Symposium Proceedings

PROCEEDINGS OF THE 8TH DESIGN THINKING RESEARCH SYMPOSIUM (DTRS8)
SYDNEY, 19-20 OCTOBER, 2010

EDITED BY
KEES DORST
SUSAN STEWART
ILKA STAUDINGER
BEC PATON
ANDY DONG
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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 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
Being a professional: Three perspectives on design thinking, acting, and being

Robin S. Adams  
Purdue University, Lafayette IN, USA

Shanna Daly  
University of Michigan, Ann Arbor MI, USA

Llewellyn L. Mann  
Swinburne University, Melbourne, AU

Gloria Dall’Alba  
University of Queensland, Queensland, AU

Abstract

The purpose of this paper is to present three perspectives for interpreting design thinking: (1) an alternative framework on learning to become a professional, and (2) two interpretations of this framework that speak broadly to a topic of “design thinking”. The first perspective draws on a framework for “an embodied understanding of professional practice” that focuses on the ways professionals form and organize their knowledge and skills into a particular “professional-way-of-being”. The second and third perspectives provide examples of using this framework as a lens for interpreting existing results from phenomenographic studies on ways of experiencing design and ways of experiencing cross-disciplinary practice. We conclude with a discussion of how these three perspectives contribute to conceptualizing a working synthesis of design thinking.

1. Unpacking “design thinking”

The idea of “design thinking” has typically represented what designers understand about design and how they go about the act of designing based on this understanding. Within this space of design thinking and acting are a complex set of interacting ideas that include “designerly ways of knowing” such as tackling ill-defined problems and following a solution-focused mode of problem solving (Cross 2006), ambidextrous mindsets for innovation (Lande & Leifer 2010), features of design such as design as learning or design as a mixture of creativity and analysis, types of design thinking such as situation-based and strategy-based approaches, and forms of design activity such as formulating, moving, evaluating, and managing (Lawson & Dorst 2009). But design is also a social process (Bucciarelli 1996) that involves thinking and working across different perspectives and often involves considerable conflict and negotiation. Looking across these descriptions it is not difficult to imagine ways that design thinking might be evident in or shared across diverse professions or might be impacted by working with people with different perspectives on complex cross-disciplinary problems.

While unpacking “design thinking” is important, a greater challenge is creating or finding frameworks to guide a “working synthesis” (Cross 2010) for understanding what it means to be a design professional (e.g., knowledge, skills, and skillful performance), how designers become professionals (e.g., learning progressions), and how educational programs should help prepare aspiring professionals for the challenges of professional practice. Such a framework needs to
speak to multiple dimensions of learning, not just knowledge and skill progression but how learning to become a designer involves “working in a different way” such as different ways of looking at problematic situations, and providing insight into puzzling complexities such as how designers can simultaneously display the behavior of a ‘novice’ in some parts of design work while displaying behaviors that are more characteristic of higher levels of expertise (Lawson & Dorst 2009, p.92). Such a framework should also push us to challenge old assumptions and connect to new perspectives. For example, Lawson and Dorst (2009) question if there is something fundamentally more to design learning than just skill acquisition:

the quotes of the most experienced designers in this book suggest they are their practices...most designers seem to feel easier describing themselves through the projects that, taken together, make up their practice...designing is not just something you do, or that you take lightly when you practice it, but rather it helps form your identity...design becomes a part of one's being because it involves so much that is personal, like your creativity, way of approaching the world's problems, your own history, learning style and view of the world (p.270).

One alternative framework that accomplishes these goals maps an interconnected space of knowing, acting, and being professionals, and illustrates the ways variations within this space open multiple trajectories for becoming professionals (Dall’Alba 2009a, b; Dall’Alba & Sandberg 2006). Here, knowledge and skills are still central to learning and professional practice, but they are embedded within an embodied understanding of practice. More specifically, not only do professionals learn knowledge and skills, “but these are renewed over time while becoming integrated into ways of being the professional in question” (Dall’Alba & Sandberg 2006, p.389).

The purpose of this paper is to present Dall'Alba's (2009a) alternative framework and to explore its use for “interpreting design thinking” through two phenomenographic studies. One study asks “how is design experienced and understood across domains” and the interpretation within this framework illustrates ways of design thinking, acting, and being shared across domains of design practice (Daly 2008a). The other asks, “how are collaborative cross-disciplinary situations experienced and understood within engineering contexts” and the interpretation illustrates ways of cross-disciplinary thinking, acting, and being within engineering contexts (Adams et al. 2009; 2010). In the following sections we summarize these three perspectives and discuss how this framework of “becoming professionals” can guide the development of a “working synthesis” for “interpreting design thinking.”

2. Becoming professionals

Learning to become a professional involves not only what we know and can do, but also who we are (becoming). It involves the integration of knowing, acting, and being in the form of professional ways of being that unfold over time (Dall'Alba 2009b, p.34).

The process of becoming professionals is always open-ended and incomplete. It entails developing and refining an embodied understanding of professional practice that integrates knowing, acting, and being in the world (Dall'Alba 2009a). This embodied understanding is not limited to individual cognition, then, but is embedded and enacted within the dynamic, intersubjective flow of activity that is professional practice. This unfolding professional way of being incorporates not only our knowing and how we act, but also who we are as professionals. It gives meaning to the knowledge and skills being developed within professional practice, while also incorporating an understanding of the practice itself. As such, the space of learning in this framework: (1) integrates epistemological and ontological dimensions of thinking, acting and being, and (2) overcomes a separation of ‘mind’ from body, in the form of embodied understanding of practice.
In this framework, development is not a stepwise process of moving through a fixed sequence of stages (see for example Dreyfus & Dreyfus 2005), but includes both continuity and change as an understanding of practice develops. As professionals learn to deal with new situations, their embodied understanding of practice evolves in qualitatively different ways. These learning progressions may lead to more comprehensive understanding of practice or they may involve refinement of an existing understanding of practice. When multiple development trajectories open as possibilities in this way, we press ahead into shaping and forming our own development within, or sometimes despite, the existing constraints. “As our activities and projects shape our becoming, we are likely to take up those opportunities that are consistent with or advance our sense of self, while resisting those that undermine our sense of who we are (Dall’Alba 2009a, p.55).” In this way, the unfolding of professional ways of being has many possible trajectories—there is no single path towards becoming a professional, no unidirectional trajectory from novice to professional. Encountering these multiple trajectories as possibilities can open up to rethinking assumptions, challenging constraints, and renewing practice. This process can be both energizing and unsettling—challenging us in what we know, how we act, and who we intend to be.

2.1 An alternative to existing frameworks

It is important to note that this framework is an explicit effort to overcome two major limitations of some existing theories of learning and approaches to curriculum design (Dall’Alba 2009a). The first limitation is a separation of knowing (epistemology) from being (ontology), which is overcome by recognizing that knowing is enacted and embodied in and through our everyday practice as professionals. Current theories of learning and approaches to curriculum typically emphasize the epistemological dimensions and neglect the ontological dimensions of learning. This carries a risk of reinforcing a static, fixed view of expertise, rather than acknowledging variability in ways of experiencing and enacting practice and the associated potential of this variation for renewal of practice. A related risk is a focus on technical mastery, which can encourage narrow conceptualizations of what practice entails. In contrast, embracing variation and ambiguities in learning enable us to recognize that becoming professionals is always open-ended and incomplete. Similarly, ignoring the role of identity in learning has been associated with challenges in transferring learning across contexts, restricting the identities aspiring professionals are invited to construct, and an inability to meet the demands of continuously shifting and interacting bodies of knowledge (Nasir, Stevens & Kaplan 2010). In Dall’Alba’s alternative framework, practice is seen as dynamic and complex, routinized as well as creative, not singular but pluralistic. The same practice is enacted and embodied in qualitatively different ways and has several meanings, just as everything we live or think has multiple meanings.

The second limitation that this alternative framework seeks to overcome is a separation of mind, body, and world. A central idea in this framework is embodiment as a condition for knowing—that the lived body provides access to the world and makes knowing possible. Due to the situatedness of the lived body, we always adopt a perspective on our world and in what we come to know. This situatedness and the ambiguities inherent in relating to our world mean we are challenged to live with pluralism and paradox as we engage in professional practice. Dall’Alba (2009a) argues that current theories of learning typically emphasize cognition and the mind, rather than embodiment of mind and self. A consequence of seeing mind, body and world as separate entities is that the significance of our entwinement with the world of practice is overlooked.
2.2 Investigating ways of experiencing practice

Phenomenographic techniques are well suited for investigating how people experience professional practice. As such, interpreting existing phenomenographic studies through an “embodied understanding of practice” framework is consistent with the underlying mode of inquiry. Phenomenography is an empirically derived research approach that is used to capture variations in understanding an aspect of the world, while revealing the critical components that comprise those variations (Bowden 2000; Marton & Booth 1997). With respect to mapping understanding of professional practice, “in any one social, historical, and cultural context, there are likely to be a limited number of qualitatively different ways in which a particular practice is understood and carried out” (Dall'Alba & Sandberg 2006, p.400). These differing ways of being professionals are logically related to each other, as they are based on the same practice.

In phenomenography, participant selection is a strategic effort to maximize diversity in participants’ experiences to enable an inclusive view within the aims of the study (Åkerlind 2005). Data collection often follows a semi-structured interview protocol (e.g., questions about experiences and the meanings associated with those experiences) to provide deep, reflective, and contextualized data within these experiences (see Mann et al. 2007; Daly 2009). Data analysis involves iteratively reading whole transcripts and sorting them into distinct ways of experiencing or understanding an aspect of the world. This process enables critical variations within a landscape of awareness to be distinguished. Finally, relationships between these distinctly different ways of understanding are explored and described. Overall, the analysis is a rigorous iterative process of being disciplined by the data, looking for empirical evidence of patterns, and seeking logical arguments in how patterns relate.

In the following sections we summarize results from two phenomenographic studies that speak broadly to the topic of “design thinking” and interpret these results through a lens of thinking, acting, and being professionals. For both studies, the goal was to map out a landscape of awareness—the breadth of qualitatively different ways people experience, give meaning to, and interact with “design” or “cross-disciplinarity”—and to describe the relationships among these distinct ways of experiencing.

3. Ways of experiencing “design” practice across disciplines

Daly (2008a, b; 2009) investigated the ways design has been experienced by professionals within and outside engineering fields to better understand what it means to design and be a designer. By focusing on how professional designers experience design, the study made visible how professionals give meaning to, and approach design—filling a theory gap in linking “how” professionals design with “what” they come to understand about design. By exploring design experiences across disciplines, the study sought to reveal patterns of experience that hold design together as a domain unto itself (see Blackwell et al. 2009; Cross 2006; Zimring & Craig 2001) as well as important variations in design thinking that may have consequences for when designers with different training collaborate on design projects. In collaborative design projects that involve multiple disciplines or stakeholder perspectives, designers may not have the same meanings for design and assumptions about shared meanings may adversely impact project processes and outcomes.

Twenty professional designers were recruited based on diversity in years of experience, gender, and most importantly disciplinary training or association. Diversity in technical design area focused on two dimensions relevant to engineering contexts: within engineering disciplines (e.g., sub-disciplines of engineering including mechanical, civil, biomedical, and chemical) and across design-related disciplines (e.g., architecture, applied chemistry and physics, dance com-
position, painting and writing, experience design and computer science, instructional design, culinary arts, and fashion design). Goel and Pirolli’s (1992) framework on invariant features of design task environments was used to justify recruitment across disciplines based on the likelihood of finding design professionals in that discipline.

Table 1. Categories of description for ways of experiencing design across disciplines (disciplines self-identified by participant)

<table>
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<th>Category of Description</th>
<th>Designers’ Experience in this Category</th>
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</table>
| **Category 1:** Evidence-Based Decision-Making | Duncan [Chemistry]  
Evelyn [Civil Engineering] |
| **Category 2:** Organized Translation | Charlotte [Chemical Engineering]  
Glenda [Dance Composition]  
Leann [Mechanical Engineering]  
Parker [Civil Engineering] |
| **Category 3:** Personal Synthesis | Hannah [Fashion Design]  
Netty [Instructional Design]  
Omar [Culinary Arts]  
Quentin [Chemistry & Educational Research]  
Roberta [Chemical Engineering] |
| **Category 4:** Intentional Progression | Alan [Architecture]  
Fritz [Computer Science]  
Isaac [Mechanical Engineering]  
Ken [Physics] |
| **Category 5:** Directed Creative Exploration | Bill [Biomedical Engineering]  
Svenson [Chemical Engineering]  
Tyson [Analytical Chemistry] |
| **Category 6:** Freedom | Jack [Painting and Writing]  
Marc [Experience Design & Computer Science] |

Table 1 summarizes the six qualitatively distinct and hierarchically related ways of experiencing design that emerged from this study (see Daly 2008a; 2009). Going from least comprehensive to most comprehensive, the categories of description include design as (1) evidence-based decision-making, (2) organized translation, (3) personal synthesis, (4) intentional progression, (5) directed creative exploration, and (6) freedom. As shown in Table 1, results did not strictly follow disciplinary distinctions. In other words, the experiences and understandings represented in this study appear to be shared across multiple disciplinary perspectives. General trends in the hierarchy relating categories include expansion of context from the immediate problem to a wider consideration beyond the problem, movement from a solution-focused design approach to one that is problem-focused, and a change in agency for who defined the problem and evaluated the design from others to oneself.

3.1 Interpretation—ways of design thinking, acting, and being

In this section we discuss study findings and translate these through the integrated framework of thinking, acting, and being professionals. In particular, critical variations in ways of experiencing design are described in terms of interactions among (1) what professional designers come to understand about the nature of design and design problems (thinking), (2) how professional designers approach design (acting), and (3) how design professionals shape their identity (being).

