The Nature of Design Thinking

Kees Dorst

University of Technology Sydney, Sydney, Australia

Eindhoven University of Technology, Eindhoven, The Netherlands

Abstract

In the last few years, "Design Thinking" has gained popularity—it is now seen as an exciting new paradigm for dealing with problems in sectors as a far afield as IT, Business, Education and Medicine. This potential success challenges the design research community to provide clear and unambiguous answers to two key questions: "What is the nature of design thinking?" and "What could it bring to other professions?". In this paper we sketch a provisional answer to these questions by first considering the reasoning pattern behind design thinking, and then enriching this picture by linking in key concepts from models of design activity and design thinking that have emerged over the last twenty years of design research.

1. Introduction

The term 'design thinking' has been part of the collective consciousness of design researchers since Rowe used it as the title of his 1987 book (Rowe 1987). The first DTRS symposium was an exploration of research into design and design methodology, viewed from a design thinking perspective (Cross et al. 1992). The second DTRS symposium strove to progress multiple understandings of design thinking by providing a common empirical basis (Cross et al. 1996). Multiple models of design thinking have emerged over twenty years of research, based on widely different ways of viewing design situations and using theories and models from design methodology, psychology, education, etc. Together, these streams of research create a rich and varied understanding of a very complicated human reality.

Nowadays, "Design Thinking" is identified as an exciting new paradigm for dealing with problems in many professions—most notably IT (e.g., Brooks 2010) and Business (e.g., Martin 2010). This eagerness to apply design thinking has created a sudden demand for clear and definite knowledge about design thinking (including a definition and a toolbox). This is quite a problematic challenge for a design research community that has been shy of oversimplifying design thinking, and cherished its multiple perspectives and rich pictures. This paper is an attempt to systematize our knowledge of design thinking by using a model from formal logic to describe its core challenge and reasoning patterns, and then enrich the picture by linking some of the most prevalent notions used in various descriptions of design thinking into this framework.

2. The Challenge: Abduction

To build up a conceptual framework that is fundamental enough to anchor the wide variety of design thinking approaches that designers take, and connect the many descriptions of design thinking that have arisen in design research we have to suspend the 'rich' descriptions of design and take the question of design reasoning back to the basics, the formal logic behind design reasoning. Logic provides us with a single group of core concepts that describes the reasoning in design and other professions. This 'poor' description of design also will help us explore whether design is actually that different from other fields—and should provide us with some fundamental insight on the value that introducing design in other fields might have. In this paper we will move from these Spartan beginnings to 'richer' descriptions of design

To cut to the core of design thinking we build on the way fundamentally different kinds of reasoning are described in formal logic, in particular the way Roozenburg (1995) has described the work of Peirce. We will describe the basic reasoning patterns through comparing different 'settings' of the knowns and unknowns in the equation:

WHAT + **HOW** leads to **RESULT**
(thing) (working principle) (observed)

In **Deduction**, we know the 'what', the 'players' in a situation we need to attend to, and we know 'how' they will operate together. This allows us to safely predict results. For instance, if we know that there are stars in the sky, and we are aware of the natural laws that govern their movement, we can predict where a star will be at a certain point in time.

WHAT + **HOW** leads to **???**

Alternatively, in **Induction**, we know the 'what' in the situation (stars), and we can observe results (position changes across the sky). But we do not know the 'how', the laws that govern these movements. The proposing of 'working principles' that could explain the observed behavior (aka hypotheses) is a creative act.

WHAT + **???** leads to **RESULT**

These two forms of analytical reasoning predict and explain phenomena that are already in the world. What if we want to create valuable new things for others, like in design and other productive professions? The basic reasoning pattern then is **Abduction**:

WHAT + **HOW** leads to **VALUE**
(thing) (scenario) (aspired)

Abduction comes in two forms—what they have in common is that we actually know the value that we want to achieve. In the first form of **Abduction-1**, that is often associated with 'problem solving', we also know the 'how', a 'working principle' and how that will help achieve the value we aim for. What is still missing is a 'what' (an object, a service, a system), so we set out to search for a solution.

??? + **HOW** leads to **VALUE**

This is often what designers and engineers do—create an object that works within a known working principle, and within a set scenario of value creation. In the second form of **Abduction-2**, we ONLY know the end value we want to achieve.

