its generalisation for transfer is a cognitive one, and indifferent on the real world. 2) It defines out issues of interpretation and understanding during design. 3) It postulates a hierarchy of design problems which is dubious, and 4) It proposes a scientific framework for design that very often will be impractical and outdated.

6 - Ideal models as repertoire for theoretical triangulation

So far in the account, the assessment of theoretical traditions in design theory has been primarily analytic; the focus has been the characteristics of the models within the narrative traditions of design theory. This chapter aims to synthesise findings, by taking up how knowledge of these different traditions for idealising design practice can inform one's own research.

The general goal underlying this thesis has been to take stock of existing narrative traditions and investigate how these traditions influence the formation of theory and the development of professional knowledge in the design domain (chapter 1.3). The examination has showed that there exist deep-running differences between the narratives in design theory, and that these will have impact on the formation of theory and knowledge in the domain in many characteristic ways. The motivation was primarily the perceived need for clarification and systematisation of existing narrative traditions.

This concluding chapter suggests a more positive strategy: How can broad knowledge of traditions be utilised as a repertoire, or a "toolbox", for research and reflection in the design domain? The suggestion here is that a positive way of utilising the variety in design theory is to make use of its potential for theoretical triangulation of design activities.

Theoretical triangulation is the use of more than one theoretical position in interpreting data. Its relevance to the design domain is that research on design characteristically is broad in scope; a large number of issues are potentially relevant to the profession. For reflection and inquiry into this domain, the ability to navigate different theoretical perspectives and methodological practices will be a benefit. As abstractions of design practice the narrative traditions indicate different "research programs" for design; different principled perspectives on how to frame inquiries in the design domain. The narrative traditions contain different principles for knowledge-

transfer between design projects, and therefore the models provide different perspectives of what and how designers may learn from projects.

This chapter sketches out and suggests how the models in this dissertation can be acquired and taken up as principled perspectives on design practice and the perspectives on knowledge-transfer these models carry. In the following, triangulation as a research practice in design research is taken up. Thereafter, the models are compared. From this comparison, the transfer-models implicit with the narrative traditions are explicated. The final section of this chapter suggests how these principled perspectives can inform one's own research. It also provides a structured presentation of the authors underlying this thesis so that further reading and orientation in these narrative traditions is facilitated.

6.1 Theoretical triangulation and ideal models

One value of broad knowledge of narrative traditions in design theory is that it will allow theoretical triangulation as an element in design research practices. Theoretical triangulation is the use of more than one theoretical position in interpreting data (Denzin 2009), implying the ability to explain practice from several theoretical perspectives, allowing different potential explanations of the same "data".

Supporting the argument for theoretical triangulation in design research is the observation that the design domain reaches broadly by a contested professional jurisdiction, and that theoretical and empirical references in this domain are project-based rather than theory-based (chapter 1.2).

The characteristic differences between design research and the classical schema for academic research are central to consider in this respect. Apparently, these two fields do not differ much. They share the idea that knowledge expands within a particular field through the use of theory and methods; that this research is concerned with validation of theories in a defined theoretical domain; that researchers share a set of conventions as well as common historical exemplars. The scientific schema suggests that problems of understanding in the field lead to contradiction and dilemmas that provokes new inquiry, new theory, and the general growth of knowledge in the field.

Design research differs from such a schema on important points. It can be characterised as both a practical and problem-based domain, and the academic schema fits poorly with the research activities which take place at design departments at universities and schools. A look at the department where this thesis is written, for instance, reveals that the topics forming the bulk of research are not defined by theoretical convergence. Research initiatives here have included topics as diverse as haptics, packaging, sustainability, interaction and usability, workshop organisation, "strategic" design management and others.

The focus for design research here, as it is at many other design departments, is not primarily the theoretical understanding of design as a "field". Research initiatives are not intended to further a theoretical tradition, but seek to answer concrete problems that are related to the design profession's work. The nature of these problems reach broad and wide; they touch on most issues relevant to design, human behaviour, society, and economics. Research topics include questions of organisations, of knowledge, of aesthetics, of best practice, and of pragmatics of industry and society.

A marked difference from academic research is that research initiatives are not pursued within the confines of a specific theoretical tradition, but opt instead to employ models and concepts drawing on a large range of traditions to pursue research problems. Design research cannot be characterised by its contribution to a theoretical "field". It

addresses multiple issues related to the profession's challenges, spreading across theoretical domains, and requires a theoretical breadth that is different from the specialisation normally associated with academic research. Correspondingly, it requires from design researchers, as well as anyone inquiring and reflecting over design practice, the ability to navigate between and consider different theoretical perspectives, i.e. narratives, on design practice and its associated problems.

The difference between academic research and design research is not lost on the wider design community. For example, a common way to identify these differences at the department where this dissertation is written is to frame design research in Jørgensen's depiction of problem-based versus discipline-based research. This depiction sees design research as a problem-driven field, contrasting this research to a general form of academic research. All research within 'design science' is a combination of addressing a certain basis of perceived problems, and working with a basis of existing theories. Jørgensen calls these the problem-based approach, and the theory based approach (figure 6.1).
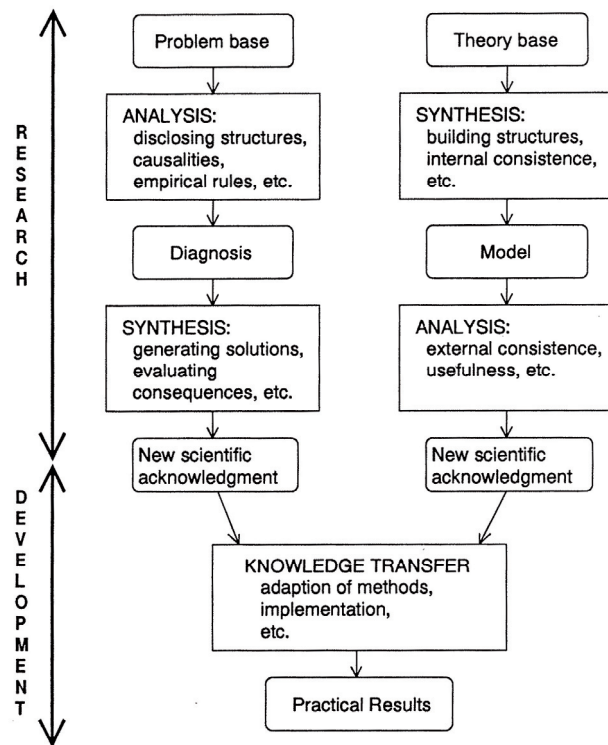
Figure 6.1 - Jørgensen's model of design research. From (Øritsland 1999).

Jørgensen's model illustrates a problematic tendency, however. The model overlooks the extent to which one's own problem understanding is *theory-laden*. It seems unlikely that one's own problem-diagnosis can be performed without any theoretical framing of the phenomenon. But from Jørgensen's model, both problem-diagnosis, and knowledge-transfer are expected to more or less "take care of themselves". Such a depiction obscures that understanding "problems" requires preconceptions on the part of the designer researcher. The diagnosis of a problem requires theoretical and normative framing of the phenomenon perceived to presenting a problem.

The risk is that one may miss out the impact that individual narratives have upon on our understanding of any problem. Without awareness of the way in which understanding is coloured by historical and traditional ways of framing practice, researchers are in danger of tacitly projecting their own preferences and assumptions. It may promote a tacit form of objectivism, where inherited and traditional ways of framing practice seldom are reflected over, and alternative ways of understanding practice seldom are explored.

Triangulation; the ability to explain the same problem from different theoretical perspectives in a conscious manner, will be one way of overcoming such tendencies. By being able to frame and explain design practice through different lenses, it is feasible that one will have availability to a greater set of hypotheses, more methodological means to explore hypotheses, and thereby a broader view of design practice.

As a caveat, one should be aware that triangulation probably will be difficult in practice, because it requires a multi-disciplinary mindset. It requires from researchers that one is able to pursue topics in a way that is informed of best research practices, yet without going into the specialisation that one expects from academic research. The challenges are obvious. An experienced researcher (in any field) will have spent years learning and internalising certain theoretical perspectives, which will shape perspectives and bias the way in which research problems are understood.

Contributing to the ability for theoretical triangulation in the design field, the findings in this thesis have identified models of professional reasoning, because these are deemed central in understanding the traditions available in design theory. The models in this thesis thus indicate different "research programs" as they provide a cross-sectional view of the abstractions that are common to base inquiries on. A value with this is that it may facilitate theoretical triangulation in at least four areas:

Longitudinal studies:
Design research is often motivated by the need to understand a fussy, problematic situation with design practice; for instance the effects of the design function in industry,

collaboration with other professions, the effects of certain methods and so on. For such problems, longitudinal studies of how design processes proceed over time are often initiated; researchers either follow a design process as it takes place in industry or follow elements of the design process, e.g. meetings, idea-generation, or brainstorming-sessions. The purpose of such research is largely to better understand key success factors and hindrances to design work as they appear in practice.

A potential problem is if researchers enter the studies with a bias. If they for instance enter the research project with the preconception that it is a research problem pertaining to social roles and professional identity, or conversely, that the research problem pertains to problems with the problem-solving behaviour. If so, then the risk is that researchers' preconceptions in reality decide much of the outcome and the conclusions of the research.

If, ideally, researchers could approach such processes with a pluralist mindset, and a repertoire of alternative, causational models, then researchers could test and examine different theoretical explanations, comparing e.g. how social models and problem-solving models explained the same work and design processes, and gain a richer understanding of the ways in which design work proceeds.

Such an approach would characteristically see the theoretical framing of design as secondary to defining and understanding the problem. If design researchers could enter longitudinal studies using a broad theoretical framing, it would have the consequences that the researcher is equipped with a richer repertoire for identifying and examining professional problems.