**Category 1: Evidence-Based Decision-Making**

For this category, design is experienced as evidence-based decision-making to find a best solution for the problem at hand. Critical attributes of ways of experiencing and understanding design for this category include: knowing and investigating multiple solution options and using
evidence, data, and resources to make decisions; valuing and maintaining records of design decisions for themselves and others; and a focus on finding the best solution for the specific design problem presented. This category is distinctive through its focus on logic, evidence, and rationality, which are consistent themes in the design literature (e.g., Lewis et al. 2006; Simon 1969). The experiences in this category illustrate an awareness of design as solution-focused towards a “best” solution that is determined based on evidence of how a solution meets externally specified problem requirements. Here, ambiguity is understood as something that can be eliminated through using evidence and documents. Documentation also plays an important role by capturing the history of prior decisions and making a case for current decisions. Ways of being are expressed as taking responsibility for making an evidence-based case for design decisions and being a skillful and consistent problem-solver.

**Category 2: Organized Translation**

This way of experiencing design focused on translating an idea into a product that works in the context of a design task. The word translation captured the way that designers talked about going from an idea or problem to an end goal of a working solution (and not necessarily the best solution). Unique attributes of ways of experiencing and understanding design for this category include: an organized and systematic approach (e.g., creating multiple ideas, trial and error experiments, data gathering, evaluation); fluid and iterative approaches; a simultaneous consideration of all of the pieces and players in potential solutions; and producing a working solution to the problem at hand.

Category 2 is distinct from Category 1 (Evidence-Based Decision-Making) by emphasizing a fluid design approach of constant questioning and translating or mapping ideas to plans and outcomes. This is an idea that illustrates an awareness of design as guided by situation specific intentions (e.g., Nelson & Stolterman 2003; Rowland 2004). The experiences in this category illustrate an awareness of design as balancing and addressing multiple pieces of a larger whole, recognizing that a “best” solution is one that works in a given context, and tolerating ambiguity by engaging in iterative cycles of trial-and-error experiments and stakeholder feedback. These understandings are enacted as a process of organized translation—breaking problems into smaller parts, revisiting previous design decisions with new information, and linking activities of conceptualizing a solution with implementing or manufacturing that solution. As such, the role of the designer is to be a translator, simultaneously considering multiple stakeholder perspectives.

**Category 3: Personal Synthesis**

For this category, design is experienced as the synthesis of resources through the personal (human) lens of the designer or design team and as such the synthesis product will be unique to the people who bring the pieces together. Unique attributes of ways of experiencing and understanding design for this category include: utilizing multiple resources as a starting point such as previous similar designs, others' work and ideas, and personal experiences and knowledge; generating design solutions from a combination of resources; building experiences to create each designer’s own intuition and repertoire; and work driven by achievement of the design goal and personal improvement.

The experiences of Category 3 are distinct from Category 2 through an emphasis on the human element of design and how design tasks are interpreted through a personal lens. A focus on synthesis and a need for defining personalized stopping rules are consistent themes in the design literature, particularly in regard to ill-structured ‘wicked’ design problems (e.g., Cross 2006; Goel & Pirolli 1992; Ritell & Webber 1973). The experiences in this category illustrate an awareness of the value of a personal lens in shaping design problems and building a repertoire, as well as accepting ambiguity as a natural part of design activity. Synthesis occurs through attending to aspects of a design that connect to personal experiences and combining diverse
resources to inform design tasks. In this way, design is a continual learning process of building intuition and a personal repertoire, driven by a personal desire to use old ways to imagine new ways.

**Category 4: Intentional Progression**

This way of experiencing design emphasizes the potential for progress a design has through taking a larger context into account. The idea of what progress meant to the designers came in multiple forms such as the design of experiments that could inform larger physics theories, making improvements on previously existing artifacts, and facilitating future progress, or expandability, of a design. Unique attributes of ways of experiencing and understanding design for this category include: a solution informed by and focused on both the situational context and the context of time, as designs could be a building block for future work and progress; a goal of contributing to problems outside of the immediate design task space; and an awareness of the continual nature of design including the lack of an externally defined stopping point.

The experiences of Category 4 are distinct from Category 3 through an emphasis on how the context of design is larger than the immediate project timeline so that goals are aimed at creating better solutions for the present as well as the future. In this way, design is guided by intentional openness to be creative and reflective (see Nelson & Stolterman 2003; Schön 1993). The experiences in this category illustrate an awareness and value for ambiguity as a central part of the design experience—that problems are loosely set at the “start” and iteratively defined. In addition, the goal of creating solutions moves beyond finding the best solution for a specific current use and context to imagining a broader timeline of future needs. These future goals are wrapped into the ways a problem is defined, what kinds of information is gathered to understand to the context, and how solutions are evaluated in terms of present and future impacts. This involves a “big-picture” perspective and taking on a role of seeing choices through multiple viewpoints and possible futures.

**Category 5: Directed Creative Exploration**

For this category, design is experienced as exploration—a fluid strategic and directed path that leaves the designer open to both opportunities and potential failure, but is directed toward an outcome that has value. Unique attributes of ways of experiencing and understanding design for this category include: an effort to investigate ideas that emerge and experiment with loosely defined endpoints; embracing risks that result from exploration of unknowns; a willingness to try new things and think beyond traditional outcomes; molding the shape of the design task through explorations and emergent opportunities; and the development of an outcome with a value perceived by others (e.g., fulfilling a need, solving a problem, forming new ideas).

The experiences of Category 5 are distinct from Category 4 through an emphasis on being flexible and open to discovering new design paths and outcomes. These discovery approaches are principled, even though there may be opportunistic deviations, and are a form of discovery-guided reflective practice (see Schön 1993). The experiences in this category illustrate an understanding of how problems exist in an exploration space, that solutions aren’t “final” and that ambiguity in design opens up opportunities for new problem and solution spaces. As such, design is practiced as discovery-based investigations that occur at the onset of a task. This enables simultaneously exploring a problem space, pushing on solution boundaries, and redefining problem attributes. This involves being comfortable with improvisation and a willingness to take risks and follow an emergent design path.

**Category 6: Freedom**

This way of experiencing design emphasizes the freedom design tasks allow, due to problem and solution ambiguities. In this way, design tasks offer freedom, even design within constraints.
Here, the boundaries of the design task are a function of the meanings designers associate with the design outcomes. This involves embracing opportunities to create any number of novel outcomes that have meaning or value for others or for themselves. Unique attributes of ways of experiencing and understanding design for this category include: the open-ended and flexible paths offered by design work; welcoming and embracing ambiguity; iteratively defining designers’ own boundaries and constraints; and a design outcome guided by a criterion of meaning (e.g., designing new genres and templates, creating foundations that have meaning beyond a single project).

The experiences of Category 6 are distinct from Category 5 through an emphasis on facilitated ambiguity by self-defining flexible design boundaries. These ideas are consistent with a view of designerly ways of knowing as being tolerant and working with ambiguity (e.g., Cross 2004) and that designers impose order on a design project by redefining the problem through solution conjectures (e.g., Akin & Lee 1995). The experiences in this category illustrate an understanding of problem formulation as an iterative process, ambiguity as transformative, and the outcome of design as creating meaning. These ways of thinking are enacted through allowing design possibilities to emerge, flexibly transforming “constraints” into “freedoms”, and the co-evolution of problems and solutions. These ways of thinking and acting represent a design mindset—a designer of outcomes—that is used not only in design situations but also as a natural part of everyday life.

4. Ways of experiencing “cross-disciplinary” practice in engineering contexts

For the third perspective, Adams et al. investigated the ways cross-disciplinary practice in engineering contexts is experienced and understood (see Adams et al. 2009; 2010). Here, the term cross-disciplinary is used to characterize a collection of practices associated with thinking and working across disciplinary boundaries such as multidisciplinary, interdisciplinary, and transdisciplinary. Rather than focus on group behaviors and outcomes, the motivation for this study was to make visible what individuals in collaborative cross-disciplinary situations come to know, learn how to do, and identify as cross-disciplinary professionals. This study provides a complementary view to Daly’s study by focusing on the social aspects of collaborating on cross-disciplinary “wicked” projects that involve integrating technical and non-technical considerations, negotiating and reasoning within and across domains, and managing trade-offs involving interdisciplinary criteria (see Adams et al. 2009).

Twenty-two engineers and non-engineers who worked in engineering contexts and had at least one cross-disciplinary experience were strategically recruited to establish an inclusive “outcome space”. Key recruitment goals were to maximize diversity in terms of the project scale and the extent to which participants interacted with others who had similar (i.e., engineers working with other kinds of engineers) or different epistemological perspectives (i.e., engineers working with a social scientist or artist). Other variations in the sample included the context of work (academia, private industry, and community service), years of cross-disciplinary experience, and gender.

Four qualitatively distinct and hierarchically related ways of experiencing cross-disciplinary practice in engineering contexts emerged from the data (see Adams et al. 2009; 2010). Going from least comprehensive to most comprehensive, ways of experiencing and understanding cross-disciplinary practice include: (1) working together to produce a better outcome, (2) intentional learning so all gain (me, my team, my stakeholders), (3) strategic leadership to enable synergy and innovation, and (4) challenging and transforming practice to integrate systems.
4.1 Interpretation—ways of cross-disciplinary thinking, acting, and being

In this section we discuss study findings and translate these through the integrated framework of thinking, acting, and being professionals. In particular, critical variations in ways of experiencing cross-disciplinary practice in engineering contexts are described in terms of (1) thinking (awareness of “difference”, situation complexity, and goal direction), (2) acting (approaches for engaging with “difference” and situation complexity), and (3) being (self-perceived role or identity).

Category 1: Working together

The experiences in Category 1 illustrate cross-disciplinary practice as working together with people who have different training to effectively find a better solution. Critical attributes of ways of experiencing and understanding cross-disciplinary practice for this category include: an iterative process of asking questions, challenging assumptions, and listening for understanding; being comfortable with asking for information that might seem obvious to an expert in that domain; knowing what you and others contribute; recognizing differences in what people know and how they communicate; and the need to take personal responsibility to be an effective collaborator. Category 1 is distinctive because of a focus on the experience of collaborating and communicating with people who have different perspectives, language, interaction styles, and ways of thinking. This appears to be a foundational category since the other categories build off of these ideas in increasingly complex ways.

As such, ways of thinking involve an awareness of differences in disciplinary training and how these differences complicate the process of working together towards an effective outcome. This awareness supports an iterative communication process of asking questions and listening for understanding with those who are perceived as relevant for determining what is desired or feasible within a bounded application space such as meeting a specific client’s needs or extending an existing application to a new context. This approach involved taking individual responsibility for being an effective collaborator and providing expertise on solution feasibility from a disciplinary perspective. In this way, different perspectives are seen as a “value-added” information source.

Category 2: Intentional learning

The experiences in this category emphasize cross-disciplinary practice as an intentional learning process so that everyone gains (me, my team, and my stakeholders). A predominant feature of these experiences is a passion and appreciation for learning that drives self-directed learning practices. Unique attributes of ways of experiencing and understanding cross-disciplinary practice for this category include: creating opportunities to learn new perspectives or ways of knowing; purposefully educating each other to collectively enable a systems perspective; learning through experience and failure; learning how to negotiate meanings across perspectives and formulate or investigate problems through multiple lenses; and a passion and appreciation for continual learning.

Category 2 emphasizes the process and outcomes of collaborative and situational learning. This category builds off of Category 1 (Working Together) because it represents a process of improving the conditions needed to work together with people with different training to address complex problems of social and global significance. Here, a focus on cooperation and collaboration expands to include social learning, a focus on complex problems expands to include social and global elements, and a role evolves from being a collaborator to being a self-directed learner. More specifically, an awareness of differences changes from recognizing disciplinary differences to respecting the difficulty of disciplinary training and learning at the intersection of differences. Creating opportunities to address complex challenges emerges through inten-
tional learning experiences that involve immersion in other disciplinary ways, seeing failure through an opportunistic mindset and having a passion for exploring alternative ways of seeing the world.

**Category 3: Strategic leadership**

The experiences that represent Category 3 focus on applying prior learning to actively enable cross-disciplinary work and outcomes. In other words, cross-disciplinary practice is strategic leadership to enable cross-disciplinary work and synergy for the best outcome. Leadership is central in that it involves being the “interface”, “connector”, or “communication specialist” to cross disciplines, organizational structures, and cultures to proactively create an environment for innovation. Unique attributes of ways of experiencing and understanding cross-disciplinary practice for this category include: making or enabling conceptual connections; building allegiances and trust; and facilitating systems-oriented strategies or frameworks that leverage diverse perspectives. Some strategies involve actively transforming a negative working environment into a positive one.

Category 3 is distinct from Category 2 (Intentional Learning) by emphasizing proactive approaches for successful cross-disciplinary discovery and innovation through managing and leveraging differences. “Orchestrating” is explicitly emphasized through a self-identified role of being a facilitator at the cross-disciplinary interface and taking the risk of leading projects towards shared and valued outcomes. This is a leadership role directed at facilitating synergy and enabling the team rather than promoting individual egos. As such, the experiences of Category 3 build off of Category 2 (Working Together) by applying prior learning from the challenges and affordances of cross-disciplinary experiences to proactively enabling successful cross-disciplinary discovery and innovation. This is situated in an awareness of how cross-disciplinary work can break down: differences in perspectives across disciplinary, organizational, and cultural perspectives; single perspective problem formulations that lead to ineffective and inappropriate solutions; an inability of disciplinary paradigms to meet economic and political needs; and a need to engage a social network of expertise. Like Category 1 (Working Together), elements of collaboration and successful outcomes are evident in Category 3; however, an awareness and understanding of what enables success expands to include issues of trust, respect, shared ownership, and inclusivity such that disciplinary, organizational, and cultural perspectives can be synergistic and open up new ways of thinking.

**Category 4: Challenging and transforming practice to integrate systems**

For this category, cross-disciplinary practice is experienced as challenging and transforming practice to integrate systems and produce an outcome greater than the sum of its parts. This transformative reflective practice involves challenging prior training and ways of thinking about what counts as “practice”, attributes of good solutions with respect to stakeholder risks, and how organizational cultures support or inhibit professional growth and social justice. Unique attributes of ways of experiencing and understanding design for this category include: critically challenging disciplinary practice and investing in the ways conflict can be transformative; integrating stakeholders as collaborators; attuning to the human aspect of complex systems; advocating less visible perspectives by taking into account the broader context; and embracing cross-disciplinarity as an everyday practice.