??? + **???** leads to **VALUE**
(thing) (scenario) (aspired)

So the challenge is to figure out 'what' to create, while there is no known or chosen 'working principle' that we can trust to lead to the aspired value. That means we have to create a 'working principle' (through a way of thinking that is close to induction) and a 'thing' (object, service, system—through a way of thinking that is close to Abduction-1) in parallel.

This will involve the development or adoption of a new 'frame'—please note that the implication that by applying a certain working principle we will create a specific value, is called a 'frame' within design literature (see (Schön 1983) and section 3.2).

WHAT	+	HOW	leads to	VALUE
		frame		

Performing this complex creative feat of the creation of a thing (object, service, system) and its way of working in parallel is often seen as the core of design thinking. This double creative step requires designers to come up with proposals for the 'what' and 'how', and test them. Designers are often seen playing around with ideas, tossing up possibilities (proposals) in what may look like a hit-and-miss process. What they are in fact doing is trying out and thinking through many possibilities, thus building up a repertoire of experiences that help them developing an intuition of what will work in the problematic situation. Empirical studies of designers within cognitive psychology have shown that designers focus their creativity and analytical skills on the creation of solutions, testing and improving them, not on analysing the problem up front (Lawson 1979). The strategy of creating solution proposals, analysing these and evaluating them, and improving them until the solution is satisfying, can be recognised right across the design professions. It could be one of the core elements of the design ability.

This establishes the designing professions as thinking fundamentally differently from fields that are based on analysis (deduction, induction) and problem solving (Abduction-1, see also Dorst (2006)). But the distinction is not very clear-cut, as we have learned that design is not one way of thinking: it is a mix of different kinds of solution focused thinking (Abduction), which includes both problem solving and a form of design that involves reframing of the problem situation (in a co-evolution process). And it also contains quite a bit of analytical reasoning, as rigorous deduction is needed to check if the design solutions will work.

3. The Response: Professional design

The challenge to work in an abductive situation is central to design (Roozenburg 1995). As a response to this challenge designers have developed and professionalised specific ways of working. This is an important point for this paper: although many of the activities that designers do (i.e., framing, ideation, creative thought) are quite universal, and thus it would be inappropriate to claim them as exclusive to design or design thinking, some of these activities have been professionalized in the design disciplines in ways that could be valuable for other disciplines. It is worth studying them for that reason. In this section we will explore the special nature of some core activities that designers use in responding to abductive problem situations.

3.1 Core design activities

Although there is great variety within the world of design, the designing disciplines can be seen to lean on five main activities in meeting their abductive challenges: *formulating, representing, moving, evaluating* and *managing* (Lawson & Dorst 2009). These are the 'carriers', as it were, of design thinking. In this paragraph we name some special ways of performing these activities that have been developed within the design disciplines.

Within '**formulating**', the key activities are the identifying of the key issues in a problem arena and the framing of these in a new and original manner (see 3.2 for a more extensive description). Within the designing disciplines, the **representation** of problems and solutions (in words and sketches, sometimes using quite sophisticated visualization techniques) is important because it allows the designer to develop their ideas in conversation with these representations—e.g., by sketching an idea, looking at it critically, altering it, taking a step back again, etc (see Schön 1983). Also, designers tend to use multiple representations in parallel,

where each representation highlights other salient features of the solution that is under development. These design steps taken (the '**moves**') can be entirely original or they can be further developments of moves that are part of the designer's repertoire or the general design culture. To keep a design project on track, there is an almost continuous **evaluation** going on. Early on in the project, when problems and solutions are still vague, this evaluation necessarily takes on a subjective nature. Later on, when everything is beginning to crystallize, the evaluations should be much more formal and objective. However, designers tend to be good at suspending judgment, and allow themselves to pursue pretty risky lines of thought. They know that bringing the full force of evaluation to bear upon a fledgling idea is a very effective way of killing it, blocking any further exploration and stifling any progress in the project. **Managing** all these activities within a design project is a subtle art. Design projects are hard to plan and control, because they are a mix of a fairly linear problem solving process and an iterative learning process that is driven by the reflection-in-action and reflection-on-action (see Valkenburg et al. 1998). Briefing tends to be a continuous process as the design options develop and get clearer—this makes resource planning very difficult.