Pilot studies:

In early phases of research, when the purpose is exploratory; to ring in the research problem and decide early hypotheses, postulate relationships and identify the central elements to be examined, a broad theoretical understanding serves a purpose by retaining a wide framing until one decide the proper framing of subsequent studies.

The ability to associate a problem with several theoretical frameworks, and check several ways of theorising the design activity will have a value by eliminating the frameworks that have little ability to explain the factors (i.e. parameters), and the causational relationships.

A broad understanding in the early phases of research will allow associating the research problem with a relevant theoretical framework before elaborating the research design, deciding on relevant theory and formulating more precise theoretical hypotheses.

Hypothesis-testing:

When design researchers are to analyse a data-set, i.e. they are confronted with examining a given problem, without carrying out empirical research, broad design research knowledge is valuable. Design researchers often deal with limited problem-complexes which require reflection and critical assessment; e.g. evaluations of best practices within a particular industry, different assessments of design work, attempts at integrating working processes with new technologies and many others. These kinds of problems are often presented to researchers, akin to consultancy work, dealing with problems in industry, available statistics, and other kinds of ad-hoc research.

For such tasks, ability to judge problems from multiple perspectives, quickly, will be of value. This allows designers to make different hypotheses and explain different aspects of designing, drawing on different theoretical traditions.

Methods:

A large part of design research aims at equipping designers with methods for solving problems of particular kinds; e.g. methods for sustainability, or methods for branding of products, methods of creativity and several others.

Such methods are always based on an implicit assumption on how designers work. The historical example here is the design methods movement, which produced design methods based on the assumption that designers work in a form of rational, decision-making, i.e. problem-solving.

It is, however, entirely feasible to frame such methods based on other perspectives. Methods based on the assumption of reflective practice, for instance, could have stressed the iterative and physical aspects of design work, allowing space for the iterative nature of design work, and the process of reflection and reframing in the course of the process. Methods based on a social perspective could stress the value of existing methods and social practices, allowing considerations of a community's history and typical kinds of problems that are resolved. These are alternatives to regarding the design process as a form of clinical reasoning from requirements to solution.

In general, the triangulation proposed here, allows researchers to run hypotheses, and postulate relationships *before* committing the research to theoretical tradition. Admittedly, the results with this thesis are still at an early stage. More work is needed before an operative model of these narrative traditions can be presented.

6.2 Transfer in design; a comparison of models

To lay the foundation for how these models can serve different research initiatives, a condensed and summarised look at these models and what they say about knowledge s is here provided. The ideal models examined throughout this thesis have postulated different ways of understanding design practice. The characteristic differences between them extend to the way in which they define and generalise design, the conventions and methods underlying theoretical development, and the more general paradigmatic outlook.

Among these differences, particular attention is here devoted to the perspectives on knowledge transfer inherent with these models. Transfer is here understood as the way in which a narrative tradition regards professional knowledge in the design domain to develop; i.e. the central elements in design transfer, and the conventions by which this theoretical domain can develop. The narrative traditions have postulated different perspectives on *what* one should learn from design practice, effectively defining the core contents of any design theory, as well as *how* this project can be carried out in a credible, authoritative and valid way.

The following section presents the perspectives on transfer in design in the form of models as a rhetorical device for grasping the narrative traditions in design theory and the perspectives they provide on research and reflection in the design domain. The transfer-model is the implicit position that follows from the characteristics of the models of professional reasoning. Given that these identify the characteristics of designer's processes of professional reflection, the transfer-model is the derived position on how knowledge in design develops from project to project, or context to context.

6.2.1 A Comparative view of ideal models

If the models of professional reasoning and their associated programs are considered as frameworks for understanding design practice, their differences are more fundamental than mere "difference of perspective". The models rest with different research paradigms entirely and thereby provide characteristically different perspectives on design. Table 6.1 displays the characteristic differences in schematic form. It presents an overview of the central stances with these models. The table shows the diversity of theoretical stances with the traditions that have been put to use in design theory.

A first topic is how they generalise a design field in different ways. This characteristic way in which similarity across the design field is understood, will to a large extent identify which elements that are important in design practice, and how one

can learn and transfer knowledge across individual design projects. The problem-solving tradition for instance, sees 'design' as including "all man-made making", leading to the view that design projects have a structure, and that one can identify decision-sequences, heuristics, which fit with different kinds of problem structures. This generalisation can be contrasted with the social tradition, which sees design as a practice that is defined by different social contexts to which the characteristics are the typical problems that the social community encounters. The social tradition thus, implicitly sees design problems as something solved more or less automatically, as the professional community develops a technological frame internalising design problems.

On a second point, the ideal models presented here have originally been established to serve inquiries with different purposes. The overall aim and purpose for research associated with these programs are therefore different. The problem-solving model grew out of a research program originally interested in cognition; how one could understand and formally model cognitive processes (so that they eventually could be programmed in a computer). The hermeneutic tradition on the other hand, was motivated by an explicit practical focus: How designers grew stocks of "prestructures" that served to structure design problems; clearly a more didactical and practically aimed research program.

A third point is that narrative traditions in design theory also contain different positions on what kind of empirical material that should be regarded as permissible data-sources for research and theorising. Since some traditions hold design research as a scientific project, a "laboratory approach" is favoured; design is subjected to controllable protocol studies, where insights and findings in turn can be extrapolated across the design field. Other traditions are based on the view that professional knowledge is personal, potentially tacit, and correspondingly, that we can only have indirect access to this kind of knowledge, such as conducted in monographs, interviews and experience-based cases, calling for an interpretative research form.

A fourth point is that the models hold different perspectives on what is being transferred between design projects, and how we can deem this knowledge credible and valid. For instance, the reflective model of design holds a constructivist perspective, arguing that knowledge arises in practice, and argues the need for self-reflection over professional frames and common methods. The problem-solving contains a more traditional positivist view of knowledge where; since we do not have access to "the mind"; knowledge is seen as growing through controlled experiments on designers' "behaviour", leading to heuristics for design practice.

	Problem-solving	Reflective Practice	Doctrinaire
Principle of generalisation	Design' is a cognitive class of problems: Due to humans' limited cognitive capacity for information-processing (bounded rationality) they cannot foresee all consequences of choices made during the design process.	Design is a professional practice characterised by interaction with clients and idiosyncracies of professional tasks. Professional knowledge and physical tools emerges from daily practices, and cannot be separated from the context of this practice.	Design is a defined professional role with responsibilites and a jurisdiction in the larger society.
Research aims	It is assumed that design problems have a structure. By means of scientific research one can develop theories and heuristics applicable for problems with the same structure. E.g. problems of decision, problems of fixation, problems of representation.	Through practice, designers construct frames of understanding and train the use of certain tools and techniques. Since this repertoire set directions for work, reflection (i.e. research) is needed to select between alternative ways of approaching and solving professional problems.	Based on a diagnosis of an unfavourable condition with the designers role in the larger society, researchers provide knowledge and doctrines to rectify this condition
Empirical sources	Laboratory and protocol-studies of design; simulated instances of design or design aspects in an environment where variables and context can be controlled and measured.	Either practitioners' critical self-reflection over common frames and methods, or: analysis of general professional discourse	Depending on diagnosis; in some instances, programmatic academic research, in other instances, doctrines are experience-based and polemical.
Transfer; ontology	Heuristics and techniques; strategies and tools for overcoming cognitive shortcomings and inclinations	Reflective and aware attitude towards own organisational principles, techniques, and frames of understanding	Domain knowledge or principled perspective towards the resolution of professional problems
Relation research and practice	Professional knowledge as application of scientific research	Research as reflection over common frames and techniques emerging from practice	Inconclusive
Research paradigm	(Post)positivist	Constructivist	Inconclusive

Table 6.1 – Ideal models of design as professional reasoning

Hermeneutic	Social	Participatory
Design problems are always unknown and have elements of learning and discovery; designers have a potentially infinite number of solutions to consider. Designers use personal "primary generators" to structure the design problem.	'Design' is a professional practice of making: Typical professional problems are shared by a community of practitioners, who develop professional knowledge as ways of solving these recurrent problems.	Design problems are typically characterised by a gap between makers and users
Since experienced and skilled designers have a larger and better stock of models for use as primary generators, the aim is to learn these and communicate them to novice designers.	The knowledge that designers make use of evolves from practice as solution-strategies for typical problems. Research may serve a role in documenting and testing the solution-structures or produce models that are both precise enough to be useful and wide enough to fit a range of problems.	Since designers may infer unproductive solutions by basing designs on own preconceptions, there is a need for methods and knowledge on how the perspectives of users best can be included in the process. The aim of research is to provide means by which designers may involve users and counter own preferences with those of users.
Interviews with experienced designers as main source. Examination of professional discourse also used.	Knowledge resides in the social community; Participatory observation or document studies	Inconclusive
Personal subjective models that may serve to prestructure the design problem	Through participation in a professional community: The technological frame	Methods, techniques
Research as documentation and analysis of subjective working practices.	Research as social science; participatory observation.	Design as a knowledge-intensive process, a fusion of design with research methods
Subjective (sic)	Science and Technology Studies, Etnomethodolgy	Applied social science

A fifth point is that these traditions hold different stances on the relationship between research and practice. Some traditions see professional knowledge as something that can be grounded in science; i.e. that design practice is a form of applied science. Other traditions are vocally arguing that professional knowledge is something that arises in practice, and that research activities have more of a supporting than a grounding role in the development of such knowledge.

In sum, the differences mentioned can be ascribed to a different wider paradigmatic worldview that authors have written from. Simon was explicitly behavioural and positivist scientific in his worldview. Schön's perspective is influenced by constructivist and pragmatist ideas. The doctrinaire positions include all and any position. The hermeneutic model is mainly based on to Popper's theories on knowledge. The social models refer to social constructivism. And finally, the participatory model is based both on the Critical Theory of the 70's, with Rittel and Webbers writings, whereas the management-tradition for user-orientation appears to have been more central at later stages.