The experiences of Category 4 are distinct by focusing on a process of questioning practices and boundaries. Where Category 3 (Strategic Leadership) involves leading teams in creating common ground and new ways of thinking, a leadership role for Category 4 expands to include being a transformative agent as well as being transformed; where Category 3 focuses on enabling cross-disciplinary discovery and innovation, Category 4 is about critical reflective practice to enable transformative learning and outcomes (for individuals, teams, stakeholders, and disciplinary practices). Category 4 involves expanding an awareness of “difference” to include lived...
experiences and recognizing how boundaries between differences are socially constructed. This awareness facilitates critical analysis of the idea of “difference” and a critical exploration into similarities across different perspectives, which leads to new inclusive practices, theories, and identities. As such, the essence of Category 4 is challenging epistemic frames comprised of skills, knowledge, values, identity, and theories of knowledge, as well as honoring differences in perspective and using diversity and conflict to transform thinking and transcend boundaries. Part of this is attuning to the human and contextual aspects of complex problems through participatory strategies that engage diverse stakeholders as partners, not just information resources. When human and contextual factors are integrated into the system, the limits of prior assumptions about “good practice” or “good science” are revealed and enable new ways of thinking about system performance. For Category 4 there is a unique and explicit identity of “being cross-disciplinary”. This new identity may involve experiences of disrespect within and exclusion from prior disciplinary communities as well as seeking out new revolutionary “homes”.

5. Concluding remarks

The three perspectives presented in this paper open up a conversation space for conceptualizing a “working synthesis” of design thinking (Cross 2010) with the potential to renew an understanding of what it means to be a design professional, how designers become professionals, and how educational programs should help prepare aspiring design professionals for the challenges of practice. We might ask: how do these perspectives characterize multiple dimensions of design learning and relate to prior work, challenging old assumptions and opening up new ways of thinking beyond skills, knowledge, and skill acquisition? In what ways might we be limiting the space of “interpreting design thinking” and what do we gain by including the perspectives presented in this paper?

The perspective on “becoming professionals” provides a framework for a working synthesis of design thinking by identifying dimensions of an inclusive space of qualitatively different ways of thinking, acting, and being professionals, and learning progressions within this space. These dimensions integrate epistemological and ontological aspects of an embodied understanding of practice that embraces the ambiguities of learning to become professionals. The existence of multiple trajectories within this inclusive space promotes conversations about the open-ended process of becoming design professionals and provides opportunities for challenging prior assumptions and renewing design practice.

The remaining two perspectives illustrate ways to begin a process for conceptualizing design thinking within this framework by interpreting the results of two phenomenographic studies through a lens of ways of thinking, acting, and being design professionals. The first study summarizes qualitatively different ways of experiencing design across disciplines that speaks to attributes of design practice that may be shared across disciplines. Going from least comprehensive to most comprehensive understandings, the categories of description include design as (1) evidence-based decision-making, (2) organized translation, (3) personal synthesis, (4) intentional progression, (5) directed creative exploration, and (6) freedom. Critical variations across these categories were interpreted through the “embodied understanding of practice” framework as interactions among (1) what professional designers come to understand about the nature of design and design problems (thinking), (2) how professional designers approach design (acting), and (3) how design professionals perceive a design identity (being).

The second study summarizes qualitatively different ways of experiencing cross-disciplinary practice in engineering contexts that speaks to the social aspects of designing across disciplines. The categories of variation include (from least to most comprehensive) design as: (1) working together to produce a better outcome, (2) intentional learning so all gain (me, my team, my stakeholders), (3) strategic leadership to enable synergy and innovation, and (4) challeng-
ing and transforming practice to integrate systems. Critical variations across these categories were interpreted in terms of interactions among (1) awareness of “difference, situation complexity, and goal direction (thinking), (2) approaches for engaging with “difference” and situation complexity as well as meeting goals (acting), and (3) self-perceived role or identity in a cross-disciplinary collaboration (being).

Collectively, all three perspectives open up a conversation space for thinking about both renewal of professional practice and the preparation of future professionals. When we take seriously the ontological dimension of professional education and the ambiguities of learning to become professionals, professional education can no longer stop short at developing knowledge and skills. A focus on acquisition of knowledge and skills is insufficient for embodying and enacting skillful professional practice, including the process of becoming that learning such practice entails (Dall'Alba 2009b, p.42).

Learning to become professionals entails integrating what aspiring professionals know and can do with who they are (becoming), including the challenges, risk, commitment and resistance that are involved. (Dall'Alba 2009b, p.43)

How do our current educational programs prepare aspiring professionals for an increasingly complex world of practice, and how could educational programs support integration of ways of thinking, acting, and being? For Nasir, Stevens and Kaplan (2010) one answer is to place identity as a core part of teaching. For Gloria Dall'Alba (2009a) one answer is to encourage “letting learn” in developing a capacity for attuned responsiveness, creating space and opportunity for variations in learning, and designing curricula to be open to inquiry where learners have agency to explore different ways of thinking, acting, and being.

Acknowledgements
The authors would like to thank our participants for sharing their experiences. We would also like to thank Tiago Forin and Saranya Srinivasan for their input on characterizing ways of thinking, acting, and being. Aspects of this work were supported by a National Science Foundation grant (EEP-0748005).
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Seeing and Hearing Design: Exploring How Visual Representations and Sound Tracks Could Be Used to Teach Design

Cynthia Atman
University of Washington, Seattle, WA, USA

Jim Borgford-Parnell
University of Washington, Seattle, WA, USA

Zachary Goist
University of Washington, Seattle, WA, USA

Katherine Deibel
University of Washington, Seattle, WA, USA

Jim Blair
Seattle Acupuncture Associates, Seattle, WA, USA

Carrie Bodle
University of Washington, Seattle, WA, USA

Vipin Kumar
University of Washington, Seattle, WA, USA

Axel Roesler
University of Washington, Seattle, WA, USA

Steve Tanimoto
University of Washington, Seattle, WA, USA

Mark Zachry
University of Washington, Seattle, WA, USA

Abstract
At CELT, we have studied the pedagogical uses of visual representations of design processes (timelines) in engineering education. Here, we continue this effort and also explore new ways to represent design process data with design sound tracks (DSTs). Our intent is to produce the auditory equivalent of visual timelines, which will not only communicate design process
phenomena, but may also provide a new way for engineering students to experience design concepts. This paper reports on our initial exploration of DSTs.

1. Introduction

Developing a broad conceptual understanding of design processes is of utmost importance in the education of any engineering student, since an ability to design is a fundamental competency for engineers. A basic question that drives our work then is how should we teach design to engineering students? How do we convey to our students that the processes of design are seldom (if ever) prescriptive, even when they are typically described in terms of procedures, steps, stages, phases, and activities? As Nelson and Stolterman (2003) argued, “Much of formal education or training is based on preparing students to better identify and solve problems creatively, quickly, fairly, rationally and prudently. This essentially reactive mode, applied to every realm of life, is reinforced and supported by well-developed procedures for problem solving” (p.15). How do we teach students that certain aspects of a design process should happen before others without implying a misleading conception of linearity, or stating that particular parts of a process are intended to be revisited over and over again, without inadvertently painting a picture of a time-consuming endeavour that any busy student would shudder to undertake? How do we teach students that designing is both understandable and achievable, while, in the same breath, also communicate that the design process is invariably variable?

At the University of Washington’s Center for Engineering Learning & Teaching (CELT), researchers are studying the impact of college and professional experience on solving engineering design problems. In one of our primary studies, we asked individual engineering freshmen, seniors, and engineering professionals to design a community playground (Atman et al. 2007). They were each given basic design parameters, and were told that they could ask for any information they needed from the researcher. They had three hours to complete the design and were asked to think aloud during the process. We recorded their design sessions, and session transcripts were then segmented. Using a rigorous inter-coder process, we used the design activities defined in Table 1 for coding each of the transcript segments. These codes (design activities) were synthesized from an analysis of seven basic engineering design texts.

<table>
<thead>
<tr>
<th>Design Activities</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Definition (PD)</td>
<td>Defining the details of the problem</td>
</tr>
<tr>
<td>Gathering Information (GATH)</td>
<td>Collecting information for solutions</td>
</tr>
<tr>
<td>Generating Ideas (GEN)</td>
<td>Thinking up potential solutions</td>
</tr>
<tr>
<td>Modelling (MOD)</td>
<td>Detailing how to build solution</td>
</tr>
<tr>
<td>Feasibility Analysis (FEAS)</td>
<td>Assessing possible or planned solutions</td>
</tr>
<tr>
<td>Evaluation (EVAL)</td>
<td>Comparing two or more solutions</td>
</tr>
<tr>
<td>Decision (DEC)</td>
<td>Selecting one idea or solution</td>
</tr>
<tr>
<td>Communication (COM)</td>
<td>Explaining design elements to others</td>
</tr>
</tbody>
</table>

Our research aim is to produce insights into the learning and doing of engineering design that enable us to produce descriptive models of design processes. These descriptive models are intended to complement the standard prescriptive methods often presented in engineering design texts. To convey these descriptive models, we graphically represent our coded data in design process timelines (Figure 1). Timelines illustrate when particular phenomena occur during design processes and are used to facilitate visual inspection of the interactions and transitions among design activities.
These descriptive data representations developed into important research tools, and we also found that design timelines can be used effectively in educational settings to illustrate important aspects of design processes for engineering students. Over the last several years, we have presented these timelines to students in engineering capstone and project-based courses in order to engage them in discussion and initiate reflection on their own design processes (Borgford-Parnell, Deibel & Atman 2010). These efforts were successful in raising students’ awareness of the many facets of design processes.

CELT researchers have also studied the potential of using other types of graphic representations of design processes for both research and educational uses (Atman, Deibel, & Borgford-Parnell 2009). Most recently, however, we are exploring new ways to represent our design process data through the development of design sound tracks (DSTs). Our intent is to produce the auditory equivalent of our visual timelines that can communicate aspects of the design process. Impetus for this DST work comes from our many interactions with engineering students and faculty who find the timelines to be powerful design learning tools, and have mentioned many times that the timelines look like music scores. We believe these DSTs may provide a new way for engineering students to experience design concepts. While we did not expect DSTs to be as effective as visual timelines in conveying overall design processes, we anticipated that they could help augment specific features of the process. Additionally, we imagine that DSTs may proffer new insights and perspectives on the design process for researchers.

In this paper, we describe the background and development of DSTs and how we have begun to explore their potential pedagogical use.

2. Background

2.1 Representing Design Processes with Timelines

The focus of this section is on representations of the processes designers use as they go about designing, with a specific focus on timeline representations. Research on design processes has been happening for some time, and various representations of design processes have been developed, including timelines, time plots, transition matrices, and networks. By far, the most prevalent way to represent processes is a timeline.

We define timeline as a representation of an element (or elements) of interest in the design process displayed on an axis (generally horizontal) that represents progression or the passage of time (e.g., Figure 1). Timelines are very flexible and can graphically present many elements of design. For example, several researchers used timelines to indicate how designers allocated their time across a set of codes to represent various activities in the design process (Atman et al. 2007; Badke-Schaub, Lauch, Neumann & Ahmed 2007; Goel & Pirolli, 1992; Guindon 1990; Smith & Tjandra 1998). Some authors used timelines to represent how designers use and refer to external objects such as sketches and physical models (Arikoglu, Blanco & Pourroy 2007; Blanco 2003). Gero and colleagues represented the function, structure, and behavior aspects of a design problem over time (Gero & McNeil 1998). Additionally, Lee, Eastman and Simring (2003) built on Goldschmidt’s definitions of design ‘moves’ and presented patterns of these movements over time.
2.2 Previous Pedagogical Use of Design Timelines

Over the years, CELT researchers discovered that design timelines are powerful research tools for illustrating the vagaries of an individual’s design process and for making comparisons across multiple design processes. When the design timelines were shown to engineering faculty members, they often provoked insightful observations and comments such as “my students should see these.” Motivated by such conversations, we developed interactive seminars to bring our design process research directly into engineering classrooms. We use an inductive pedagogical approach (Prince & Felder 2006) wherein we present a brief overview of our research and its methodology and then (without discussing our findings) ask students to analyze a set of design process timelines (Figure 2).

![Figure 2. Timeline Activity Handout. Timelines represent typical low-performing, average-performing, and high-performing freshman and senior engineering students.](image)

Students are asked to write down their insights, which are then shared and discussed with the class. We then discuss our empirical research findings with the students, and observe that most often our findings reinforce and extend the students’ insights. With this method, the timelines help students to access and reflect on their conceptions of design, to see how design processes play out in different ways, and to link their prior knowledge to current research findings. See [http://depts.washington.edu/celtweb/teaching/classroom.html](http://depts.washington.edu/celtweb/teaching/classroom.html) for more information on these interactive sessions.

2.3 Sonifications

Representing data with sound is essentially the same concept behind data visualization—translating raw information into something we can understand. One of the earliest and most widely-known examples of sonification is the Geiger counter (Kramer et al. 1999). By translating airborne radioactive particles into clicks from a speaker, we can simply and easily hear the levels of radiation. Other sonification uses are found in various science disciplines. In computer science, for example, Berman and Gallagher (2009) have used sound to help software developers better understand programs by hearing them. Essentially, like visualization, sonification aims to use our sense of hearing to make complex or abstract data understandable. Sonifications are also used in the arts. One of our coauthors, Carrie Bodle, used sonifications of data and strategic placement of audio speakers to create what she calls “spatialized sound installations that concern the relationships between art and science, translating inaudible or invisible phenomena into sensible experiences” (Bodle, 2010).
3. Methods

Two elements of our on-going exploratory work are to discover new ways to descriptively represent design process phenomena and to apply those representations in the education of engineering students. This particular paper focuses on the uses of design timelines and sonifications of timelines, called design sound tracks (DSTs). We asked colleagues from various disciplines to join us in this exploration—first as participants, whom we interviewed, and then as collaborators on this paper.