All of the activities highlighted above have been professionalized within design practice in interesting ways—knowledge about these practices has been gathered in various streams within design research. References here could include almost every paper and book written in this academic field.

3.2 Beyond problem solving: frames and reframing

How this design behaviour is different from problem solving has been illustrated most eloquently by Armand Hatchuel, as he compared two problem situations (Hatchuel 2002). Picture a group of friends coming together on a Saturday night. The one problem situation is that they are 'looking for a good movie in town', the other problem situation is that they set out to 'have a good time'. The first situation can be dealt with through conventional problem solving, the second situation requires design thinking. Hatchuel argues that there are three important differences between these situations. The first difference is that the design situation includes the (unexpected) expansion of the initial concepts in which the situation is initially framed ('a good time'). This makes the solution a process, instead of a one-off decision. There is no dominant design for what 'good time' would be, so imagination needs to be applied. A second difference is that the design situation requires the design and use of 'learning devices' in order to get to a solution. These 'learning devices' include (thought) experiments and simulation techniques. Thirdly, in designing, the understanding and creation of the social interactions is part of the design process itself. The group of friends needs to develop a way of reaching a solution that cannot be supposed to exist before the design situation arises. From this example we can see that design undoubtedly includes stretches of conventional problem solving, but that it also contains 'something else'. At the core of this 'something else' lies the activity of 'framing'. 'Framing' is the term commonly used for the creation of a novel standpoint from which a problematic situation can be tackled—this includes perceiving the situation in a certain way, adopting certain concepts to describe the situation, patterns of reasoning and problem solving that are associated with that way of seeing, leading to the possibility to act within the situation. We have already seen above that the ability to frame and reframe is central to reasoning in design situations (Abduction-2). Einstein is quoted as saying that 'A problem can never be solved from the context in which it arose'—and apart from the circularity of this statement (if the issue could be solved from its original context, it would probably have been solved before even registering as a real problem), it is true that designers tend to reframe the issues before them in a way that makes the problem amenable to solution (for an empirical study into reframing behaviour, see Paton & Dorst (2010)).

Designers tend to want to reframe, even in situations that present themselves as a problem solving (Abduction-1) problem, where reframing would not be strictly necessary. Cross has

remarked that designers tend to see many problems AS IF they were design problems (Cross 2007).

There are two important reasons for designers to concentrate on the framing of a problematic situation:
1. 'The design problem' is not stable, but changeable (Dorst 2006) Design problems are sometimes vague, often full of inner contradictions and as a result they are always open to interpretation. This process of interpretation and re-interpretation through framing is a crucial part of design creativity, it allows design to take flight and move into truly new territory. There is also a practical reason for problem evolution. The different parties that together make up the design situations are often quite unrealistic in their expectations of what design should achieve (always the highest possible quality, against the lowest possible costs). The early solution proposals that drive the problem evolution show what solutions could realistically be achieved.

2. In the real world, problematic situations arise when the equation (*what' plus 'how' leads to 'value'*) that an organization has been operating under somehow doesn't work anymore. It can be very hard to fathom what's wrong: should the 'what' be changed, the 'how' could be wrong, the 'frame' that drives the implication could be faulty or maybe the organization is misreading the values in the world? There are different ways of dealing with this problematic situation. Initially, organizations often react in a way that requires the least effort and resources: they set out in a problem solving manner to create a new 'something' that will save the day while keeping the 'how', 'frame' and 'value' constant. This is often the nature of the design situation as it first presents itself to a designer, implicitly framed by the client organization—and the designer has to explore whether the level at which the central design problem is perceived and understood by the client is right for the problematic situation to be fruitfully approached by the designer (Paton 2010). Often, the problem-as-presented first needs to be 'deconstructed' (Hekkert et al. 2003) or opened up.