6.2.2 Transfer-models with narratives

Among the differences between narratives, the principled perspective of transfer is central for understanding how knowledge in the design domain develops, and the underlying rationale for research and inquiry in the domain. The transfer-model is strongly affiliated with how authors have chosen to generalise the field of design; some authors see the similarity between projects as design being a professional role, others as a cognitive challenging issue, and so on. This "principle of generalisation" as it is stated here is important both for rhetorical reasons; it is a simple way of grasping the differences between narrative traditions; and as a source for understanding how transfer in the design field is expected to take place. Because it differentiates the important form the unimportant, it singles out important elements in knowledge-transfer across the design field.

In the following, these perspectives are presented as transfer-models. The models largely seek to explain *what* is being extracted from design projects, *how* one is assumed to epistemically reflect over and test the items being transferred, and the valid *reapplication* of insights in new projects. A template for the analysis is given in figure 6.2.
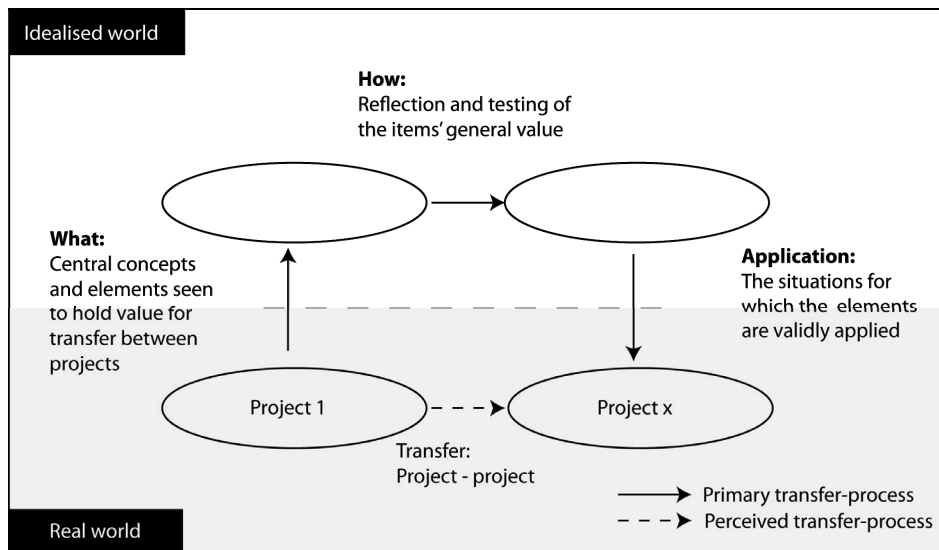
Figure 6.2 - Template for examining perspectives on transfer.

The problem-solving model; transfer of heuristics

The problem-solving model of design provides a "scientific" model of knowledge and learning in design. As a general principle, it asserts the similarity across design fields by a cognitive assumption; that design problems are all the situations where one seeks to achieve a desirable situation that is different from the existing one. The challenge inherent with design in practice is seen as a problem of cognition: Limitations in human reasoning will render it difficult to foresee both potential solutions and the consequences of these.

Central for transfer is the view that design problems have a 'structure'. By proposing heuristics and tools, and test their applicability with different problem structures, researchers may find improved ways of solving and approaching different problem structures. The general model of transfer is thus that through observation and experimentation on design behaviour in controlled environments; a laboratory, one may scientifically test different heuristics and tools that aid designers in overcoming the cognitive challenge that design tasks represent.
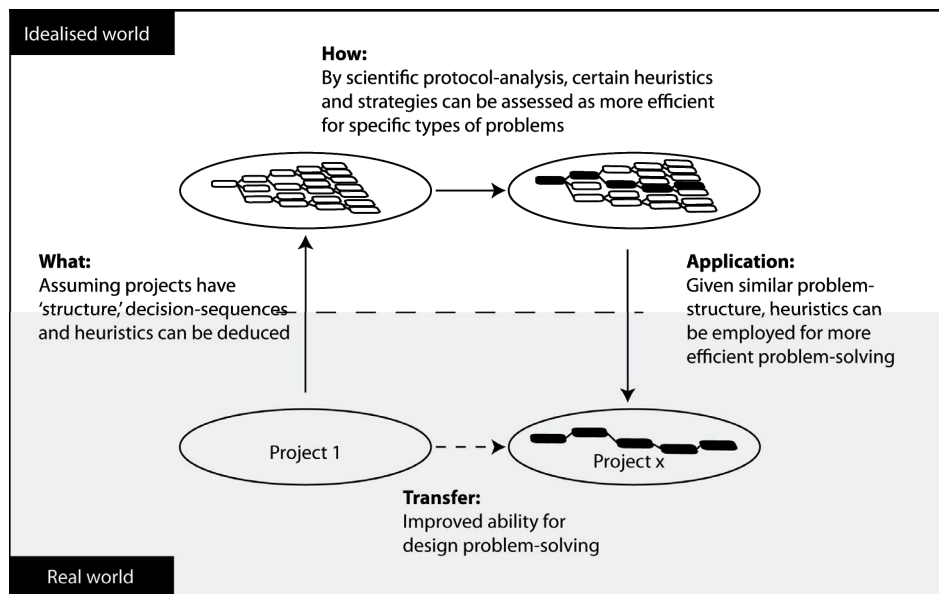
Figure 6.3 - Transfer in design as the problem-solving model depicts it

The reflective model; critical inquiry into working practices

The principle of generalisation with the reflective model is that design practice should be considered as professional work. In the context of design practice, knowledge develops through practical experience, and it includes interaction with materials, clients and stakeholders. Through practice, designers develop frames for understanding and treating problems, and familiarity with tools and materials by which problems are reflected over. These general items are, however, troubled by the fact that design problems always are unique, leading to the need to reflect over and maintain a reflective attitude to the perspective and methods that one commonly employs.

Concrete design projects provide an opportunity to test and evaluate the usefulness and fit of these individual frames. Design projects are therefore important as opportunities to reflect over the extent and application of one's own professional perspectives and methods.

In the reflective model, transfer takes place more or less automatically; by experience, designers naturally develop and evolve their ways of framing problems and testing solutions. The argument is that designers need to be aware and reflect over the effectiveness of framing problems in different ways, for the reason among others, that one is conscious about one's own perspectives and how they shape solutions.
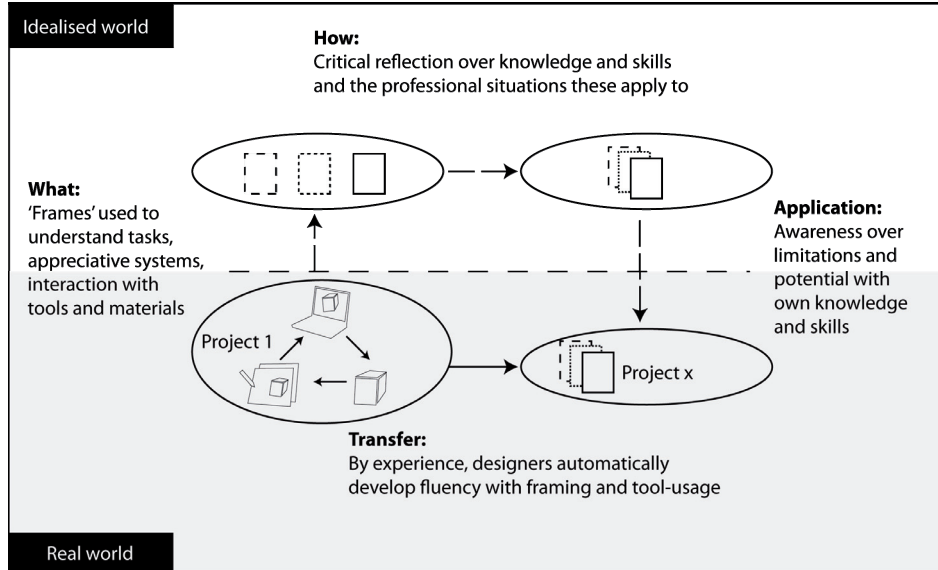
Figure 6.4 - Reflective transfer

The doctrinaire model; responsibility and jurisdiction

The range of different publications that have been subsumed here under the label doctrinaire share one generalising principle: They locate a pertinent issue with the profession and prescribe a way in which this issue can be remedied.

The design role can be seen as primarily a professional role and responsibility; certain domains, e.g. aesthetics, are seen as designers' area of responsibility. Proper ethos, models, and strategies for solving problems in a way that is up to the standards of the profession are seen as necessary elements for solving these.