3.1 Sonification of Design Timelines

Using the SuperCollider (see http://supercollider.sourceforge.net) programming language, we produced nine design sound tracks (DSTs): three from first-year engineering students, three from senior engineering students, and three from practising engineers. Balancing between data resolution and reasonable time constraints, the three-hours covered by each timeline were scaled to 90 seconds. Four types of DSTs were produced: tonal, bell, drum, and interpretive. All use the pentatonic scale as the greater space between the frequencies may help improve the DSTs’ comprehensibility. The tonal, bell, and drum sound tracks are all direct mappings of the eight design activities, shown on the timelines, to eight tones, bell sounds, or percussion instruments.

The interpretive version moves away from a literal translation of the data, however. In addition to mapping the design activities to distinct sounds, we added additional features to the soundtracks to emphasize aspects we view as important elements of good design. For example, to highlight the importance of early problem scoping (PD and GATH), we raised the volume of PD and GATH sounds early in the soundtrack. Similarly, to emphasize the need to transition between activities, we tracked the number of minutes spent on an activity to effect a timbral change (more noise) depending on how often the participant moves between different activities. More details about the interpretive and other versions may be found in a technical report (Goist, Deibel, Atman & Borgford-Parnell 2010).

3.2 Participants/Collaborators

We presented DSTs to six educators in various disciplines. After interviewing each participant, they then collaborated with the CELT researchers on this paper. The following participant descriptions are in the order in which they were interviewed:

1. Mark Zachry is a professor in the Department of Human Centered Design & Engineering at the University of Washington (UW). He states that he is interested in “the design of communication...message design at a very low level, and design of communication strategies at an organizational level.”

2. Steve Tanimoto is a professor in Computer Science and Engineering at UW and is also an accomplished jazz pianist. He researches computer-based learning environments and currently focuses on problem solving and design using artificial intelligence technology. He describes his expertise in the field of design as bringing classical artificial intelligence ideas and web technologies to the design of collaborative systems.

3. Vipin Kumar is a professor in the Department of Mechanical Engineering at the UW. His teaching interests are in the areas of design processes, conceptual design, machine design, and manufacturing. His research focuses on the emerging area of microcellular polymers. He states that “I have championed in my teaching here, to teach the essence of the axiomatic approach...because it questions people’s perception and people’s... normal idea of the design.”

4. Axel Roesler is a professor for Interaction Design in the Division of Design, UW School of Art. He is Chair of the Interaction Design program. His research focuses on the inte-
3.3 Design Sound Track Interviews

Using a semi-structured, 90-minute interview protocol, we asked participants for the insights they gleaned about design from the DSTs and their equivalent timelines. We first provided each participant with a poster-size version of nine design timelines (Figure 3) and asked them to describe their initial reactions. We specifically inquired about how the timelines could be used to facilitate teaching design in their disciplines.

![Poster of nine timelines (36"x20") shown to interviewees.](image)

We then introduced the DSTs and demonstrated the interactive web page we developed for playing them. Figure 4 shows the web page used for selecting a timeline and the particular soundtrack type that would be heard (e.g., bell sounds).
Once the timeline and the soundtrack type were selected, the DST-player interface appeared (Figure 5) and the participant listened to the DST while watching a progress bar scan horizontally across the timeline. The progress bar shows exactly where in the design process and to which design activities the participant was listening.

After listening to several DSTs, participants were again asked for their reactions, how the DSTs might be used pedagogically, and how to improve or change the DSTs for the various applications they had in mind. Following each interview we made improvements and changes to our selection of DSTs and used the updates in subsequent interviews. This provided opportunities to collect feedback on each DST variation.
4. Results

Given the breadth of participants’ teaching, research, and practice interests, we got exactly what we expected—a wide range of reactions to the timelines and DSTs and interesting suggestions for how they might be used in the classroom. Table 2 lists categories of participant comments.

Table 2. Categories of comments on pedagogical use of design timelines

<table>
<thead>
<tr>
<th>Comments</th>
<th>Mark</th>
<th>Steve</th>
<th>Vipin</th>
<th>Axel</th>
<th>Carrie</th>
<th>Jim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall useful</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Promotes broad conceptual understanding</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Emphasizes importance of specific design activities</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>• Problem definition</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Iteration</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>• Gathering info</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>• Communication</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>• Modelling</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Cascade process</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>If production was automated, use timelines to...</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>• Help students reflect on their own design processes</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Show UCD opportunities</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Use in design teams</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
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</tr>
</tbody>
</table>

4.1 Illustrating Design Concepts with Design Timelines

A point that emerged repeatedly from the interviews was that being able to see actual design processes depicted in the timelines helped to make more concrete concepts that can seem abstract, fragmented, and artificial to students. Students are often taught with prescriptive models of design steps or phases, visualized with flow-charts and Gantt charts—all of which can reinforce a notion of linearity and de-emphasize the iterative nature of design.

Illustrating broad conceptions of design processes: Participants observed that one of the strengths of the timelines is that they emphasize and illustrate conceptions of an entire design process, or as Axel stated, “there’s a story here.” Carrie perceived the power of timelines to communicate the complex nature of the design process and as a way to instantiate the training and dedication it takes to master the process. Students who are new to contemporary art sometimes think that making art is simple and the process is seen as subjective. She proposed that if her students were, “looking at a graph like this they understand that coming to, perhaps, a simple solution or an elegant solution is...actually a really complicated process...and it’s really difficult to teach.” She stated, “I would use the timelines to emphasize and reinforce the difficulty/training_complexity it takes to create something elegantly simple.”

Steve suggested that a timeline “can be a great tool for making students more aware of the process, how it can unfold.” Axel, Mark, and Jim also posited how timelines could remind students of the many activities involved in design work and the variety of ways those activities may be distributed throughout a process.
Illustrating aspects of a design process: Participants also noted that design timelines illustrate aspects of design processes that prescriptive models do not, such as the need for periodic gathering of information. Vipin, for example, suggested that the expert designers “are collecting information well into the process...they’re open to new information.” He also recognized that “the expert design...is using a lot more iteration.” Readily evident in the expert and some of the advanced student design timelines is the consistent progress towards project realization that incorporates a great deal of transitioning between activities, looping back, and parallel processing. That process, identified by CELT researchers as a Cascade Design Process (Atman et al. 2007), is associated with design expertise and higher quality designs. Vipin, Jim, and Axel commented that this process was well represented in the timelines.

While examining the timelines, Vipin commented on how they illustrate how communication is attended to at multiple places throughout the process and not simply near the end. This was also seen by the other participants, and Axel noted that in the “higher-performing ones...communication stretches more into the beginning.” Mark also noted that for the experts, “problem definition happens sort of more intensely at the beginning of the process, and then...gets returned to.”

4.2 Teaching Design with Design Timelines

Participants suggested several novel pedagogical applications of design timelines. Axel proposed that more advanced students could be given existing design timelines and then asked to “do a reflective component and have the student tell the story.” He suggested that the stories would help students to think deeply about each aspect of a design process, and it would also give them the opportunity to discover the limitations of the timelines. Steve suggested that if the process of collecting and coding design activity data was simplified and automated, then timelines could be produced by student designers to evaluate their own design processes. Additionally, the student timelines might be useful for making comparisons between members of a design team.

Mark thought that if timelines could be generated for a user-centered design process (UCD) then they could be used to show that “if you are truly invested in the user-centered paradigm and you’re going to involve users from the beginning of the process as you’re gathering, generating a model...potentially, there’s different ways to involve users in all of these stages.”

4.3 Teaching Design with DSTs

Participants’ reactions to the DSTs were much more varied than their reactions to the timelines. Each of them felt that the DSTs had pedagogical potential. However, Mark, Steve, and Vipin—the engineering faculty—felt that the current DST versions had more limited potential than did Axel, Carrie, and Jim. Vipin, for example, suggested that DSTs may be most helpful in emphasizing both the good and the bad aspects of repetition in a design process, although he felt that due to the complexity of the DSTs it was important to view the corresponding timeline while listening. Table 3 categorizes participants’ comments on DSTs.
Table 3. Categories of comments on pedagogical use of DSTs

<table>
<thead>
<tr>
<th>Comments</th>
<th>Mark</th>
<th>Steve</th>
<th>Vipin</th>
<th>Axel</th>
<th>Carrie</th>
<th>Jim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spurs new thinking/imagination</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A difference between seeing and hearing design processes</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Emphasize importance of specific design phenomena</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Modelling</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Evaluation</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Iteration</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Repetition</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Project Realization</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Need to view timeline while listening to a DST</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use personal DSTs for reflection</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Which version works?</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Tonal</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Bells</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Drums</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Interpretive</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Depends on objective</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Listening to design helps students think about it in new ways:* Mark felt that much of what he could discern in the DSTs was readily seen in the timelines, although he did suggest that DSTs might be used to jog students’ imaginations. He stated “I think what’s cool here...is that this causes you to think about design work differently, to see or hear things this way.” Jim also thought that “in some ways you may hear it when you don’t see it.” Steve suggested “there might be some value to introducing it to get people to kind of take a broad perspective...to get an idea of, oh, the relative frequency of things happening.” He also suggested that blind designers might have “surprising insights” if they listened to DSTs.

Carrie suggested that people experience sound much differently than what they see. She stated, “Modelling is so dominant, and I think that comes across much more through sound.” Steve also noted that “Modelling is like the bagpipe groan. It’s always there in the background.” Carrie posited, “you start to really get a feel for...how complex the design process is...there is a large distinction between what you see (visually) and what you hear.” She proposed that the distinction may be in how we experience time through the representations: “I’m experiencing the sound through time, but visually what I see is static.”

*Students seeing and hearing their own design processes:* Jim proposed that if it were possible for a student to map her own process with a timeline, generate a DST, critique it with an instructor, and then redo—she could actually hear if improvements were made. “It’s all about balance and timing,” he posited, “How do you teach that...well, you teach with your tones...You’ve got to give feedback to let them know where they’re going...in a way that would allow them to make an adjustment in the process.” Similarly, Mark pondered whether individual designers had their own unique sound, and whether students might benefit from making individual DSTs and comparing them to experts’ DSTs. He stated, “I’d like to see these generated...for individuals, and actually want to see if there’s some sort of signature sound associated with their work. Vipin noted that “if you hear monotone, it’s not like you’re doing a high performance task.”
4.4 Suggested Changes to DSTs

Several participants suggested that using pure tones in the DSTs allowed listeners to concentrate on the represented design activities, and not confuse what they hear with associations to music or instruments. Axel thought that we should be, “working with sound signatures that are not instruments...so they don’t bring us into some sort of musical tradition.” Mark, on the other hand, thought that instruments might make each activity more distinct, and Steve suggested that if an instrument was chosen that reflected the nature of an activity then it might act as “a mnemonic for the type of activity instead of just purely an abstract sound.” He also suggested that if the pitch increased as the DST progressed that it would be easier to distinguish when iterations occurred.

The notion that DSTs might provide both a cognitive and an affective experience was suggested by several participants. Both Carrie and Axel proposed that the eight design activities should be recorded separately and played on different speakers (surround sound) so listeners could experience them more distinctly and differently.

5. Concluding remarks

Our participants felt that design timelines are pedagogically useful and each could imagine using them in their teaching. Several participants felt that if producing timelines could be automated then they would have even greater utility for teaching and learning design. In their current configurations, DSTs hold promise for augmenting the pedagogical potential of design timelines. Participants recognized the DSTs as novel means for communicating, emphasizing, and creating interest in various aspects of design processes. Paraphrasing Bruce Archer (1965), Axel stated, “The real design process is a mess compared to this prescriptive version of it, and the good designer knows that this mess is always what takes over, and the good designer is good at navigating this mess.” Timelines and DSTs—either separately or in tandem—might help students to ground their design work in more realistic, comprehensive, and beneficial conceptions of design processes.

Acknowledgements

This work was supported by the National Science Foundation (grants RED-9358516, ROLE-0125547, ARRA-0943242), the Boeing Company, the College of Engineering at the University of Washington, the Mitchell T. and Lella Blanche Bowie Endowment, and the Mark and Carolyn Guidry Foundation. We would also like to thank Jennifer Turns, Robin Adams, Jason Saleem, Susan Mosborg, Monica Cardella, and Ken Yasuhara for their support in our various research endeavors. Our special thanks to all the dedicated students and professionals who participated in our research.
References


Design Thinking: A paradigm on its way from dilution to meaninglessness?

Petra Badke-Schaub
Delft University of Technology, Delft, Netherlands

Norbert Roozenburg
Delft University of Technology, Delft, Netherlands

Carlos Cardoso
Delft University of Technology, Delft, Netherlands

Abstract
This paper is a critical view on design thinking, addressing both, the limitations of the traditional design thinking research as well as the contributions of the new approach, often referred to as design thinking movement. The traditional design thinking approach has meanwhile produced a broad research history but has to cope with its fragmented variety of empirical results, due to a lack of theoretical integration; the new view on design thinking as management strategy is not grounded on empirical studies or evaluations and suffers from an ambitious and too general concept. Both approaches could gain from each other in different ways.

1. Introduction
A new movement called "design thinking" gains increasing attention across different disciplines. This movement promotes "design thinking" as interdisciplinary and innovative strategy. However, there is a question of how to integrate or distinguish this concept from the existing traditional design thinking approach.

Defining a complex concept such as intelligence or behaviour such as designing is always a difficult endeavour. When introducing a new definition, one has to state which parts do and do not belong to the defined field, area or concept. Hence, a new definition makes a difference, ultimately becoming vulnerable to all kinds of critical feedback. However, there are a number of advantages in creating a new definition. On the one hand, it has the potential to avoid ambiguity. On the other, it facilitates communication within a particular research field, as well as amongst scholars from different disciplines. Furthermore, a clearly defined concept supports the integration of empirical results of different research approaches and studies. This is especially true in a genuinely interdisciplinary area as design research where a minimal consensus is necessary to arrive at a common understanding, and finally to progress in the field. Although empirical research on designing does not have a very long tradition, design thinking has gained the position of a paradigmatic concept describing design-specific cognitive activities that designers apply during the process of designing (Dorst 2009; Visser 2006).