Experienced designers can be seen to do this by searching for the central paradox, asking themselves what makes the problem hard to solve, and only start working towards a solution once they have established the nature of the core paradox to their satisfaction (Dorst 1997). The word 'paradox' is used here in the sense of a complex statement that consist of two or more conflicting statements—true or valid in their own right, but they cannot be combined. The core paradox, is the real opposition of views, standpoints or requirements that requires inventive design solutions or a reframing of the problematic situation. This is stark contrast to analytical problem solving, that takes place in a 'closed world' where there is no way to redefine the problematic situation (because the way in which the solution has to work is already set in stone). In her writings on Engineering Ethics, Caroline Whitbeck flags the way designers deal with paradoxes as a key special element of design thinking (Whitbeck 1998).

4. Varieties of design thinking in professional practice

Until now, design thinking has been described as a single way of thinking. The picture that has emerged will have to be broken up again as we move away from this abstraction. A first step can be made by looking at design thinking from the perspective of distinguishing different levels of design expertise (Lawson & Dorst 2009).

4.1 Levels of designing

Design is not only done by professionals is also part of everyday life. This **Naïve** state of designing is adequate for everyday use in conventional situations. Many students that enter design schools will display this naïve design behavior. They have a relatively superficial set of design solutions that they know, choose between and wish to emulate. Despite having strong convic-

tions, students at this stage find it difficult to express what they know and want—they do not have the language.

The **Novice** state involves the exploration of what design is, finding the 'rules of the game'. The main objective of education is the search for principles behind the surface of 'good design', to replace the isolated instances of the naïve designer with considered thought about the deliberations that went into a design proposal. This is also the first time students encounter design as a series of activities, as a process. The key characteristic of the **Advanced Beginner** is the recognition that design problems are highly individual and situated. Design problems at this level are considered to be less amenable to the use of standard solutions (the 'rules of the game') than they were to the Novice. The **Competent** designer can handle and understand all the normal kinds of situations which occur within the design domain, and becomes the co-creator of the design situation, through strategic thinking. This ability to steer the development of the design problem puts the designer much more in control over the project. Designers with some professional experience would be **Proficient** designers. They are good and probably successful in their chosen profession. Then on the next level up the **Expert** designer ('expert' as in 'better', not as in 'specialized') is known for a certain approach or set of values that is expressed through his/her design work. This level may be characterized by a more or less automatic recognition of situations and a quick, intuitive and dead-sure response. The **Master** designer has taken their way of working to a level of innovation that questions the established way of working of the experts, and their work is seen as representing new knowledge in the field. Such work is published in various ways: not just through design outcomes, but also through pamphlets, reflective papers, interviews, etc. The work of a **Visionary** is explicitly developing or even redefining the design field that they are working in. This might not lead to realized designs at all, but will be expressed in design ideas, exhibitions, and publications.

This linear progression is a gross oversimplification of the realities of design thinkers. Most importantly, we should see this as a process of gathering a whole repertoire of ways of design thinking, adding new ones as designers get more experience. Apparently there are at least seven different ways of design thinking that have been professionalized within the design professions: choice based, convention based, situation based, strategy based, experience based, developing new schemata and for some, redefining the field. Each of these seven kinds of design thinking come with their own methods, tools and their own critical skillset. Research among student and expert designers has revealed that these levels impact heavily on the strategies a designer uses to tackle abductive problem situations: the lower levels of expertise are bound to be more problem-focused, as the proponent will have less solutions, examples and frames in his/her repertoire, and not enough experience to apply constructive forethought in the design process. More experienced designers work in a solution-focused manner (Cross 2004).

4.2 Layers of design practice

Design thinking can also be understood to take place at different layers. Most thinking about design (and the vast bulk of design research) has always focused on what happens within design projects. That is a natural choice: projects are where the real design work takes place, and the projects are the main economic unit of any design enterprise. Yet when we study design thinkers more carefully, we observe several layers of design activity—not just within projects, but also higher-level design activity that work across projects; the layers of 'process' and 'practice' (Lawson & Dorst 2009). Leading designers develop their own ways of working, specific and quite explicit processes that underpin all the projects in the firm. They also create the 'practice', the intellectual (and physical) environment in which design takes place. In the following quote Ken Yeang is reflecting on the role he plays in his own architectural office:

> Any architect with a mind of his own, whether by design or default will produce an architecture which is identifiable to that architect…I had to study ecology, I had to

study biology; that was the basis for most of my design work. I'm trying to develop a new form of architecture. We have this climatically responsive tropical skyscraper agenda and each project we try to see whether we can push an idea a little bit further…I give every new member of staff the practice manual to read when they join. They can see not just past designs but study the principles upon which they are based. We work these out over time, over many projects…. I do competitions more as an academic exercise. I treat competitions as research projects….it motivates the office—gets them excited—lets the mind develop new thoughts and themes. I put all the drawings together an publish a book… 'it's research, it develops ideas.'