Central for transfer are therefore authors themselves and their ability to diagnose pertinent and general issues with the profession. Judging from the assessed material, such diagnoses display varying degree of soundness, and the material assessed ranges from armchair-based polemics to robust scientifically tested, and philosophically grounded theories. The doctrinaire model thereby assigns a central position for authors (experienced practitioners and researchers), in the larger project of knowledge-transfer for the product design profession.
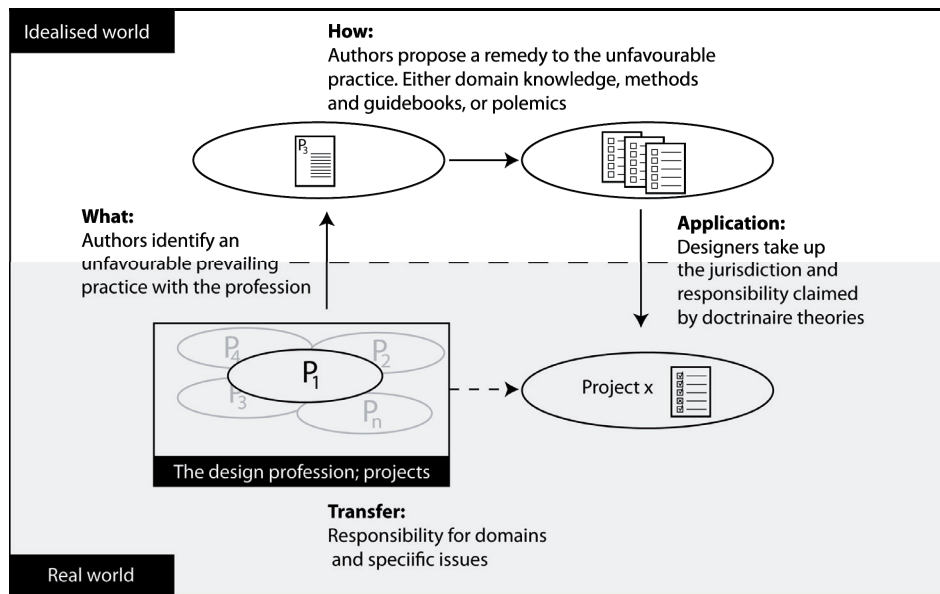
Figure 6.5 - Doctrinaire transfer

The hermeneutic model; mental models and loose ideas

In the hermeneutic model, design practice is seen as a general problem of variety reduction (Darke 1979); because there are potentially infinite solutions to every design problem, designers must constrain the number of solutions to be evaluated. While designing, designers therefore establish mental concepts, simple ideas and conceptions which guide idea generation and subsequent evaluation.

The process of professional reasoning in design is seen as akin to Popper's model of scientific discovery; the conjecture-analysis model (Bamford 2002). The term for the mental conceptions that constrain the solution-space and give rise to conjectures is *primary generators*; they serve as ways in to the design problem and they may both be loose ideas and groups of concepts.

Transfer in design can by this account be seen as a process of developing "stocks of models" in designers' mind. Prestructures of many kinds are learnt and acquired through experience, but this process can be catalysed by examining and documenting how designers think about and structure professional problems.

In other words, the central source for developing and expanding professional design knowledge is the inner world of experienced or skilful designers, as lesser experienced designers can learn particular ways of thinking about and constraining design problems.
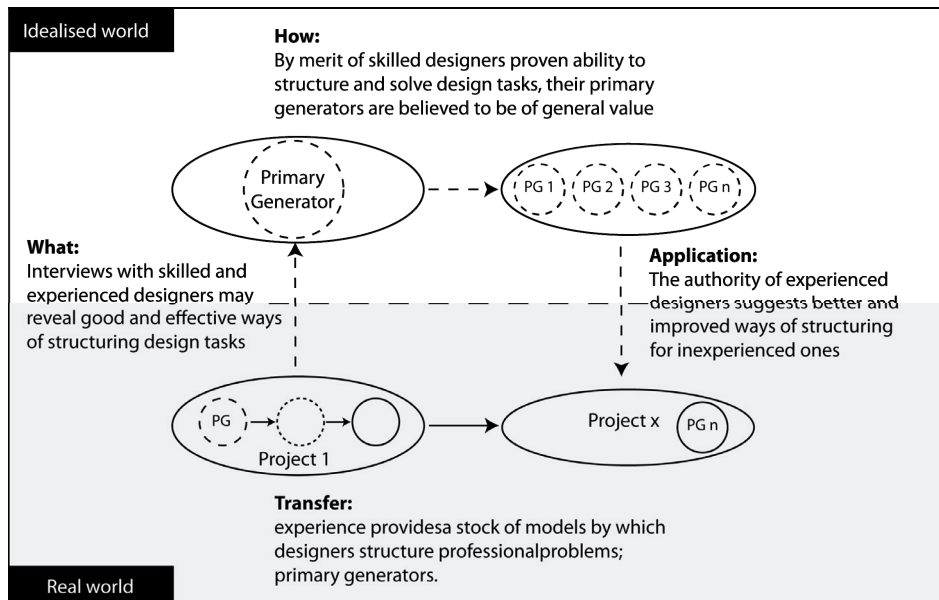
Figure 6.6 - Hermeneutic transfer

The social model; the community as source of knowledge

The social model of design holds the view that designers should be regarded, primarily as members of a professional community. The typical practical problems in design work define also the knowledge and intellectual structure in the design field.

As members of a profession, designers are exposed to typical recurring problems. For these recurring problems, solution strategies evolve, and these may range from simple rules of thumbs to robust scientific theories and models. Such knowledge-items constitute a 'technological frame', and is retained and maintained through the community of practitioners that share the same type of professional problems.

Transfer in design is therefore much a matter of participation in the professional community. It is through interaction with other practitioners one learn ways of framing problems and common models to employ in the design process. An important aspect here is the importance of understanding typical professional problems; the 'typical' professional problems are problems that a group of people share, i.e. they are characteristic for a "social field". Typical problems can be defined by geography, industry, or other social demarcations. It is therefore a perspective that is different from the general design theories, which seek to define 'design' on a global scale. Under the social model, designers from different social contexts will have very little to learn from each other.
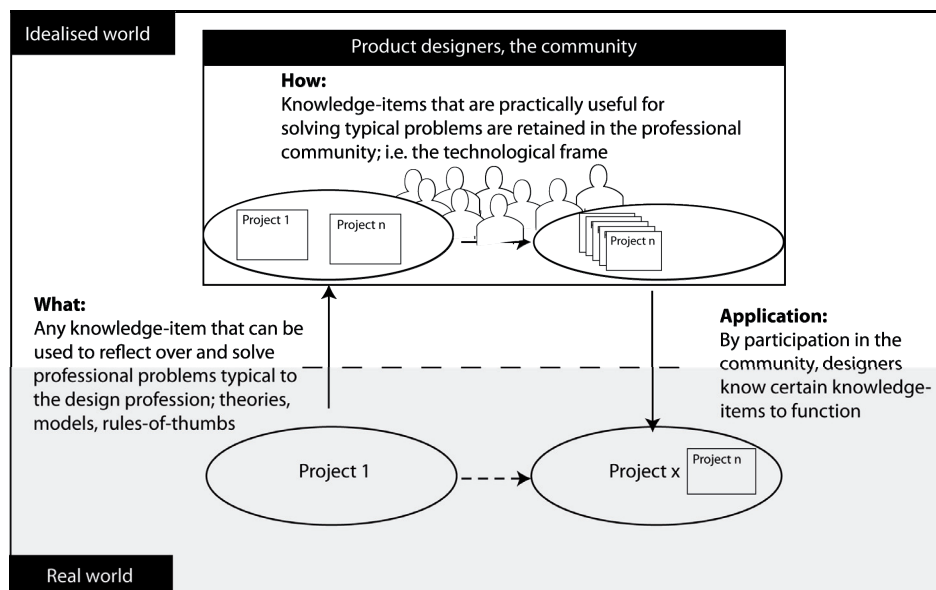
Figure 6.7 - A social model of transfer in design

The participatory model; transfer of techniques for user-involvement

The participatory model of design sees the design process as primarily a task of overcoming the gap between makers and users. When engaged in designing, designers will invariably project both their own preferences and their own understanding of the design problem to be solved. Including users in the process is a way of overcoming one's preconceptions and make sure that the product serves a role for those it's intended for.

Framed in this manner design is centrally about inclusion, facilitation, and cooperation. The designer's task is primarily to reconcile conflicts that arise from several different stakeholders and social groups holding an interest in the product.

Transfer of knowledge in the design domain, as it is understood here, is not the growth of personal knowledge, but the improved ability to facilitate and include conflicting perspectives in the design process. The participatory model thus implies a methodological focus where the outcome often are particular techniques intended to involve users at an early stage; games, metaphorical interviews, scenario-building and so on. The argument has been raised that participatory design research represents a fusion between academic research and design practice: As designers take on the information-sensitive tasks of involving people, reconciling interests, and challenging own concepts, the need for improved abilities in elementary scientific methodology is argued to become more central, and in many ways represents a break with the classical conception of the designer as a making artist.
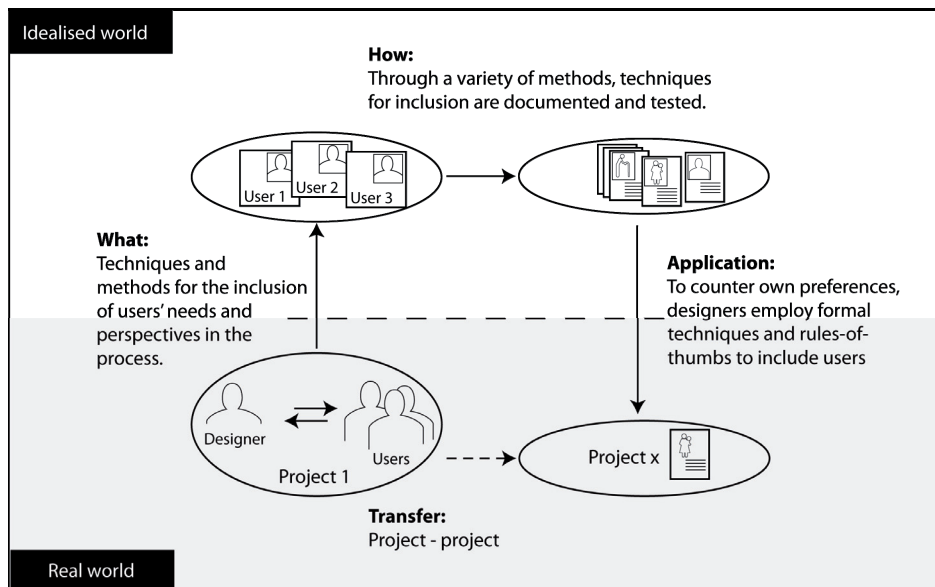
Figure 6.8 - Transfer according to the participatory view.