Concepts change throughout time due to the fact that new knowledge has been created and/or theoretical developments deliver new ways or explanations. Thus, the question arises, what exactly constitutes the knowledge which led to a new understanding, a new concept of design thinking? With the publication of his book entitled “Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation”, Tim Brown (CEO of the design consultancy IDEO) emerged as one of the major promoters of the ‘new’ design thinking ‘movement’
The main argument for underlying this movement is the need for innovation in order to face the current and future global challenges,

“an approach to innovation that is powerful, effective, and broadly accessible, that can be integrated into all aspects of business and society, and that individuals and teams can use to generate breakthrough ideas that are implemented and that therefore have an impact.” (Brown 2009, p.3)

This approach is on the one hand a claim for a visionary business strategy (Lockwood 2009; Martin 2009; Verganti 2009). On the other, the authors envision a power of designers to influence the world and thus to have an impact on society. However, the new design thinking approach does not refer or acknowledge the results from research on this same topic over the last decades.

In this paper we want to shed light on the question why has the traditional concept of design thinking been overtaken by industry as a mainly business and management approach. Although the concept of design thinking has been established and widely accepted in the scientific community for as long as 25 years, the ‘new’ movement seems to ignore this approach by ambiguously redefining its core principles. We will discuss briefly three main principles of this framework and by this we will try to explain why this sweep over is not beneficial for the scientific development of design thinking research. We will finalise with a brief extrapolation of necessary changes in order to arrive at a more comprehensive and integrated scientific knowledge of design thinking research. Ultimately, such changes ought to be applicable to education and practice, continuously building on empirical research and contributing to the further theoretical development of the field.

2. Design Thinking: the new approach

In the following we analyse the key presuppositions which characterise the ‘new’ design thinking approach. The analysis is mainly concentrated on the elaboration and statements which Tim Brown (2009) conveys in his book “Change by Design”. He defines design thinking as “a discipline that uses the designer’s sensibility and methods to match people’s needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity” (Brown 2008, p.86). Brown stresses three basic premises of the ‘new’ design thinking approach:

1. Design thinking is equally relevant for designing products and spaces, as to the design systems or dealing with abstract problems such as services. This premise is also true for the traditional approach. However, it is important to state that whereas design thinking research has until recently referred mainly to the design of products, whilst neglecting systems and services, both aspects are now gaining more relevance for the customer and thus for the designer.

2. The primary goal of design thinking is disruptive innovation to gain competitive advantage on the global market. This statement has been claimed decades ago, and as such it does not provide new insights nor does it point to new behavioral strategies or requirements. In fact, it has already been more than forty years since practitioners in engineering design developed the first methodologies, which aimed at supporting the design process and, consequently, the development of innovative products (see for example Kesselring 1954; Pahl & Beitz 1984). And at the same time, 1952, Alex F. Osborn, the godfather of brainstorming, published the book “Wake up your mind: 101 ways to develop creativeness.”

3. Design thinking is human-/user-centered, and thus based mainly on non-obtrusive methods such as observation. Brown for instance states:
Design thinking is valuable not just in so-called creative industries or for people tasked with designing products. Rather, it is often most powerful when applied to abstract, multifaceted problems: improving a guest experience at a hotel, encouraging bank customers to save more, or developing a compelling narrative for public-service campaign (Dust jacket, back panel).

This premise refers to the main dogma of the new design thinking approach, which strongly focuses on the user whilst leaving the designer behind. Design thinking is part of the managerial task and thus can be done by different people other than designers. Hence, design thinking is not an activity reserved to the designer but can be, or better needs to be, done also by other people involved in the innovation of products and services development processes.

In the following we will examine three major characteristics of this approach in more detail, the design thinker, design thinking as business and management activity and design thinking as roadmap to improve society.

2.1 The designer as design thinker

Brown (2009) describes the designer as (design) thinker who is supposed to realise high market impact in organisations, the ‘white knight’ guaranteeing to arrive at innovative solutions:

Design thinking is an approach that uses the designer’s sensibility and methods for problem solving to meet people’s needs in a technologically feasible and commercially viable way. In other words, design thinking is human-centered innovation (Brown 2009).

The underlying argumentation is as follows: The designer is considered as design thinker when he/she is capable of dealing with the constraints of the usual design projects. Here the approach is very close to the rationalistic approach assuming that the designer is able to cope with all the often quoted characteristics of the nature of design problems, which make designing complex and difficult, such as: ill-defined, not one best way etc. (Simon 1973) that all requires particular attention. These characteristics are not specifically pointed at; it is more like the designer can move forward throughout the process without being deterred by these potential bottlenecks. Brown explains:

In contrast to the champions of scientific management at the beginning of the last century, design thinkers know that there is no “one best way” to move through the process ... the reason for the iterative, non-linear nature of the journey is not that design thinkers are disorganized or undisciplined but that design thinking is fundamentally an exploratory process; ... (Brown 2009, p.17).

And further:

The best designers match necessity to utility, constraint to possibility, and need to demand. These design thinkers rely on rigorous observations of how we use spaces and the objects and services that occupy them; they discover patterns where others see complexity and confusion; they synthesize new ideas from seemingly disparate fragments; and they convert problems into opportunities (Dust jacket, back panel).

According to this description, the capabilities of the designer as design thinker do guarantee a successful process and product. The design thinker has taken the role of a general problem solver and manager who—in case that the designer is promoted into the right environment—will deliver innovative results. According to Brown (2009) designers who embrace design thinking, follow many methodological approaches and act in a way that may be considered as
best practice. Obviously, Brown does not present a realistic descriptive approach but draws an idealistic picture, which is not supported by empirical investigations so far. Instead it has been repeatedly found that practicing designers do not typically follow methodological procedures (Badke-Schaub et al. 2005; Birkhofer et al. 2005).

2.2 Design thinking in business and management

Design and design thinking are not tasks only for designers but an inherent requirement for business and management leaders: “Design is now too important to be left to designers” (Brown 2009, p.37).

Brown argues that design thinking should be written into the DNA of any company. However, Brown is unclear about how managers would or should establish design thinking. While Brown describes examples of recommended methods, such as brainstorming, prototyping and visual thinking as means to arrive at innovative solutions; he does not explain which methods should (or should not) be used and adapted in which situations. Ultimately, he is vague on explanations how these methods can be applied in the managerial and business context?

Further explanations of how design thinking as business strategy can conquer the world are given by Martin (2009) in his book on “The Design of Business: Why Design Thinking is the Next Competitive Advantage”:

Design thinking is the form of thought that enables movement along the knowledge funnel, and the firms that master it will gain an inexhaustible, long-term business advantage. The advantage, which emerges from the design-thinking firms’ unwavering focus on the creative design of systems, will eventually extend to the wider world. From these firms will emerge the breakthroughs that move the world forward because design-thinking firms stand apart in their willingness to engage in the task of continuously redesigning their business.

2.3 Design thinking as roadmap to improve society

The vision of the ‘new’ design thinking approach is the “change by design”, explained by Brown (2009, p.115) as follows:

Design has the power to enrich our lives by engaging our emotions through image, form, texture, color, sound, and smell. The intrinsically human-centered nature of design thinking points to the next step: we can use our empathy and understanding of people to design experiences that create opportunities for active engagement and participation.

Evidently, Brown claims here for a better world through “engaging our emotions”. However, it is more than questionable why and in how far the use of emotions will lead to better products. Whenever emotions are involved in society, hardly any positive consequences can be drawn from that. Yes, emotions enrich our life but they do not make it easier.

The other aspect of emotions Brown refers to is related to empathy. He states that empathy of the designer leads to designing better products. However, there is no proof for this assumption. In fact, as empathy is always biased by a person’s own perceptions, experiences and mental models, we should instead ask the question: How can we support the young, right-handed, western designer to design user-centered products, systems and services without using his empathy? Given the fact that users themselves sometimes do not know what they want or need (Leonard & Rayport 1997), in such situations the designer’s empathy would lead to a dead end, anyhow.
In summary, we can state that Brown’s (2009) ‘new’ design thinking approach presents a prescriptive or even idealistic view, which is ultimately formulated at a rather low resolution level. The instructions are not empirically nor theoretically supported; they are a generalization of his own experiences packed in a kind of popularized management problem solving approach. Taken “Change by Design” as pars pro toto design thinking ends up being used to cover a broad range of meanings transferred into the management discourse, propagating such ‘theory’ as the successful approach to disruptive innovation. It is a prescriptive conglomeration stressing the relevance of different activities, such as collaboration, exploring and integrating options, low-fidelity prototyping and interpretation.

In his column “Design Thinking: A Useful Myth?” Don Norman (2010) calls this ‘new’ approach a myth which “is nonsense, but like all myths, it has a certain ring of plausibility although lacking any evidence.” The broad acceptance of this notion of design thinking, especially in industry, seems to stem from its fashionable format and the ‘hero’-function ascribed to the designer. However, the emerging breadth of the construct has led to a dilution of the concept. Although some of the proposed suggestions may be convincing in terms of ‘grandmother’s wisdom’, the approach does not put forward any kind of empirical investigation or evaluation of the premises. There is no intention to better understand the underlying cognitive processes that the traditional design thinking approach stands for. Consequently, without any consensual conceptualisation and operationalization of what constitutes the approach consists of, the scientific value of the concept of design thinking is meaningless. The practical impact on design as profession might be positive as long as the expectations can be fulfilled by the designer.

3. Design Thinking: the traditional approach

In this part we focus on the main characteristics of the ‘traditional’ design thinking research approach and discuss also some of the limitations and shortcomings deriving from it. The issue ‘design thinking’ received substantial attention as consequence of the first Design Thinking Research Symposium in Delft taken place at the TU Delft, Netherlands, in 1991. Quoting the organisers of the DTRS in the description of the history of the Design Thinking Research Symposia “… looking back to the first workshop in 1991, it is perhaps difficult to recall just how little ‘research in design thinking’ was going on then, compared with today.”

Many workshops, workgroups at conferences, symposia etc. were initiated and are still continued with different focus but all pursuing the main emphasis on the research of questions such as: How do designers solve design problems? What exactly is the thinking process designers pursue during their design activities? How can thinking processes that guarantee innovation best be taught and how can they be supported in daily practice?

Of course, the very general issue about how human thinking works involves a variety of sub-issues and thus a huge diversity of research approaches to fill in the puzzle with new insights. Here we do not intend to provide an overview of the valuable research which has been done but rather want to ask the critical question where we are now.

3.1 Explaining the non-observable

What is thinking? What are thinking processes? Following the thinking process from the input information to the individual response (see Figure 1) it is obvious that the internal world of the designer, where thinking takes place, is hidden; thus we can only observe those parts where we gain access to from the external world. The consequence is that only the product, the outcome or (in our case) the designers’ behavior itself can be feasibly observed. Furthermore, we can define indicators of inner components and processes, which we classify as part of the thinking process steering the exchange between internal and external world.
If, for example, a person solves a mathematical equation, we can describe the mathematical problem and its characteristics as input situation. Subsequently, we can observe the response and the solved equation. Therefore, we are in a position to conclude that the person has the relevant knowledge to solve this kind of mathematical problem. This is of course easier to observe compared to complex processes where reasoning procedures and all kinds of different information processes run which have no observable materialization but are represented and stay in the brain for further use. Obviously the latter one is much more difficult to research.

3.2 Defining the non-definable

As pointed out in the beginning of this paper, it is of major importance to define the area of interest to make clear what part(s) of the concept(s) we are talking about. There are several ways to come up with a definition. One possibility is to describe the essentials of the concept as a list of characteristic elements. We have done so and identified creativity, visual thinking, reasoning and expertise as characteristics of design thinking. These characteristics are based on thinking processes such as: information search and generation, mental imagery, assessment and evaluation, structuring and learning (Goldschmidt & Badke-Schaub, in this volume). However, there is also a downside to a definition which consists of a list of constituents—a list is always incomplete and often non-exclusive. As the list can never be complete and mostly entails elements at different levels of granularity, the choice of elements and the resolution stage is, to a certain extent, arbitrary and thus this kind of definition is not satisfying.

Another way to define a concept is a model-based definition. Figure 2 depicts a model of the sequential process of design thinking. The design process starts with the representation of the problem, which at first is answered by the internal search for an applicable routine. In case there is a routine available, this will be implemented and, if it is successful, the task is accomplished. If there is no routine available, the designer tries to remember similar cases from the past. However, if this does not provide any ideas on how to approach the situation, the next step is to generate a new idea or solution to the problem. If this is not successful, the problem might be reframed and the process starts anew. This is an iterative process where the different loops can be investigated separately and the single steps detailed.
Figure 2. A basic model of the process of design thinking.

The advantage of such a model-based definition is the highly concrete ‘if-then’ description, which makes empirical evaluation of the assumed relationships feasible. The disadvantage though, is the inherent assumption that the underlying concept is homogeneous. However, designing is a rather complex concept, which consists of more dimensions on several levels.

In summary, there are no consensual attempts to define design thinking or to explore to what extent it constitutes processes different from other activities, situations or disciplines—questions that have been seriously asked and investigated only by a few authors, for example Visser (2009).

3.3 Fragmenting design thinking into isolated sub-issues

Design thinking is a complex behavior within a complex context and as such—comparable with complex problems—it is hardly decomposable into independent sub-problems (see Figure 3). On the other hand, it is not feasible to think of a research approach that is prepared to assess and analyze data in a setting with all influencing variables, which are not properly defined yet. Moreover, research on design thinking has been carried out by different disciplines, each one not necessarily taking into account the broader picture. Researchers in cognitive psychology, for example, have a different interest in design thinking compared to computer scientists. The latter follow their own discipline-specific goals, as researchers from engineering or architectural disciplines do. Thus, there is both a need to integrate the various results from different disciplines as well as to encompass the several facets of the concept in order to achieve progress in research.

Obviously, design thinking research covers a broad interdisciplinary field with research questions at different resolution levels. Views on designing can differ depending on general concepts, such as new product development and product life-cycle approaches, with specific technological challenges making design thinking unique. Therefore, it is necessary to be aware of the broad range of characteristics which are to be taken into account for different design situations. For example, there is a significant amount of empirical evidence showing that experienced and novice designers work in different ways; in the same way, also the other fields of variables such as project context or the customer consist of further parameters which need to be taken into account.
Research therefore should provide a description of the specific situation in terms of parameters, as well as an indication of their importance. An example can be seen in Figure 4, where a less typical design situation with clear goals is presented. There are many variables involved in this situation, but these are not interconnected. The designer has enough capacities to cope with the problem in a situation that is not risky. Many stakeholders are involved and there is continuous feedback available. A situation showing this type of pattern seems to need most consideration of the social aspect, the involved stakeholders. Of course, other patterns of variables would show a different picture. Ultimately, this would probably lead to dissimilar assumptions, with a need to assess variables with reference to the design process.