It is interesting to note that Ken Yeang and other outstanding architects that were interviewed make clear that the stack of frames that the design firm works with are a key element of the professional design practice. They report different strategies to adopt, maintain, develop and express the frames of the organization. The practice of these outstanding designers, deliberately creating and maintaining a repertoire of frames in their offices, could inspire developments in other disciplines where the application of 'creative' or 'innovative' thought often takes place in a much more happenstance manner. All too often, creative/productive reasoning is seen purely as a moving-away-from existing solutions, only to be done when sparked by a crisis (or 'surpise' (Schön 1983)). In contrast, the professional practice of framing we described above consists of a sustained effort to create a set of well-considered original approaches to the issues of the field that can become an important part of the intellectual capital of the firm. The embedding of this higher layer of design thinking into the organisation will create an environment in which the pursuit of novelty and progress becomes a natural part of the firms' overall practice, instead of an ad-hoc panic-born scramble for novelty. It is also living proof of the fact that design thinking, though creative and open-ended, is not chaotic or beyond the control of reason. Initiating design projects through the thoughtful consideration of frames that have been developed within the context of an organization is a far cry from the popular notion (also to be found in management literature) of design basically being a rather magical, wild, more or less random trial-and-error process.

5. Applying design thinking in business

Until now we have concentrated on exploring what professional practices the design professions might have to give to other fields. The question of what is appropriate then of course depends on the needs of those other fields. Those may be many different activities and skills, depending on the application domain. Let us take the field of Business as an example and return to the point made earlier that in the business world, problematic situations may arise when the equation (*what' plus 'how' leads to 'value'*) that an organization has been operating under somehow doesn't work anymore. This could be paraphrased as:

???   +   **???**   leads to   **???**

(what)   (how)   (value)

If the Abduction-1 approach of creating a new 'what' doesn't help, the organization could be going to the Abduction-2 mode and also create a new 'how'. The organization might do this by just applying one of the other 'frames' that it has in its repertoire.

???   +   **HOW**   leads to   **VALUE**

frame	
frame	**practice**
frame	

We have seen in 4.2 that the collection of frames that an organization has at its disposal defines its Practice. Alternatively the organization might hire a consultant or designer that uses his/her experience to bring a new frame to the problematic situation. That frame could be added on to the practice of the organization for this particular project, quite superficially. If on the other hand the frame is adopted into the practice of the organization itself, transforming that practice, we talk about fundamental innovation. This type of innovation requires an organization to go beyond adopting frames, break away from its current ways of working and world view (or 'mental model' (Smulders 2006)). This is where the processes of design thinking and business innovation are potentially most intimately linked.

6. Conclusion

Professional design practices that can be caught under the label 'design thinking' can take many forms, and have the potential to impact disciplines that seek to adopt a 'design thinking' approach in many different ways. The basis of design thinking is more or less the same in all cases, but this paper has shown that there is a huge variety in kinds of design reasoning (Abduction-1 and Abduction-2), design activities (formulating, representing, moving, evaluating, managing), levels of design thinking (the 7 levels of expertise) and layers of design thinking (project, process, practice).

Moreover, in the example above we have seen that 'design thinking' can enter the life of a business on four different levels: as the design activities within an existing frame (Abduction-1), as design activities that involve reframing (Abduction-2), where the frame originates from the existing company practice, as the (skin-deep) adoption of a new frame that has been brought or developed by an outsider (design consultant), and as the deeper transformation of the organizations' practice through the true adoption or creation of a new frame within it. These different applications of design thinking require the thoughtful application of widely different elements of design thinking from the broad array presented in this paper. For instance: working within an existing frame we could use convention-based and situation-based design thinking, while creating a new frame within the organization would probably require ways of thinking that are associated with the higher levels of design expertise.