6.3 Practical implications: Narrative traditions as frames for theoretical triangulation

Responding to the question of how these abstractions will impact theory and inquiry, the account here must resort to arguments of a more speculative calibre. Providing advice to how one should utilise the theoretical traditions of design theory, requires that one presumes the nature and characteristic of this practice. It may be worthwhile, therefore, to recall that there are three arguments underlying the view that theoretical triangulation will be beneficial in design research.

Firstly, the product design field has a 'project structure'. It is defined by the practice and the projects that designers do, and therefore encompasses an array of issues ranging from creativity, social collaboration and management to individual knowledge domains subject to the role and professional jurisdiction, such as aesthetics, consumer theory, ecology, and technology to mention a few. Compared with this, a shortcoming of generally accepted research methods is that they always have a limited scope; the inherent premises and assumptions will constrain the organisation and execution of inquiries.

Secondly, if design research aims for a research practice that is carried out in an *informed* manner, knowledge of existing traditions will be necessary in order to make use of previous findings. Understanding the historical concerns in design theory will enable design researchers to navigate the field with more certainty.

Thirdly, design theory is troubled by conflicts over "correct" ways of modelling design. There exist contending schools of thought and the discourse can be excluding in nature. If one is enabled to treat different narrative traditions as tools in a toolbox rather than as correct or erroneous research approaches, the quality, not to mention soundness, of one's research is likely to improve.

The next section summarises the models that have been unearthed in this thesis, and tentatively displays how these models provide different research programs, or paradigmatic perspectives on how reflection and research can and should be carried out. It does so within a framework that takes up, the general research program associated with each narrative, and the general aims for design research. It moves on to state "typical" research foci, hypotheses and questions, and identify the permissible empirical sources for research within each narrative. For purposes of further reading and orientation in the traditions of design theory, exemplars and important works within the individual traditions are presented. These works are classified as: 1) Conceptual; the works that have defined and presented the rationale for a narrative tradition. 2) Secondary; literature that contextualises the conceptual works or the narrative tradition.

3) Methodical; works that suggest how design research could or should be carried out.
4) Exemplary; examples of research within individual traditions.

The problem-solving model

As a general program for research in the design field, the problem-solving tradition holds that professional design knowledge develops through formal analytic research on designers' behaviour. By using research methods such as laboratory studies, researchers can provide heuristics; simple solution-strategies that designers can reuse for different problems and whose primary purpose is to overcome the limitations of human cognition. Additionally, one will find in Simon's writings, more conceptual topics in a "science" of design; representation, evaluation, and structuring are examples of issues of which Simon suggests we should develop a better conceptual understanding.

The aim for any design research is to facilitate reasoning in design and provide aids to overcoming cognitive obstacles. Design is generally seen as a process of goal-based reasoning where the designer reasons back and forth between requirements and proposed solutions, and this process is cognitively taxing. But through cognitive science, researchers can provide general heuristics and algorithms that help in overcoming the cognitive obstacles that design represents.

Central in this account is the view that problems have a 'structure'. It is possible to develop solution-heuristics, programs, which can be reused in instances where a similar problem structure is encountered.

The permissible empirical sources within this program are decided by the behaviourist heritage. Laboratory studies of design are regarded as the central source for insight as it provides a controllable environment. In a real or virtual (class-room) laboratory, researchers may observe and measure what designers do and analyse these findings in terms of their impact on design result. Topics measured typically include difference in behaviour between expert and novice designers, or the effects of various tools on design performance. As a general observation, the impact of the problem-solving tradition can be witnessed in the widespread tradition for basing design research on laboratory studies.

As a program for design research, the cognitive tradition invites hypotheses and inquiries on matters of design which are cognitive in nature, for instance: How designers solve recurrent challenges, how designers choose between alternatives, assessment of different ways of organising the design process, and the use of tools and aids to overcome common cognitive impediments.

Table 6.2 below identifies central authors within this tradition. Among the exemplars with this tradition, the instances of this program in design theory should

probably be differentiated in a "strong" and a "weak" tradition. The "strong" tradition has retained the cognitive and symbolic intention from Simon's program. It includes research on cognition in design. (Dorst et al. 1996), representation (Brereton 2004), and formal models of the design process (Gero 1990). The "weak" tradition retains primarily an applied focus in design, but uses terms and central stances from the problem-solving model (Jones 1992; Pahl et al. 1996; Roozenburg and Eekels 1995).

For applied purposes, one should note that counter-arguments to and criticisms of this program are a recurrent theme in design theory. Among these are that one could expect that the problem-solving program was explicit on how insights arrived at in the laboratory can be validly transferred to a real-life design project. In psychology, this is known as *ecological validity,* implying the assumption, on how the laboratory experiment is similar to a real world setting. But the cognitive assumption of the problem-solving model glosses over the difference in contexts, and provides few terminological or conceptual cues to the question of how insights are transferred across different 'task environments (Chapter 5). Apart from this, researchers should note that the problem-solving model by definition suppresses reflection on how designers interpret, and how they subjectively understand the design process.

Conceptual	Secondary literature	Methodical	Exemplary
(Newell and Simon 1972)	(Rowe 1987)	(Dorst et al. 1996)	(Pahl et al. 1996)
(Simon 1973, 1996)	(Crowther-Heyck 2005)	(Akin 1986)	(Jones 1992)
(Newell et al. 1958)	(Chua Soo Meng 2009)	(Carroll 2006)	(Roozenburg and Eekels 1995)
(Asimow 1962)	(Bousbaci 2008)		(Gero 1990)
	(Dorst 2006)		(Youmans 2011)
	(Gedenryd 1998)		(Brereton 2004)
	(Hey and Agogino 2007)		
	(Gardner 1986)		

Table 6.2 - Authors in the problem-solving tradition and relevant secondary literature

The reflective program

As a program for design research, the reflective model sees design as a professional practice. Characteristic to any professional practice is that it gives rise to particular ways of thinking and reflecting over professional problems as well as training with the tools and materials (sketches, models) that are integral parts of practice. Professional knowledge is seen as emerging from solving everyday professional problems. Consequentially, the reflective model rests with a more or less automatic transfer-principle, in that learning from experience is the primary source for developing professional capability.

From this view, the central aim for design research is seen as facilitating reflection and awareness over common practices; ways of framing problems, and materials and tools used. The departure point for *any* systematic inquiry in design practice will be the existing frames and tools which are the currency of professional practice (and not, e.g. a postulated entity such as problem-spaces). The role for research is primarily to reflect over and test existing knowledge. Rather than regarding research as the production of knowledge, the purpose of research is rather seen as to question whether the knowledge practitioners hold is sound, and how this knowledge can be put under scrutiny and improved.

Throughout his writings, Schön suggested several reflective research approaches, which all held in common that they were interpretative ways of reflecting over the theories and knowledge designers held: Frame reflection (Schön 1993) promotes awareness over one's own perspective; espoused theories versus theories in use (Argyris and Schön 1978) focuses on the fact that the theory one claim to hold very often differs from the theory that is actually followed in practice; and a tentative categorisation and definition of designers' knowledge can be found with *Rules, Types and Worlds* (Schön 1988).

A concrete research strategy can be found in *The Reflective Practitioner*. Here Schön suggests that such research can take one in four forms (Schön 1983, p 309):

- Frame analysis: the study of the ways in which designers frame problems and roles.
- Repertoire-building research: Description and analyses of images, category schemes, cases, precedents and exemplars.
- Research on fundamental methods of inquiry: Overarching theories, from which designers develop on-the-spot variations.
- Research on the process of reflection-in-action itself.

As a template for research in design, the reflective model suggests that one may raise hypothesis and carry out inquiries on the ways in which designers frame problems, and the interactions they have with tools and materials.

As empirical sources for design research, the reflective model suggests self-reflection and learning from experienced practitioners is the mode by which knowledge in professions may expand, but primarily in a complementary role. Since "knowledge" is understood to be created in practice, conscious methods can provide reflection over everyday practices; ways of dealing with common problems, and typical approaches. Such reflection can potentially lead to better ways of framing and depicting professional problems. The view on empirical source for research is thereby nearly opposite from the problem-solving model; practice cannot be separated from the context in which practitioners work; understanding the characteristics of this context is therefore a premise for any reflection over practice.

The examples here, in table 6.3 include Schön's texts primarily. Additionally, there are several examples from design theory where the reflective model is used as abstraction for reflecting over how designers use sketches and models in their work.

Conceptual	Secondary literature	Methodical	Exemplary
(Schön 1992, 1995)	Waks (2001)	(Schön 1988, 1993)	(Dearden 2006)
	(Chua Soo Meng 2009)	(Schön and Wiggins 1992)	(Adams et al. 2003)
	(Goldschmidt 2008)		
	(Goldschmidt 2003)		
	(Cross 2007)		

Table 6.3 - Literature in the reflective tradition

The doctrinaire program

Framing research in the doctrinaire tradition will imply that the development of professional knowledge critically relies on authors' ability to infer a relevant diagnosis of the profession, its responsibilities and role in society. Doctrinaire models thereby rest with authors' appreciations and horizons, and will in this way contain a strong normative component regarding how designers should work, particularly the issues they should attend to.

The central element in doctrinaire models is a belief, and a concern, that the responsibility of design practitioners extend to a certain domain. This implies a normative stance on the profession's role in society and, consequentially, that acquiring

and learning certain domains may improve practitioners' ability to fulfil this role. Under the doctrinaire model, authors contribute within a specific domain of knowledge and argue its relevance and importance for the profession. Since this "tradition", as mentioned, reaches wide, examples are probably the best way of illustrating how this tradition relies on diagnosis of the larger profession and its role in society:

- Product Semiotics is one central example of an influential tradition in design. Its doctrinaire position is expressed through the implicit stance that products can and should be regarded as objects of *communication*. The assumption is associated with formal analyses on product grammar, of products as signs, and other semiotic approaches.
- Sustainability is another example. Here, the argument is that products in general must conform to principles of environmental soundness, sustainability and that designers have an important role to fulfil in this respect. The tradition provides models and methods enabling designers to attend to such issues while designing.
- Innovation theory is a third example; the perspective that designers have a central role for ensuring novelty and creativity in products and the way in which products are produced.