4. Concluding remarks

In the past decades, we have seen the emergence of a design research community. Within this community a research culture has been established, producing a broad range of results on various issues of design thinking. However, the whole picture is still not convincing—because there is no such thing as a whole integrated picture. The knowledge gained appears to be fragmented, without obvious approaches to arrive at a moment of consolidation.
This situation is described in an analysis by Dorst (2008), as a period prior to a revolution according to Kuhn’s (1962) concept of paradigm shift. Dorst argues that after forty years of design research, there has been an increase in the number of anomalies regarding core assumptions. Such assumptions have not been properly addressed. Furthermore, they have been mostly ignored by the design research community, because there is a general feeling that “their normal way of working is under threat, and this makes them acutely uncomfortable.”

Furthermore, the research development of the traditional design thinking approach is losing its innovative force. Current research topics, as well as research methods, are mainly following and repeating topics and methods of the last decades—thus missing a shift of focus and new enthusiasm. We will briefly stress three issues which should be re-considered:

I. Major (or solely) emphasis on cognition—what roles do motivation and emotion play during design thinking?

In accordance with Brown (2009), we would like to state that emotion is a topic which has yet to gain more attention. Emphasis should be placed on emotion as part of the designer’s thinking process. Why is there a need for research on design thinking in addition to the cognitive level? Designing is an activity comprising thinking processes, such as: generating solutions, evaluating information, visualizing representations and developing strategies, while learning and building up experience. These processes are modified and moderated by emotions. For example, if a person gets angry in a specific situation, his/her cognitions will change, his/her behavior will be affected and so will the outcome. The same is true for the social context which also has an impact on the designers’ motivation, cognition and emotion. Thus, designing is more than a cognitive process. Designing is also dealing with uncertainty, affecting thinking processes in different ways. The motivation to explore new situations, and to take risks while thinking in new ways, is different amongst people. Evidently, broader access to the designer as human being is necessary. Whilst, design thinking is a cognitive process, the actual behavior is determined by cognitive, motivational and emotional processes. Emotions are driven by the cognitive appraisal of relevant events, internal or external, enabling people to respond appropriately to these events (Scherer 2005). Additionally, within the field of emotions further topics, such as preferences or attitudes, are to be mentioned as these may have an impact on the design thinking process.

II. Focus on design teams—is the design team: interdisciplinary, geographically dispersed and culturally diverse—where is the individual designer?

Designing is an individual activity but it takes place in a social context (Bucchiarelli 1994), where the characteristics of a team play an important role. During the last decade, the focus on design teams has been increased. However, research on designing in teams is still very scattered and existing results are not really comparable. Sometimes the teams investigated are set up in an ad hoc manner; some are project teams, others are in geographically dispersed context, or composed of different disciplines, and so forth. The comparability of these results must be questioned and a way to structure the variety of research results is needed.

Furthermore, cognitive processes steering the individual design activities will be modified in the group context. In such cases, different processes take place on how individual mental models develop in a team context (Badke-Schaub et al. 2007) and how they influence the team’s process. Here, empirical research is needed, but also a theoretical underpinning of these processes is still missing.
III. Design thinking research methods: is there more than case studies and protocol analysis?

Empirical studies are important for developing and evaluating theories. There are different approaches to execute empirical studies and the one that is chosen should match with the research question(s). This means that the more explorative the research question, the more appropriate is a qualitative research approach. Unfortunately, most of the research in the field of design thinking seems to be explorative, with a lack of scientific rigor in terms of data assessment, analysis and interpretation. Protocol analysis, often referred to as a valid method for safeguarding the quality of the research, is not necessarily the only and best way to arrive at meaningful data, and by no means is a guarantee for quality. Also, the field setting itself does not necessarily deliver valid results compared to laboratory studies, due to the fact that it is very difficult to capture data without all kind of interferences. A further understanding of designers’ thinking processes is important, if we are to be prepared to deal with future challenges in education and in design practice.

The new concept ‘design thinking’ as business strategy comes along as a kind of ‘re-definition of the concept’ without reference to the existing traditional design thinking concept. Visionary ideas, such as those formulated in the new design thinking approach, might help to widen the view and look at designing in different ways. Therefore, a better defined approach should provide a kind of a process model of designing as innovation and transformation process—where, how and when the designer will be involved, how are the tasks of the designers framed compared to the marketing people, etc. There seem to be some first attempts at developing more elaborated strategies which provide guidelines for managers suggesting how to cultivate creative equity proactively within their organization (Person & Schoormans 2010).

Obviously, there are more issues in design thinking research which need to be addressed in the following years, because it is essential to enhance progress and knowledge to scientifically support the designer.
References


Poetic Design: An Investigation of Expert Poets and their Creative Processes

Erin L. Beatty
Lancaster University, Lancaster, United Kingdom

Linden J. Ball
Lancaster University, Lancaster, United Kingdom

Abstract
Expertise in poetry writing has been a neglected area of psychological research. This is despite the fact that poetic expertise represents a unique area of artistic creativity that can inform our theoretical understanding of creative reasoning. At the same time, studies of poetic expertise could also shed new light on the similarities and differences that exist between innovative concept exploration and evaluation processes that arise in artistic pursuits and those that take place in more technology-oriented design practices. Most of our current knowledge in the area of poetry writing derives from autobiographical accounts written by expert poets (e.g., see Curtis 1996, for a typical collection of essays) or from a few recent studies of novice poets (e.g., Groenendijk et al. 2008). Although such evidence is useful in identifying issues that may be associated with poetic expertise, it nevertheless remains critical to pursue in-depth empirical work focusing on the imaginative activities of expert poets themselves. To achieve such an empirical understanding we have recently embarked on a programme of research to examine poetic expertise and sources of inspiration in poetry composition, with a close eye on exploring the parallels between creative processes in the poetry domain and those in the design domain. Our research methodology is twofold. First, we have been conducting interviews with poets to gather some reflective data on their creative processes and sources of inspiration. We summarise the results of this interview study in our introductory section. Second, we have been conducting laboratory-based studies of expert poets undertaking writing tasks while verbally reporting their thoughts using a ‘think aloud’ technique. These data follow up some observations from our interview study, and we focus the present paper on reporting key aspects of these think-aloud data. Overall our findings demonstrate that key elements of design thinking may well be generic aspects of creative endeavors aimed at producing novel and valued outputs, rather than being restricted to core design disciplines. Our ultimate goal is to develop a cognitive model of the reasoning processes that underpin ‘poetic design’ that is informed by a theoretical understanding of design thinking. We anticipate that this model will engender new insights that will also allow us to challenge and extend established views of design expertise.

1. Introduction
People are capable of incredible feats of creative endeavour across all domains, yet our understanding of the processes by which these creative acts occur remains limited (Runco 2007). Poetry composition is a particularly neglected research area, which is surprising given its status as a key domain of creative expression. Most of our current knowledge concerning the nature of poetry-writing skills derives from autobiographical accounts written by expert poets (Curtis 1996; Mengert & Wilkinson 2009). While these first-hand reports are valuable in introducing issues that may be associated with poetic expertise, it nevertheless remains essential to validate and extend the insights deriving from these reports through in-depth empirical analyses that focus on expert poets’ imaginative processes.
The few existing empirical studies of poetry writing tend to adopt an educational perspective and assess how novices write poetry. For example, Groenendijk et al. (2008) examined the impact of writing processes on final poems in students who were novices in poetic composition. It was found that writing production in the first half of the session, and revision toward the end of the session, were associated with better quality poetry, whereas pausing and early revision had a negative effect on poem quality.

Most empirical evidence in the poetry domain, however, is centred not on poetry composition but on how students read and interpret poetry. For example, Eva-Wood (2004) found that college students who were instructed to ‘think-aloud’ and ‘feel-aloud’ while reading poetry made more elaborative and better quality comments than students who were only requested to think-aloud. Earthman (1992) found that college freshman read literature in a ‘closed’ manner, while graduate students read in a more ‘open’ manner. Graduate students were open to ambiguity and layers of meaning in texts while freshmen were unwilling or unable to cope with such complications and subtleties.

Peskin (1998) compared how novices and experts constructed meaning when reading poems. Experts made allusions to other literary works, contextualized a poem within its poetic domain, and anticipated the direction of the poem’s progression. Novices made such connections infrequently and achieved only simplistic representations of poems that lacked depth. They also spent less time overall attempting the task than the experts. Peskin’s findings illustrate how difficult understanding poetry can be for novices, and imply that processes of composition will likewise be difficult for those with limited experience. Moreover, such observations underline how important it is to investigate the nature of expert performance in order to derive a rich understanding of the creative processes of those who are genuinely skilled within this domain.

Much of the difficulty surrounding poetry composition seems to derive from the task’s ill-defined nature. Ill-defined problems are those where goals are vague, where optimal solutions are unknown, and where limitations of the problem space are unclear (Simon 1973). Poetry writing exemplifies this definition, with the poet typically starting from a point where they have uncertain goals, unclear constraints, and a limitless set of actions that can be taken. Indeed, there are no universal rules that dictate what a poem can or cannot be, despite the availability of dictionary definitions like a poem is ‘a composition in verse, usually characterized by concentrated and heightened language in which words are chosen for their sound and suggestive power as well as for their sense, and using such techniques as metre, rhyme, and alliteration’ (Collins English Dictionary 2003). Poetry composition, therefore, is most certainly an ill-defined problem in the same way that innovative design is conceived to be (Ball, Evans, Dennis & Ormerod 1997; Simon 1973).

The overlap between poetry composition tasks and design tasks in terms of their lack of definition is useful from a research perspective since it suggests that common processes may underpin activity in both domains. Our initial research on poetry composition used a retrospective interview methodology to examine issues surrounding sources of inspiration and the nature of writing and revision processes (Beatty & Ball 2010). We found evidence suggesting that poets are most commonly inspired by ‘familiar’ things, that is, aspects of life that are essentially ‘ordinary’, ‘mundane’ or ‘everyday’ (e.g., daily experiences, family circumstances and personal conflicts). The degree of commonality across these poets was striking, and probably attests to the simple fact that what was familiar to these individuals was also what they were passionate about. This passion was explicitly acknowledged by some of these poets when they explained that successful poetry makes the audience ‘feel’ something, and that the best way to embody such emotional connotations within the poem is to feel something yourself about what is being written.
With regard to the writing process, poets indicated that they commonly worked from an initial idea or ‘first line.’ There seemed to be a wealth of evidence supporting the poets’ tendencies to find an early way into the poem via a key objective or concept that paved the way toward subsequent solution exploration. We think this practice shows striking similarity to the role of ‘primary generators’ as described by Darke (1979) in the context of architectural design. Darke observed that her designers tended to impose a limited set of objectives on the task as a way to constrain the space of possibilities and to allow solution exploration in a ‘conjectural’ manner (i.e., by testing the adequacy of initial conceptualizations of a solution). Such objectives related to notions such as wishing to express the site, wanting to maintain social patterns or aiming to provide for a particular relationship between dwelling and surroundings.

We are intrigued by this notion that primary generators may serve such a crucial role in sparking off the writing process during poetry composition. Our previous observations seem to validate the role of primary generators in providing the poet with a platform to ‘frame’ their subsequent exploration of a topic in a conjectural manner while also affording a way for the poet to manage the complexity of the poetry-writing task itself. Solution-focused behaviour and the conjectural aspect of poetry writing also seemed to reveal itself in the dominant role that revision played in the process, with our poets describing revision as something that they needed to do as well as an aspect of the process that they enjoyed.

The study that we present in this paper aimed to follow up some of our key observations from our interview study relating to the nature of inspiration and the apparent role of primary generators in poetry composition. It is a preliminary examination of poetry composition in a laboratory-based setting that entailed data collection focusing on expert poets undertaking writing tasks while verbally reporting their thoughts using a standard ‘think aloud’ technique (see Cross 2001). Such verbal protocol studies, although prevalent in design research (e.g., Cross, Christiaans & Dorst 1996), have been criticised since thinking aloud may not only be a poor way to illuminate non-verbal processes that arise during design (Lloyd, Lawson & Scott 1995) but may also have a reactive effect on design activity, changing the nature of the design process itself (Davies 1995). Lloyd et al. (1995) conclude that although “concurrent verbal reports can reveal some aspects of design thinking there are many types of design thinking that remain impervious to concurrent verbalization requiring different methodologies for analysis”. Notwithstanding these caveats we nevertheless believe that there is much that can be discovered about activities such as designing and poetry writing by adopting the think-aloud technique, although we acknowledge that any findings need to be validated via methodological triangulation using other techniques such as in vivo observation (Ball & Christensen 2009) and ethnographic analysis (Ball & Ormerod 2000).

2. Method

2.1 Participants

Two participants (2 female, mean age 40.50) were recruited on the basis of having published poetry. Participants had between 22 and 30 published works including one book each. They had been writing poetry on average for nine years and writing in general for 15.5 years. Both poets held a master’s degree in creative writing.

2.2 Procedure and Materials

Participants were asked to perform a writing task in response to a writing cue selected from the following list: a memory, family, home, place, distance, ocean, love, desire, hate, hope, good, evil, tree, hands, existence, the galaxy, God, and nature. These cues were generated by an independent pair of expert poets in collaboration with the researchers. Participants were given 30-45 minutes to write until they produced a poem that they were satisfied with. At this point
they were given a short break before choosing a second writing cue and repeating the task. While the participant wrote the poem they were asked to think aloud. After the writing task participants were asked to select a poem and were then given a short interview in reference to that specific poem. All think-aloud data and written work were recorded using a digital video camera that was placed on the desk adjacent to the participant.