This framework has been developed out of a deep concern with the fact that nowadays, lots of disparate vaguely creative activities are combined under the label of 'design thinking'. Design thinking however is a quite specific and deliberate way of reasoning, elements of which that have been professionalized within the design disciplines in ways that could really benefit other fields. But in order to realize the true value that 'design thinking' can have for these fields, we need to articulate the kinds of design thinking and their application much more subtly and in much more detail than has been achieved in this brief paper. The frameworks presented here could be the backbone of such a new interpretation of design thinking.

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Edited by
KEES DORST
SUSAN STEWART
ILKA STAUDINGER
BEC PATON
ANDY DONG

DTRS8

**INTERPRETING
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Design & Layout:
Bec Paton
Ilka Staudinger

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INTERPRETING DESIGN THINKING

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EDITED BY
KEES DORST
SUSAN STEWART
ILKA STAUDINGER
BEC PATON
ANDY DONG

DTRS8 INTERPRETING DESIGN THINKING

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These are the proceedings of *DTRS8: Interpreting Design Thinking*, a two-day symposium set up to stimulate discussion between design thinking researchers, business researchers and practitioners about the ways design activities, design skills and abilities (aka 'design thinking') can be interpreted for other professional fields. *DTRS8* was hosted by the University of Technology, Sydney—Faculty of Design, Architecture and Building. The symposium took place on October 19th–20th, 2010.

The papers for the *DTRS8* symposium have been double blind refereed by eminent scholars, in a process that took a year from the first call for papers.

Introduction

It has now been almost twenty years since the first DTRS symposium, and research on design thinking has matured immensely since those early days. It has resulted in a steady and growing stream of publications. Recently a number of books were published that capture design thinking from various perspectives.

In the last few years, the notion of 'design thinking' has also become popular outside the design professions—it is a buzzword in the business world (amongst management scholars and professionals), and we can find 'design thinking' mentioned as an exciting new paradigm for dealing with problems in sectors as a far afield as education, IT and medicine. This creates an opportunity for the design community to be heard and valued in its approach, and for people that were trained as designers to exert their influence outside the traditional design professions.

This success does raise the question what that 'design thinking' really is—what it consists of, what its strengths and weaknesses are, what skills, abilities and character traits support someone's capacity to be successful in design thinking, and which key elements of design thinking are transportable beyond the core design disciplines.

While we do not have all the answers yet, the challenge that the *DTRS8* organisers see before the design thinking research community is to play a role in interpreting design thinking for other disciplines. In doing so, we will overcome the relative intellectual isolation of 'design thinking'—traditionally, it has always been defined by distinguishing it from other kinds of thinking and problem solving approaches. Yet defining 'design ability' and 'design expertise' as separate and exclusive to the inner circle of design graduates limits our ability to engage with other disciplines. The *DTRS8* symposium is built on the premise that our knowledge of the nature and qualities of design thinking is now strong enough to reach out. The researchers and educators in the DTRS community have developed perspectives on design thinking—some of these are broad and endeavouring to be all-encompassing, others are much more detailed in focussing on key aspects of design thinking (like the role of creativity, etc). The *DTRS8* challenge was to look at what these particular perspectives, insights, theories, models and sets of tools for design thinking can bring to other fields that are seeking to incorporate it.

DTRS8 brought together a rich mixture of eminent design researchers from across the world, in a setting that was quite small (approximately 50 people), resulting in high-quality discussions. The objective of *DTRS8* was to use these conversations to start up a broader intellectual discussion on the nature, strength and value of design thinking.

In these proceedings you will find papers that report upon a reflective conversation with people from a different discipline, papers that are theory-driven: for instance creating an in-depth, logical comparison between abductive design thinking and problem solving behaviour that is at the basis of other disciplines. And you will find empirical and applied papers, such as reflective case studies tracing the adventures of practitioners from different disciplines involved in design-thinking-led projects.

We hope that the publication of the papers in these proceedings will stimulate further ideas and discussion!

The *DTRS8* Organisers would like to thank the reviewers of the papers, the volunteers who facilitated and recorded the workshop sessions and the participants for their inspiring discussions.

DTRS8 Organisers:

Kees Dorst
Susan Stewart
Ilka Staudinger
Bec Paton
and Andy Dong