The point to be made is that the relevance of any knowledge domain to practice is not self-evident. Hypothetically, counter-arguments could be raised depending on one's perspective of the profession and its responsibilities. Against the semiotic tradition for, instance, an argument could be the view that form is secondary to function, if the designer were to be more technically inclined. Against sustainability one could argue that ecological concerns are unimportant in a free market economy, if the designer were so inclined. Against innovation theory, the argument could be raised that innovation is something that management holds responsibility for, whereas designers' responsibility resides lower in the corporate food-chain.

As a general template for design research, a tendency of the doctrinaire programs is to suggest that authors and researchers should and must take a stance towards practitioners' role and responsibilities in the larger society. They must consider how the profession carries out its tasks, whether there are flawed practices with these, and if so, how these can be remedied. Knowledge in the design field evolves by researchers (authors) taking care for and normatively decide upon areas of responsibility. Judging from the history of the field, experienced practitioners and others have an important role to play, by virtue of their oversight, experience, and acquaintance with the larger workings of the profession.

The kind of hypothesising and inquiring this tradition opens for is virtually endless. So are the methical conventions and empirical sources for this tradition. The element

to consider at this level of analysis, is that for practically oriented design theory, the diagnoses that can be found underlying inquiries and publications, ranges from off-hand assumptions to well-argued observations of the practice and its responsibilities. The doctrinaire perspective displays a spectrum of methodological perspectives; from rigorous empirical scientific studies, via experience-based reflective accounts, to polemical doctrines written with affective appeal.

Presented on this level of detail, one will be hard pressed to state any caveats with this approach. Criticism is mostly relevant on a case-by-case basis. Of the few general critical observation is Rowe's (1987): Doctrinaire models may pose a problem in that they, ideally, may present the designer with an overwhelming amount of different theoretical frameworks to take into account. In the case where these frameworks are contrary, the designer may experience cognitive overload; for example, with a caricature, when the judgements emerging from aesthetic considerations of the product concept are contrary to those that emerge from ecological considerations.

The examples presented here provide examples of doctrinaire models of many kinds; from the classical perspective of Vitruvius, to more modern applied perspectives. Table 6.4 shows examples of works which have held this implicit view of knowledge-transfer in design.

Conceptual	Secondary	Methodical	Exemplary
(Vitruvius 1914)	(Rowe 1987)		Sustainability: (Papanek 1971)
			Sustainability: McAloone & Bey (2009)
			Semantics: (Vihma 1990, 1995)
			Semantics: (Monö 1997)
			Semantics: (Krippendorff 2006)
			System design: (Sakao and Lindahl 2009)
			Manufacturing: (Boothroyd et al. 2002)
			Design for emotion:

Table 6.4 - Examples of works with a doctrinaire view on transfer

The hermeneutic program

The program for the growth of knowledge in the design field that Darke postulates is one of "subjectivity"; the way designers prestructure problems, through primary generators, are determinants for which solutions to design problems that are found. The central aim for research activities can be seen as documenting and publishing mental

structures that experienced designers hold. Darke exemplifies this by postulating the central problem of novice students as having a limited "stock" of models to draw from when solving problems, and correspondingly, the growth of this "stock" is a way in which designerly knowledge expands.

In other words, the central source for developing and expanding professional design knowledge is the "inner world" of experienced or skilful designers, and in this way lesser experienced designers can learn particular ways of thinking about and constraining design problems.

This program calls for an indirect kind of research, where interviews and monographs are the way in which the ways of thinking can be documented and presented to the larger community. One should note that this is a traditional way of learning in design fields; analysis of especially skilful designers in the form of e.g. monographs have been made since well before the works of Darke and Hiller et al.

The kind of hypotheses and inquiries it opens for are mainly examinations of how skilful designers think about their problems, and reflections over whether such ways of structuring design problems have a general and wider value across the profession. Alternatively, the model could be seen as an entrée to reflect over how problems are structured in a given project. One could, for example, follow Darke's tenet, that designer use vague ideas to prestructure design tasks, and ask what impact such structures have had in a given project.

Methodically, pursuing a program of subjectivity will encounter challenges in that subjective perspectives are hard to assess. One of Schön's central arguments, for instance, is that the espoused theory very often differs from the theory-in-use, potentially qualifying the hermeneutic approach to design research.

The empirical sources for the development of design knowledge are therefore, under this model, mainly interviews, and reflective, experience-based accounts on how one thought about the design problem at a given time. The implicit stance is that interviews and experience-base accounts are the central sources for development of professional design knowledge.

Table 6.5 shows that apart from Darke's account, examples can be found with Lawson (1994) and Cross & Cross (1996). A related way of seeing design processes; namely that these mental prestructures should be actively formed and manipulated in order to achieve a directed end-product, can be found with Lerdahl (2001) and Snoek & Hekkert (1999).

Conceptual	Secondary	Methical	Exemplary
(Hillier et al. 1972)	(Bamford 2002)		(Lawson 1994)
(Darke 1979)			(Cross and Cross 1996)
(Coyne and Snodgrass 1992)			(Lerdahl 2001)
			(Snoek and Hekkert 1999)

Table 6.5 - Literature in the hermeneutic tradition

The social program

If professional design knowledge is regarded as a social entity, the primary source for reflection and research is, like in the reflective model, the existing practices in a community. Design research should aim for disclosing the ways in which design problems are made sense of and structured, and how models and templates are used to solve typical problems. This perspective opens for several types of studies.

For design research, the social model suggests a focus on the social community in which designers work; common working practices as well as models and working theories that are particular to a given community. The model opens for consideration of the social differences existing between designers of different industry, geography or other social context. Bucciarelli for example, used an ethnographic approach, participatory observation, to inquire the "culture of designing" across different projects and industries; excavating the social practices during design and development (Bucciarelli 2003). Vincenti used document studies to unearth the development and institutionalisation of professional knowledge codes in the aviation industry. He followed the development of industry standards from qualitative rules-of-thumbs to the more formal, and nominally scientific, current standards (Vincenti 1990).

The methods and principles for epistemology that the social model favours, reach as wide as the social sciences. But central for this model is probably that one understands the concept of "social fields"; i.e that knowledge resides with a group:

> *In this way design is a social process, i.e. if we ask 'What is the design?' at any time in that process my response would be, following Durkheim, that it exists only in a collective sense. Its state is not in the possession of any one individual to describe or completely define, although participants have their own individual views, their own images and thoughts, their own sketches, lists, diagrams, analyses, precedents, pieces of hardware, and now spread-sheets which they construe as the design. (Bucciarelli 1988, p. 161).*

Additionally, if one follows the conceptual view that professional knowledge emerges from common typical problems, the model does suggest a certain level of reflection and awareness over what items or entities that are recurrent in the tasks that designers encounter in work. According to Vincenti, when designers recurrently encounter problems of the same kind, there will be a drive toward decreased uncertainty, i.e. a need to choose between alternatives with greater degree of certainty. This drive will be central for the development of knowledge. What items that are recurrent, will however, always be depending on the industry or group in question.

Since the social model can be equated with a social science perspective on design, the permissible empirical sources for research are as wide as with these sciences. With the examples here, in table 6.6, they range from the participatory observations of Bucciarelli to the document studies of Vincenti.

Conceptual	Secondary	Methodical	Exemplary
(Vincenti 1990)	(Bijker et al. 1987)	(Bucciarelli 1988)	(Ingram et al. 2007)
(Bucciarelli 2003)	(Bijker 1995)	(Button 2000)	
		(Cross and Clayburn Cross 1995)	

Table 6.6 - A social model of design; literature within tradition

The participatory program

As a program for research and reflection, the participatory approach to design sees the main practical challenge of design work as overcoming own preconceptions in the course of work. The principled view is that there will be a gap between users' and designers' understanding of a product, and if this gap is not attended to, the product will develop in way that is ill-fitted with users' wants and needs.

The development of knowledge in design under such a view is primarily a matter of developing methical approaches to include users in the design process. This inclusion can typically be performed on one of three levels:

1. Co-creation: Users are invited in and participate in the conceptualisation and subsequent stages of the design process.

2. Exploratory and participatory research: Designers make use of social science methods, e.g. probes or ethno-methodology, to observe situations of use and identify needs, problematic situations, or potentials for new, improved solutions.
3. Post-hoc testing: The traditional user-oriented form, where a product concept or solution is tested for use in a laboratory or real-life context.

A characteristic with the participatory tradition is that designers' own perspectives, in the form of artful, creative abilities are relegated to a secondary position. The organisation of the design process is at the fore.

Methodically and empirically, the participatory tradition has a wide scope, including approaches that vary from simple ad-hoc techniques, to theoretically grounded approaches to design in an inclusive manner. One of the tendencies this model may promote, however, is a more research-intensive design practice. Challenging own conceptions, and treating data, information, and perspectives of others is a complex task that requires stringency of methods. Cross-cultural perspectives and the rejection of own hypotheses and preferences is a challenging task:

> *For example, one of the major challenges in the planning and architectural practices today is the communication gap between the design team, the various levels of 'user groups' and the wide array of specialised consultants to the process. In the future, the new co-design languages that support and facilitate the many varieties of cross-cultural communication will become highly valued* (Sanders and Stappers 2007, p. 16).

The classical caveat with participatory approaches concern the level of education users can be expected to hold. When users are presented with conceptual solutions in various contexts, they cannot be expected to have the same level of imagination and ability to read models as designers involved. Correspondingly, participatory design attempts can be criticised on this ground; that an element of creation will be necessary to any design process, but that users will be ill-equipped to formulate exactly how solutions should be embodied.