3. Results

The results of the study reported here focus only on the poets’ think-aloud responses. For our purposes the poem produced is of less concern than the process by which it was produced. It is an important caveat that this study pursues a focused examination of the very initial writing stage. Our earlier research indicated that a great deal of time is spent by poets on the revision processes that occur much later in a poem’s chronology, but for our current area of investigation we were concerned solely with how initial writing takes place and how a partially-formed idea gets transformed into something more concrete—in this case a first draft. The two sets of writing that are discussed here are both based on the writing cue ‘home’, allowing us to see the differences in how two poets explored the same stimulus cue.

3.1 Cue Selection

Initially our participants focused on choosing a writing cue, and we suggest they were attempting to balance exploring their available options while at the same time limiting their options so that they had a point from which to work. Participant 2, for example, seemed to have a reason for rejecting each cue word, as evidenced in the following quotation:

> Distance, family, a memory, tree, good, hope, love, home um. I’ve recently written a whole series of poems about distance so I’m going to reject that one and which also connects with family and things like that, so I’m going to disregard that one. Ah love—too general ... Quite like home, quite like tree—fairly concrete. Good. Good’s a bit abstract. Really home, might go with home ... (Participant 2)

Participant 1 initially had an idea based on something they had been thinking about independently: ‘I’d already seen the word home so I thought maybe this is an opportunity to do something um that I’m already exploring in which home would fit, as would love.’ Participant 1 then seemed to change their mind and attempt to explore the other options before finally deciding:

> Maybe I’ll do something completely different and go for tree. I think maybe that will be the easiest thing. I think I’ll go for- Unless I do them all. Feeling a little overwhelmed. Right. Tree. I’ll do tree. No. I won’t. I want to do home really, no point in fighting it... (Participant 1)

After these moments of indecision this poet remained committed to home and love as their cues.

3.2 The Initial Writing Process

Participant 1 was very associative in their initial idea generation. Much of their verbal protocol was filled with incomplete statements reflecting perhaps the speed at which ideas are generated:
Okay, right, so if I am thinking about the home and the idea of home being an ugly crap place full of—I want to say plastic. What makes a home, okay so home discomfort, so if I go for opposites what I wouldn't consider home discomfort, cold, which would also be damp, also be um noise say and well if I'm thinking of the island home I have in my head there's also smell, dirt, plastics—nothing natural…(Participant 1)

But fairly soon in the process they started to think more structurally:

I'm wondering (pause) what I need to do with these, what do I want to do with these, what do I want to set up? So I think it is the idea of loving something...(Participant 1)

After answering the structural question with the concept 'love', Participant 1 then moved back to more associative thinking. After a series of associations they centred on a concept: 'I'm thinking about setting a scene, setting a notion of what this home is. This is my home. This is what I love. So the love has got to be a discomforting love.'

Participant 2 initially had a personal focus toward the writing cue and began by listing the places that she had lived and from there explored what she had already written about these places. Then they began to eliminate different places on this list that had already been written about. From there, though, there was a key shift in thinking. Participant 2 switched from a personal focus to an external focus: 'I suppose I could go with ideas of home. Other people's home not just my own.' After some further explorations they decided to 'draw a little house for lack of something else' and then there was a pause followed by an idea:

Oh maybe I could do that. You know when kids draw houses they put the windows in the corners because they haven't worked out how to do them in the middle of the wall. Something about a child drawing a picture. Hmm much better if I actually had a child's picture. They do a blue line for the sky that just floats and they do a zig zaggy green bit that floats and the house floats...(Participant 2)

This idea then became the sole focus of their poetic writing. Two things are particularly interesting about this quotation. First, the idea came about from a drawing that was initially without a specific intention. Second, the zig zag green concept that was present to begin with and was expanded to:

The grass zig zags from left to right and holds the houses—house could there be more than one house. The grass zig zags from left to right—it's a nice rhythm. The grass zig zags from left to right and holds the da da up holds the—(pause) fence posts holds the fence posts up (annotates the drawing)... (Participant 2)

Rather than pursuing it further ('I just do some bits in between rather than carry on with that') this concept remained relatively unexplored during the middle phase of the writing but was edited in toward the end of the session. There seemed, therefore, to be strong evidence of an initial line being produced. The next line that was produced was: 'The child knows the sky is blue but doesn't see the join the way that earth and heaven meet.' This line was then made the first line of the poem where it remained. This poem advanced in a superficially linear fashion with the narrative being focused on the child drawing a picture of the home. As the drawing in the poem is completed so was the sketch that the poet was working with. This sketch was referred back to during the writing phase. Roughly 16-17 minutes into the writing a twist in this narrative begins to be introduced:

The teacher asks who lives there. (Pause) I don't know hmm I wonder. I remember doing things with children a long time ago to do with emotional behaviour problems so you didn't do it as who lives there but who would you like to live there so you made
this imaginary place and gave children an opportunity to talk about people who’d died or people they missed. I could use that... (Participant 2)

The rest of the writing is spent elaborating the conversational exchange between the teacher and the child and the other details of the drawing.

Participant 1, by comparison, was much more experimental in their writing, trying more lines and different approaches to the idea. They were quite critical of their assessments of the writing produced: ‘No it just doesn’t have any rhythmical or lyrical merit.’ Several themes remained constant in their writing, specifically those of household plastic and pollution. They stated that: ‘And I am very aware of the critic and the outside eye and the judgment here and I suspect that I just need to go that’s okay. Right so I see whether this is the right first line.’

Roughly halfway into the total time taken the first line that remained until the end appeared ‘tininess desires a cotton bud leftovers crave a zip lock bag.’ These units ‘tininess’ and ‘cotton bud’ had appeared earlier, but it wasn’t until they’d all appeared separately that they were combined. The writing remained quite associative throughout the process and the poem that was produced at the end of the session was very different from the one produced by Participant 2.

4. Conclusions

Our conclusions will be limited to three themes: 1) the nature of initial idea exploration in poetry writing; 2) the importance of primary generators (as reflected in first lines) in shaping the emerging poem; and 3) the role of sketching in poetry composition.

For both participants their initial exploration of the writing cues seemed to focus on examining the available cues and rejecting them. This could be a reflection of their attempts to frame and restrict the problem space. Both participants commented on the quantity of cues and the lack of concrete specificity of some cues (i.e., love, a memory, good). Participants were strongly motivated to frame the task in such a way as to make it achievable given the time constraints. While participants were told they could have as much time as they wanted they did not want to spend hours writing.

Participant 2 had a strong single anchor for their writing task and that was their idea of a child’s drawing. This parameter seemed to be successful as they were able to produce a fully developed draft in their writing time. Participant 1 remained more exploratory and associative in their writing and they were relatively unsatisfied by their product throughout the task. Indeed, the participant suggested they had been overly ambitious given the time available when they stated that: ‘The thing is I’m trying to do something too big in too short a space in time.’ From the design literature we know that design problems and solutions are fluid and flexible in nature. In relation to the issue of co-evolution of problem and solution spaces, Dorst and Cross (2001) reported that the designers they studied: ‘...did not treat the design problem as an objective entity’, rather, individual designers took different interpretations and those interpretations themselves changed constantly during the course of the task.’ The associative and exploratory nature of Participant 1’s initial progress in the task is certainly consistent with this conceptualization of problem solving behaviour.

The idea of co-evolution of problem formulation and solution concepts also seems to relate closely to the role of primary generators in design (Darke 1979) and the attendant view that design activity is highly conjectural in nature, whereby experienced designers use solution attempts as ‘experiments’ that assist them in identifying relevant information about the problem. In contrast, novices may get stuck in their attempts to understand the problem before they even begin to start generating solutions (Cross 1990), essentially getting bogged down in the problem space. Consistent with the concept of primary generators in design our pres-
tent results seem to substantiate our previous findings indicating that lines produced early on in the writing process tend to act in a highly generative manner, shaping how the poem is subsequently developed. In other words we suggest that initial lines within the poem function in a way similar to that of primary generators in design. Moreover, such initial lines appear to remain in the poem relatively intact and unrevised. In our previous interview study poets indicated that the first line was crucial in starting the poem (Beatty & Ball 2010). Participant 2 certainly seemed to be consistent with these reports. Initial lines that they produced remained relatively unchanged and were not discarded. The poet seemed to make use of a single primary generator—in this case it was a child’s drawing of a house. In sum, in relation to the role of primary generators and solution-focused processing in poetry composition, there seemed to be substantial evidence supporting the poets’ tendencies to find an early way into the poem via a key objective or concept that paved the way toward subsequent solution exploration.

Finally, a surprising finding was the use of sketching by the second poet. We were intrigued to see a sketch appear completely spontaneously and to be so closely connected to the insight into the writing problem. The direction of the entire exercise was changed as a result of the idea that occurred to the participant while they were sketching for a ‘lack of something else’ to do. Sketching has a long history of investigation within the design literature (Purcell & Gero 1998). We are unaware of any previous assessments of sketching with regard to poetry writing. We are interested to see if sketching allows for thought exploration that is not sufficiently formalized so as to be verbalized aloud. Though this hypothesis seems to be supported in the present study, only through further data collection can we determine if it holds true beyond this single case.

In summary, our findings underline key parallels between design activity and poetry composition: first, the importance of problem framing and exploration; second, the use of primary generators; and third, the use of sketching. The presence of these three design-oriented processes in poetry composition suggests that they may have more to do with general aspects of creative endeavour for producing novel and valued outputs rather than being solely present in the design domain. These areas certainly warrant further research and we are currently building up our sample with the intention of generalizing our conclusions when they are drawn from a larger number of individuals.

Acknowledgements

The work was funded by EU Marie Curie Framework 7 and the National Science and Engineering Research Council of Canada. We thank the poets for their time.
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Design Facilitation as an Emerging Design Skill: A Practical Approach

John Body
ThinkPlace, Canberra, Australia

Nina Terrey
ThinkPlace, Canberra, Australia

Leslie Tergas
ThinkPlace, Washington, United States

Abstract
Design facilitation marks a distinct and emerging role for designers. This paper describes and identifies key skills and attributes for the design facilitator. The paper argues that the role of the designer is being extended from the sole expert designer to a participatory inclusive designer (Saunders 2008). This changing role is being driven by the organisational contexts in which designers work. Increasingly, designers are working in public sector organisations, which are under pressure to respond to both community and stakeholder needs as well as to deliver on government policy. Growing evidence shows that public organisations have adopted design thinking to help design and deliver better public services.

This paper explores the new role for designers to supply design services to meet the increased demand for public organisations to bring multiple voices together to address organisational design challenges and delivery of public services. The designer skills required are in the area of design facilitation, which is the ability to bring diverse groups of people together, address the power imbalances and provide the environment for constructive communication between stakeholders. Design facilitation also acts to ensure breadth of perspectives are present and heard, including the citizen’s perspective.

This paper draws on over 15 years of practical experience by the authors who have worked with government on challenges relating to the design of organisations and the design of public services.

The design thinking approach referred to in this paper was initially developed in the Australian Taxation Office from 2001. It drew heavily on design mentors including Professor Richard Buchanan (at the time Head of the School of Design at Carnegie Mellon University), Darrel Rhea (CEO of Cheskin Added Value), Jim Farris and Lauralee Alben (at the time principals of Alben Faris Design) and Tony Golsby-Smith (Founder of Second Road). In addition, Richard Hames and Marvin Oka provided thought leadership in the area of working with complex systems.
1. Increasing complexity of design applications

1.1 Application of design to more diverse fields

The field of design thinking is being applied to increasingly more diverse and complex areas, for example, the design of social and economic systems. These systems are generally the domain of government. One of the early applications of design to a large social and economic system is the Australian taxation system. (Junginger 2006; Body 2007; Terrey 2008; Terrey 2009). The interest from this work is now spreading across Australian Government agencies as they seek to improve ways in which the community is engaged in the design of services that affect them. There are many other examples internationally of the increased involvement of people in the design of systems and services, including those listed by the UK Design Council (2010) and Service Canada (2010).

1.2 Complex adaptive systems

Designers of social and economic systems are involved in the design of what are termed “complex adaptive systems” (Waldrop 1992). A key characteristic of complex adaptive systems is that they comprise many individual agents who act independently, and this makes these systems inherently hard to predict and hard to reverse. The study of complex adaptive systems suggests ways to work with complexity, rather than against it. A reductionist approach to complex adaptive systems does not work. Breaking systems down into smaller and smaller parts is not an answer for dealing with complexity because it does not allow the interdependencies between the parts to be observed. Complex adaptive systems are more sustainable when they can demonstrate more variety than other systems because this means they have more capacity to adapt and change. Complex adaptive systems, because they cannot be accurately predicted, can give rise to unintended consequences from planned interventions. Unintended consequences are often negative consequences. They can never be eliminated but through a strategic approach, involving multiple perspectives and extrapolation of time, they can be reduced.

2. Increasing requirement to consult and engage

Governments are increasingly expressing a requirement to consult and engage. Many policy implementation issues faced by governments can be traced back to a failure to engage early enough with those affected. Recently, in Australia, the Government faced significant backlash from those affected by the proposed Resource Super Profits Tax. In a letter to shareholders, Rio Tinto’s Chairman, the head of one of Australia’s largest mining companies, stated, “Rio Tinto, like the rest of the mining industry, has grave concerns about the fundamentals of the new tax. It has been developed in a vacuum and is divorced from the day-to-day realities of business” (Du Plessis 2010, p.1). This is but one example of a policy implementation issue arising from a design process divorced from all the necessary considerations.

Governments around the world are learning from these policy implementation issues, and they are becoming increasingly interested in engaging with those affected by change during the design process. Charles Leadbeater (2004, p.53) describes five possible scenarios of increased public engagement with government around the design and delivery of service:

1. Providing people with a more customer-friendly interface with existing services;
2. Giving users more say in navigating their way through services once they have got access to them;
3. Giving users more power to make their own decisions about how to spend money allocated to their education or operation;
4. Involving people as co-designers and co-producers of a service so that they actively participate in its design and provision; and
5. Providing people with platforms, environments, and peer-to-peer support networks to allow them to devise their own solutions collaboratively amongst themselves.