When orienting oneself in this tradition, it can probably be considered as a truism that interaction design is the leader in this field. Information-intensive product context, short development cycles, and few barriers to prototyping are probably contributing factors. References in table 6.7 include both authors from this tradition and explicitly product design focused authors.

Conceptual	Secondary literature	Methodical	*Exemplary*
(Rittel and Webber 1973)	(Sanoff 2007)	(Sanders and Stappers 2007)	(Fulton and Marsh 2000)
(Cross 1972)			(Stappers and Sleeswijk Visser 2007)
(Norman 2002)			(Binder et al. 2008)

Table 6.7 - Literature in the participatory tradition

6.4 Concluding remarks

This final assessment of the ideal models of professional reasoning has indicated central elements and an overview of the larger narratives these models are parts of. In doing so, emphasis has been given to the transfer-models implicit with the models, and how these narrative traditions may serve as research programs for inquiring design practice and the furthering of professional knowledge in the field. The aim has been to show that the many narratives may serve as a useful repertoire for triangulating design activities. They provide different perspectives on design and the elements that are important to consider.

For triangulation in a given research situation, the models suggest different focus and consequentially that different elements in design processes have a value for transfer across the design field. The problem-solving model idealises design as a process inhabited by the designer and the requirements of the problem, suggesting that heuristics for solving different types of problems are the currency of any design theory. The reflective model considers tools and materials, stakeholders, and the designer's different frames of understanding as central elements in a design process; suggesting that critical reflection over skills and habitual practices are the currency of a design theory. The hermeneutic model focuses on designers' personal ways of structuring problems, suggesting that the loose ideas and notions that designers hold are central. The doctrinaire models hold that designers should adhere to specific knowledge or certain perspectives; suggesting that the furthering of these domains are the value of a design theory and that researchers have a central role in the production of this theory by normatively taking stances on the issues that are important and relevant to professional practice. The social models include the community designers belong to, and categorises design practices according to their typicality. This suggests that one should look to the community and within particular industries to identify and further particular elements of knowledge. It also serves as a qualifier, as it implicitly claims that design theory have little general value beyond particular industries or communities sharing the same kind of typical problems. The participatory model suggests that inclusion and interaction with users are the central challenge in design processes, thus suggesting techniques and methods, as well as an empathic mindset, as the currency of design theory.

Concerning the reasons for this divergence, it is tempting to think of the differences as owing to the fact that authors have operated with very different understandings of design, while still referencing a common concept of 'design'. Since 'design' subsumes quite a large set of activities (cf. chapter 2.2.1), it may appear that authors have operated with prototypical conceptions of design, and construed their results across a larger design field, whereas their empirical basis has been confined to what in retrospect appears as a very narrow focus: The problem-solving model, for instance, is based on

cognitive research into confined problem-solving tasks, where the end-goal is clearly defined. The ensuing model fits well with design tasks that display such characteristics, e.g. types of technical engineering activities. The reflective and the hermeneutic models on the other hand, have an empirical basis with the early stage conceptual designing, where one still searches to understand the design task and the end-goals it poses. I.e it emphasises the creative and artful elements of designing, and empirical materials are usually constrained to relatively simple kinds of design processes, e.g. early phase or crafts-based design. The social models implicitly constrain design to large projects where several professional groups are involved, and the participatory approach suggests an antithetical stance to romantic views of design, seeing design as a process of facilitating the creative abilities of users, constraining empirical material to the kinds of products where use poses a "problem".

But while the fact that these authors write from a dissimilar 'design' concept may be a source for confusion, one may also argue that the plurality they present is a benefit to the design research community. The models are committed to different theoretical traditions, which are potentially valuable in that they promote a large range of perspectives with which to reflect over design practice: Cognitive, pragmatic, romantic, particular, social, critical and empathic; these are an enormous scope in theoretical traditions. While the theoretical landscape is difficult to gain a comprehensive view over, the perspectives and inquiries they open up for are broad.

7 - Conclusions

Concluding this excursion into design theory, what are the lessons learned? How does the thesis contribute to a greater understanding of design? Here it is argued that this can only be answered reflecting over the current status of design research and design theory.

The thesis has taken up how ideal models in design theory lay trajectories for the growth of professional knowledge in the field of product design. It has done so by examining how authors within this tradition commonly idealise the element of professional reasoning. The thesis has furthermore examined conceptual structures with these models and examined how criticisms in existing discourse identify problems with the correspondence between models and practice.

The findings should be of value in a practical and professional context. The thesis identifies narrative traditions with different principled perspectives on design practice; it identifies some of the central stances with these traditions; and thereby characteristic ways of describing and abstracting design work. For practical situations in industry, this is held to provide insight into a valuable repertoire of perspectives since design functions can be troubled by simplistic and contradictory understandings of how designers work and the problems and challenges this work gives rise to.

For the same reasons, the thesis is believed to be of value in an educational context. Knowledge of different theoretical traditions gives rise to a broader repertoire for explaining and reflecting over design practice, as it induces reflection across several issues and knowledge domains.

But primarily, the thesis addresses practices in the tradition termed 'design research'. Within this tradition, there is uncertainty and lack of consensus concerning the fundamental assumptions and premises in the common project of developing knowledge for design professionals; concepts and generalisations, and accepted research methods are both debated and contested. Different research programs have been proposed, ranging from Frayling's open perspective; that design research can be carried

out *for*, *into*, or *through* design (Frayling 1993), via the historical positivist program in design research (chapter 5), and even to the negative standpoint that design research should be rejected entirely, because design is about practical experience and that tacit, experience-based knowledge is the only currency within this profession.

This programmatic uncertainty creates problems. Particularly, it creates problems for the general ability to perform *informed* research. Awareness of how research problems have been dealt with in the design domain, so that findings of predecessors can be included is hampered by the programmatic uncertainty. In the literature, premises will vary from author to author, rendering the relation and relevance of individual pieces of research unclear. The extent to which this programmatic uncertainty causes methodical and conceptual problems is seldom reflected over in design theory. On one hand, there is the widespread position that one should embrace the theoretical plurality in the field (Buchanan 2004), but on the other hand, what this theoretical plurality actually implies is still rather open.

The question is how this plurality impacts the credibility of research and research findings. If researchers can draw from a range of different metaphors, use different empirical sources, and employ different research methods, while still subsuming all of these practices under a common 'design' label, then it appears that at least some theoretical work remains to be done in this field. The situation appears to demand reflection over fundamental positions in the common research project rather than the expansion and furthering of this project in new directions.

This is the background against which this thesis has been written. It appeared necessary to unearth basic assumptions associated with the narratives in design theory with the aim of improved critical reflection, rather than breaking "new" ground in the form of, e.g. new and better models.

The underlying motivation for this concern is the belief that design research is still both necessary and needed, as it is a central element in the furthering of professional knowledge. The ability to articulate the knowledge-structure of the profession, formulate sound research projects, and contribute to the growth of knowledge in this field, is of central importance to practitioners and industry. Today, design research needs critically aware self-reflection because in the current educational and industrial context, it is generally expected that professions are capable of associating their knowledge-structure with science and research. Developments such as the Bologna Process, for instance, have led to a practice where design education faculty increasingly is qualified on basis of academic merit, in addition to practical design experience. Financing of research underlying textbooks and design literature increasingly depend on governmental research bodies. Lastly, in the jurisdictional disputes that design practitioners have with neighbouring professions, the ability to model and theoretically

explain the knowledge underlying what designers do is a central element. All these trends point towards the need for a robust and intellectual structure, where designers can formulate and reflect over what the profession knows, and how this knowledge can be furthered.

7.1 Contributions

The contributions of this thesis are improved knowledge of the theoretical heritage and traditions in design theory and the ways in which these traditions influence inquiries. Narrative traditions constrains the production of theory and the understanding in the design field, and through concrete investigations, the dissertation has provided a cross-sectional examination of these traditions and contributed to the ability for precise theoretical inquiry in the design domain.

The thesis explains and analyses some of the characteristics of different traditions, and reveal some of the perspectives and potential examinations that different traditions open up for. Thus, the awareness and understanding of design theory as a repertoire of approaches and stances that in different ways provide schema for the growth of designerly knowledge is enhanced.

The general problem opening this thesis was a concern for the theoretical principles underlying knowledge-transfer in the field of product design. Based on the theoretical perspective of the semantic view of theories, the general problem was constrained by posing the research questions:

1. Which are the central idealised models of professional reasoning in the parts of design theory relevant to product design?

   and

2. *How, characteristically, will the ontology of these models constrain and influence theory production in product design?*

The thesis has addressed these questions firstly by reviewing the models of professional reasoning implicit with central traditions presented in chapter 3. The examination shows that, historically, design practice has been defined by a large range of variant conceptions in theory: Design as a goal-oriented process, Design as reflective practice, Design as hermeneutic search, Design as a social process, Design as a participatory process and doctrinaire models of design.

The second question has been answered by means of several investigations from different perspectives. The first, an exemplary investigation of the conceptual structures associated with three of the models, was presented in chapter 4. The examination showed how the different conceptual structures open for different ways of reflecting over the role of the designer's understanding in the execution of a design project; how designers reflect over a problem, how solutions are generated, and how solutions are discriminated and judged.

Another investigation was into the discourse surrounding the problem-solving model, which was presented in chapter 5. The examination shows that despite the central role and ubiquitous use of this model, one should keep in mind that its use comes with a string of qualifiers attached: 1) It contains a reductive depiction of the many contexts and environments designers work in; its generalisation for transfer is a cognitive one, and indifferent on the real world. 2) It defines out issues of interpretation and understanding during design. 3) It postulates a hierarchy of design problems which is dubious, and 4) It proposes a scientific framework for design that very often will be impractical and outdated.

In the last chapter, these findings were synthesised. The implicit models of knowledge-transfer in design were interpreted and modelled, and the way in which these traditions could serve as programs for theoretical triangulation in design research were discussed. These results can be useful primarily for researchers who need a systematic and historical introduction to the repertoire of approaches that have been used in design theory.

7.2 Further work

All research is a work-in-progress, and this is no exception. The thesis has shown that there exist many different theoretical traditions in design theory, and that gaining a full oversight of the myriad ways in which these traditions lay trajectories for design research is a large task.

To further the work in this thesis, three activities are suggested:

1. To further elaborate the understanding of the models presented in the thesis

2. To empirically examine the correspondence between the assumptions in these models and design practitioners' perception of their practice, and

3. To expand the framework with models omitted by the thesis.

Concerning the first activity, working with the thesis has led to the conviction that both design theory in general and the product design profession would have much to

gain from an improved ability to navigate and triangulate the theoretical traditions existing. A natural next step in this respect would be to develop more easily accessible models, or frameworks, for research initiatives in the product design domain. These models can be based on the findings in this thesis, which presents conceptual structures, main concepts and their relation, and exemplars of inquiries. The benefit of such models is to facilitate design inquiry by lowering the threshold for theoretical triangulation and to allow for early what-if diagnoses, enabling researchers and practitioners to alternate between perspectives on design theory, comparing e.g. social models and cognitive models of practice.

Developing such models would require further elaboration of the idealised models presented here. It would be necessary to take up the ontology of all the different models, and to pursue criticisms also for the other models in the way the exemplary approach in chapter five suggests, before the subsequent publication of these in an accessible format.

Concerning the second point, another initiative is to further and critically examine the empirical basis for these models. I have in the thesis assumed that the different idealised models of design reasoning were sound and well-argued abstractions of design work. The inquiry showed, however, that many of these models rest with surprisingly simple assertions.

This can be exemplified by the principles of generalisation on design that underlie these models; i.e. the implicit diagnosis of what the main challenges of design work are. The hermeneutic model sees the challenge of design as that of "constraining the infinite number of potential solutions", whereas the problem-solving model sees the problem as primarily that of structuring and decomposing design problems. It is still an open question whether these assertions cover how designers perceive their work, or whether there are good reasons to hold that design should be framed in the context of these assertions.

One should note, for instance, that many of these models make use of generalisations which exclude reflections over social differences in design work; social demarcations, such as the differences between types of designers (e.g. type of industry, size of projects, geographical location), are mostly absent. It seems improbable that a design theory can be expected to be valid across both geographical and industrial divides with little or no reflection on the differences between these groups.

At the same time, different models of design often rely on an analogy with the scientist, seeing designers simply as creative scientists. This is the case both with the problem-solving model, which perceives the designer as a technical problem-solver, and the hermeneutic model which essentially appropriates Popper's conjectural model of hypothesis-generation for design purposes. The common assumption that there is a

likeness between designers and scientists seems improbable, and is also an assumption that deserves closer scrutiny.

A practical first step to empirically examine whether these models fit with practitioners' perception of their own practice could be to examine the type of responsibility that designers in a particular context hold, thereby gaining empirical documentation of common working procedures, and potentially, situations with these procedures that designers find challenging.

This could be a ground to compare theoretical models with actual working conditions and lead to a reflection over the similarity, and/or differences between theoretical models and professional practice. The focus of the empirical examination proposed here would be to inquire into the abstractions that generalise and explain practical doing, on the basis of their central role for learning and furthering of professional knowledge. Such a research project could, in time, lead to better and improved models of designers' work and thereby improved ability to understand the challenges confronting the profession in live practice.

Concerning the third point, a last issue that will need attention in a furthering of this work is to expand the map of models with models that have been omitted. This point is discussed in the next chapter.

7.3 Discussion

At the end of the thesis, it is necessary to address the degree to which the findings here can be trusted. Has this thesis succeeded in answering the research questions, and has it done so in a methodically credible way? My contention is that two issues are most pressingly in need of consideration: Are the models presented representative for design theory? And, has the thesis succeeded in showing how different narratives will influence the development of theories and knowledge in the field? The first question addresses the representativity of findings, the second is a question on the influences these models have upon the production of theory in the design domain.

Representativity

The intention of the thesis, as stated in the research question, has been to locate the "main models" of professional reasoning in design theory relevant to product design practice. The question of representativity is therefore central: Has the thesis succeeded in displaying the most relevant and central models in design theory?

Admittedly, there is a wealth of models existing and therefore the selection with the approach here may be deficient. One example of an historic model that has been overlooked is Broadbent's framework where design reasoning is categorised into four

types; either pragmatic, canonic, iconic, or analogous forms of reasoning (Broadbent 1973). Another model that could have been taken up is the common perspective that designers reason by a fluctuating change between *abstract* and *concrete* domains (Dorst and Cross 2001).

In particular, criticism for not including the product semantic model in the thesis might be put forth; the semantic model is an element in the large narrative tradition that holds that products can be regarded primarily as means of *communication* and bearers of meaning. This program has developed a considerable theoretical body, historically associated with architectural and the writings of Charles Jencks, drawing on the semiotic tradition of Pierce and Saussure. In a product design, or design context, the central authors include Krippendorff (2006) and Vihma (1995).

This may point to a problem of omission; that the method employed here has not succeeded in displaying central models. It may also indicate a problem with how these models have been categorised in the thesis.

Addressing, firstly, the omission-problem, the criticism is obviously valid. There are good reasons to argue that the thesis should have been larger in scope if one were to credibly include what all potential readers may have understood by the "main models" of design theory.

But this is also a question on the resources that may feasibly go into a PhD-project. It is necessary to frame the theoretical inquiry in one way or the other, and the assumption guiding this thesis was that the conflicts surrounding the positivist discussion in design appeared as a feasible starting point. The focus on the discourse and the conflicts in this had the benefit that one would examine models that had left a mark, or had an impact, on the larger design community.

I must therefore make the concession, in retrospect, that this approach does not provide robust arguments why these models should be considered "main". The reader should therefore be aware that several other models exist in design theory, and that the centrality of the models here is debatable. Some models are missed out with this approach, but that should not refute the value of the thesis, as the belief is that the efforts succeed in providing an overview from which one can start discussing and reflecting over the narrative traditions in design theory.

Secondly, the categorisation of these models needs attention. The models as they are presented here are not "all inclusive, mutually exclusive". There are overlaps and convergences between these models, and they do not indicate exclusive traditions, as the tradition in design theory is to mix models and perspectives quite freely.

But more importantly, the models are unevenly categorised if one considers the theoretical heritage associated with each one of them. Some of the models stand for large research traditions, whereas others have had lesser impact.

The original challenge with this thesis was the need for a methodical perspective that could align the different theoretical traditions in a comparative way. At least since the critical tradition associated with Kuhn, we have known that such paradigmatic comparison must make concessions, because there does not exist a neutral high ground from which paradigmatically different theories can be compared. Therefore, a cross-sectional approach was selected. The semantic view of theories was settled for, and the particular focus was the presumed models of professional reasoning. Particularly, the goal was to identify *different* assumptions in this regard; different programs for design research, and different frameworks for the production and documentation of knowledge in a design context.

Like any categorisation, this choice has the effect that it suppresses some perspectives, and establishes undue focus on others. As the focus was the *difference* in models of professional reasoning, rather than e.g. quantitative analysis of impact, large traditions that could be assumed to have a fairly similar perspective on reasoning were lumped together.

One of the effects of this is that the categorisation suppresses, e.g. the semantic perspective of design, simply by subsuming it as one of several "doctrinaire" positions. Several other large traditions in design theory have fallen victim to the same: sustainability, usability, a fairly large tradition on branding and marketing, or, for the more technically interested, design for manufacturing.

It is therefore important to point out that the doctrinaire model indicates several large theoretical traditions that are important in their own regard. An alternative approach, which could have resolved this uneven categorisation, could have been to trace the various theoretical traditions on basis of their impact in the design community. This would have been another thesis entirely, however. The reader should be aware of the shortcomings with the approach selected here.

Influence on theory

A second question is whether this thesis has managed to show how these models influence theoretical inquiries as common assumptions on the process of designerly inference. I.e. is there a relationship between these models and how design theory proceeds and develops, and has the thesis succeeded in showing this relationship?

In favour of answering yes, I would hold that the thesis has shown central characteristics with these models, and given a depiction of how these characteristics

influence theoretical developments. And it has been done in a manner that is both explorative and fairly new to the design community.

In favour of answering no, however, one could argue that the lack of strict definitions with this thesis is problematic. Both the decision to retain an open understanding of 'design', and the lack of an essential definition of 'ideal models', could allow for unduly subjective understanding of the topics in this thesis. And thus raise the question whether this is an instance of a researcher enforcing own perspectives under the pretences of scientific authority.

To answer that, I would argue that considerable time has been spent identifying the premises and research traditions associated with these models. The assumption has been that these are important sources of impact and influence on design theory. But the question of how assumptions "influence" a theoretical field is endlessly more complex than this assumption allow for. Maybe one could have used discourse analysis to examine how fundamental positions in the discourse changes over time. Maybe one could have asked how industrial developments and new technology influenced the discourse. These are also relevant and interesting questions when examining design theory. And they indicate the breadth with which this theoretical tradition can be understood and examined.

The last arguments point to an inherent danger with nearly all kinds of theoretical research. They are necessarily interpretative, and they are written from the researcher's own perspective. I have accounted for my understanding and problem diagnosis in chapter 2. Considering the lack of definition of what an ideal model really "is", my response would be that it is a necessary concession to make when comparing different paradigmatic perspectives.

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Index of concepts

Index of authors

List of figures

All figures by author except where stated otherwise:

List of tables

Contents, expanded