Figure 1. The extent of community involvement

Leadbeater (2004) describes an increasingly ambitious stance towards community engagement that is not without risk. He describes a significant shift in the power of decision making from government towards the community. The risks to embrace in such a stance come from providing greater relevance and greater innovation in designs that affect the community. The risks to mitigate result from a loss of control—loss of control over decision making, loss of control of the design process and loss of control of governance.

To embrace the positive risk and mitigate the negative risk requires considered techniques. Co-designing with the community is not about asking people who don’t know how to design about subjects in which they have no expertise. Equally, co-design should not be about asking people what they want. Co-designing with the community is about bringing a breadth of perspectives to the design challenge to develop a design that is, as Larry Keeley (2010, p.5) of Doblin Group describes, a balance across what is desirable from a customer perspective, what is possible from a technology perspective and what is viable from an organisation perspective.

Figure 2. Desirable, Possible, Viable—Adapted from Keeley (2010).
3. Design facilitation: a new role for designers

Design facilitation is an emerging role brought on by the necessity to facilitate conversations across broad groups to grapple with the questions of desirability, possibility and viability. The answers to these questions do not exist in one mind. The institution’s policy intent, the customer’s needs, the possibilities offered by technology and other fields, and the requirement for an organisation to remain viable over the long term are often competing. The design facilitator has the daunting task to navigate through these perspectives while serving as a catalyst for the identification of new solutions and opportunities to align seemingly disparate interests. The design facilitator drives the engagement of people through the design process; which is fundamentally a constructive and optimistic process of searching for possibilities. The engagement of people becomes increasingly necessary as the complexity of the design challenge increases. The design facilitator must be able to navigate through complexity. This is not about over simplifying issues in a reductionist sense. As Oliver Wendell Holmes [1] is quoted to have said: “I would not give a fig for the simplicity this side of complexity, but I would give my life for the simplicity on the other side of complexity.”

To strive for a solution on “the other side of complexity”, the design facilitator engages with all those people who can shed light on the complexity and how that might extrapolate over time and place. The design facilitator is the broker of an extended conversation that seeks a design respecting complexity while being as simple as it can be.

4. The role of the design facilitator

4.1 The design facilitator’s role is to:

- Obtain a clear, shared understanding of the intent of the change with those who will take a part in designing the change. This seemingly straightforward activity is a critical determinant of the success of the design project;
- Assemble the right people to address the design challenge, and align them towards a common and constructive vision. This includes:
  - people who hold the intent of the change;
  - users and others affected by the change;
  - specialist disciplines such as policy makers, legislative drafters, HR specialists, IT specialists and operational specialists who will deliver the outcome; and
  - design specialists such as user researchers and information designers who bring design expertise to the challenge;
- Determine the best process to engage these people. A mix of techniques is available, and the design facilitator must work through a series of considerations to choose the right mix of techniques for the situation;
- Manage specific design events, for example, a large workshop, an interview, a focus group or a small design team;
- Maintain focus on design thinking as a means to construct new futures, as opposed to merely analytical, problem-identification thinking. This includes the ability to deploy generative techniques to get stakeholders to create innovative options and concepts of what could be, and this often needs to be achieved quickly and iteratively;
- Ensure that the output of a design event is sufficiently robust to progress the design, and that it has the ability to combine with other design outputs to get closer to addressing the design challenge.

4.2 Contrasting design facilitation with generalist facilitation

A design facilitator is different from a generalist facilitator. Although a design facilitator has some of the skills of the generalist facilitator, there is a different focus directed at designing and making. A design facilitator takes a group through a collaborative process of design thinking to
create a picture of a future state that doesn’t yet exist and one which is better from the perspective of multiple stakeholders and points of view.

A general facilitated session is described by Michael Wilkinson (2004, p.23) as “A highly structured meeting in which the meeting leader (the facilitator) guides the participants through a series of predefined steps to arrive at a result that is created, understood and accepted by all participants.”

Whilst a facilitated design event may contain some of these features, it may contrast quite significantly. It might not be highly structured and it might not follow a series of predefined steps. The objective is not a result that is created, understood and accepted by all participants, although that may be a by-product of the process. The objective of a design event is to create and develop a design that works for the sponsor, the user and those who have to deliver it.

Design facilitators guide groups through a design thinking approach that is heavily influenced by observation. As Peter Senge et al. (2005, p.84) describes “You observe and observe and let this experience well up into something appropriate. In a sense there is no decision making. What to do just becomes obvious. You can’t rush it.” This becomes the basis of Theory U described further by Senge et al. (2005, p.88) as Observing, Presencing and Realizing.

Design facilitators have a driving force to produce a design. They have a heavy focus on making something in the design process. They are very interested in how one event connects with other activities in the design process. They are interested in the people dynamics but only in as far as they can be used to progress the design.

### 4.3 Selecting design facilitators

Recruiting design facilitators is challenging. It is not an established profession with which people identify. The skill sets can be hard to uncover in a standard selection process. The attributes that make a successful design facilitator include:

- **A strategic perspective**: The design facilitator can work beyond today’s current operations and imagine what could be two years or five years into the future. The design facilitator can project beyond the immediate teams involved, work with very diverse groups of people, work with complexity and embrace the ambiguity of these diverse views;

- **A human perspective**: The design facilitator must have credibility with a range of groups of people. Strong emotional intelligence is needed to understand the nuances within the groups of people involved in the design. The ability to work with the most senior people in an organisation and at the same time work with the most disadvantaged client groups requires a combination of confidence and humility in the design facilitator; and

- **A design perspective**: The design facilitator must be able to design. Design facilitators must be able to explore, to observe, to conceive an idea with a group and then have a strong disposition to develop the idea to make and enhance the design. They must be prepared to prototype, fail and then improve, and they must not be complacent. “Prototyping is a way of sharing mental models. If you are prepared to prototype then it means you are prepared to fail” [2].

### 4.4 Personal qualities of the design facilitator

The right attitude will be valued as much as the right skills. The design facilitator must be inherently curious with a strong sense of inquiry. Their perspective must be broad with lateral or peripheral vision to look for opportunities that may not suggest themselves. At the same time, the design facilitator must recognise what can’t be changed and work within constraints, although they will often test these constraints to ensure they are genuine. To encourage divergent thinking, the design facilitator will suspend judgement. Design facilitators will have
a strong desire to help others and get satisfaction from seeing a group reach a breakthrough. Although the design facilitator encourages lateral thinking and diverse opinions, they have a strong sense of purpose and can bring conversations back to addressing the design issue at hand. At the right time the design facilitator will drive for convergence. The design facilitator has a well developed ability to visualise and represent ideas back to the group. The above qualities suggest paradox. The design facilitator is very comfortable with complexity and ambiguity.

5. Key considerations for a design facilitator

5.1 Divergence and convergence

A key attribute of a design facilitator is to understand when a group needs to diverge and when a group needs to converge. Different people have different appetites to diverge and converge, and the design facilitator needs to be able to read the group and the design challenge to determine what is required. Divergence for an indefinite period is not good design because nothing gets produced from the process. Convergence too early will result in a poorly formed design that does not accommodate the complexity of the situation, and it is therefore likely to be too simplistic. A design that is the result of rapid convergence is unlikely to stand the test of going into production and is likely to result in implementation failure. Thus, the design facilitator must have the skills to balance group divergence and convergence. Design changes in complex systems are much less expensive to make early in the project lifecycle rather than later when significant rework needs to be done.

5.2 Exploration, innovation and evaluation

Another way to think about divergence and convergence is in the three stages shown below. Many design companies have some derivative of these three stages:

- **Explore**: to understand insights into the community;
- **Innovate**: to generate possible solutions to meet user needs while achieving the policy intent efficiently;
- **Evaluate**: to select which services will proceed to implementation.

Exploring is characterised by techniques to understand the user context. Exploring involves a mix of qualitative methods such as ethnographic research and quantitative methods such as surveys and operational information. Customer insight is “A deep truth about the customer based on their behaviour, experiences, beliefs, needs or desires, which is relevant to the task or issue, and rings bells with the target group. The important element about this truth is that it is powerful enough to bring about behavioural change and can be used to inform decision-making by policy officials or those involved in designing or delivering services” (Customer Insight 2006, p.9).

Innovating is characterised by generating design options and better design questions to be addressed in subsequent iterations. This phase depends on ideation and creative thinking to be effective. Customers are still involved by participating in prototyping. Prototyping is important for this stage because it allows designers to make mental models visible.

Evaluation is characterised by techniques to select the ideas to take forward. This includes evaluation before the service is launched, as well as after. Critical to this stage are tools and techniques to measure the effectiveness of the service in terms of desirability, possibility and viability. Evaluation criteria are progressively refined as each iteration moves closer towards a refined implementation ready prototype.

The following diagram shows the iterative process that the design facilitator navigates to diverge and converge.
5.3 Specific techniques for different stages

The design facilitator has at their disposal a range of techniques that can be used at different stages of the design process. Some techniques are appropriate for all stages, while others are best suited for a particular stage.

Exploratory techniques can include surveys and simulations to observe the interactions and relationships between the service and the user. Qualitative data can be part of the exploration phase. Focus groups can also shed light on user needs. Observing users by employing ethnographic techniques is a very effective approach. Social media is increasingly being used to connect with the user constituency.

Innovation techniques will often involve some form of workshop. This may be a formal workshop or a less formal design team that forms around a design challenge.

The techniques most commonly found in practice are evaluative techniques. Perhaps the most overused and least effective evaluative technique is a consultation process conducted via email that seeks comments on a near final product. Whilst easy to conduct, its value is mainly in ticking the box that a consultation process has been undertaken. Other evaluative techniques of more value are the use of simulations in the user’s context or a simulation laboratory to observe the interaction between a service and the user. Focus groups are a way of obtaining evaluation information about a product or service. Surveys and other data sources can also provide evaluative information.

The design facilitator determines the appropriate technique to gather user insights. Several of these techniques involve getting people together with a view to either exploring with them, innovating with them or evaluating with them. For the application of each technique, the design facilitator becomes the coordinator of that particular design event.
5.4 Choosing the type of design event

There are a number of different design events, each with its own form:
- Strategy design workshops seek to uncover the direction an organisation should take;
- Design planning workshops aim to develop the agenda of design projects that will deliver on the strategic direction;
- Product or service design workshops uncover the experience of specific groups of users and design improvements to that experience; and
- Process design workshops design aspects of organisational capability to deliver the new product or service. They aim to design the staff experience associated with the change.

5.5 Choosing the participants

There are four perspectives that need to come together during the design process. On occasions these four perspectives will be present in the one event. On other occasions the four perspectives may be involved separately. The four perspectives are:
- The holder of the intent. This perspective is the champion of the change. Without this perspective being strongly emphasised, the chances of success are significantly reduced;
- User. The user perspective, whilst a central consideration, is often not brought into the conversation. In some design exercises, there is a reluctance to involve the very people that are most affected by the change. An assumption is often made that the user perspective is known by the other people involved. Successful design exercises have authentic involvement from the user community;
- Specialist. There are specialist disciplines involved in developing design solutions. These include people with expertise in the law, in information technology, in learning and development of staff, and in the operational systems and processes of the organisation. These specialist disciplines are most effective when they can be brought together in multidisciplinary teams to solve design challenges together; and
- Designer. The design facilitator role is a required discipline because this function balances and coordinates all perspectives. Others in the design discipline include those with specialisations in conducting user research or in visualisation of the progressive design.

5.6 Choosing the space

The logistics of an event can appear to be too trivial to spend time on. However, the logistics can make or break an event. A good space will have good natural light, space to move around and plenty of horizontal or vertical surfaces on which to develop or display emerging thinking.

5.7 Expect the unpredictable

The world is a messy place and things rarely go according to plan. Sun Tzu in The Art of War (2009) says that a strategy is correct until the first arrow is fired. Therefore, all the best laid plans of facilitation are good until reality strikes. The best designed workshop or series of workshops must accommodate changes that will inevitably occur when designing within the dynamics of a complex adaptive system, which by definition has many interdependent parts making independent decisions. Therefore, the system can change unpredictably. The role of the design facilitator is not suited to someone who wants high levels of predictability and order. The design facilitator needs skills not only in facilitation but also in leadership, strategy and change management that will allow the design facilitator to navigate when reality strikes.
Conclusion

With the increasing application of design to complex adaptive systems, such as social and economic systems, an important design role is emerging—that of design facilitator. Complex adaptive systems are made of the collective actions of many actors or agents who make individual decisions that have an interdependent and collective impact.

The design facilitator works with the different groups that make up the system with a view to developing designs that are desirable for the user, possible technologically, viable for the organisation and in the case of large community systems, meet the policy intent.

A complex web of perspectives must be navigated by the design facilitator who must have some rare qualities—a strategic / temporal perspective, a human / empathetic perspective and a design / making perspective.

Design facilitators bring these skills to bear and must address confusingly conceptual and mundanely practical considerations as they carry out the role that is being increasingly demanded by those who manage social and economic systems.

Acknowledgements

The authors have developed the ideas in this paper by working on some of the largest social and economic systems in Australia and New Zealand, and they acknowledge the efforts by these organisations to improve service delivery for people in the community by adopting design approaches.

Notes

1. This quotation is attributed to Oliver Wendell Holmes (1809-1894) an American physician, professor, lecturer and author. It is cited in a number of blogs and wikis, but cannot be verified in scholarly dictionaries of quotations.

2. This quotation came from Larry Leifer of Stanford’s dSchool in a conversation with John Body in January 2010.
References


Designing Participation: Reconsidering agile ridesharing with evolutionary distributed design thinking

Margot Brereton
Queensland University of Technology, Brisbane, Australia

Sunil Ghelawat
Queensland University of Technology, Brisbane, Australia

Abstract
This paper explores design thinking from the perspective of designing new forms of interaction to engage people in community change initiatives. A case study of an agile ridesharing system is presented. We describe the fundamental premise of the design approach taken—deploying simple interactive prototypes for use by communities in order to test the design hypothesis, evolve the design in use and grow the community of participants. Real-time use data and feedback from participants influences our understanding of the design approach and feeds into the gradual evolution of the prototype while it continues to be used. We then reflect upon this form of evolutionary distributed design thinking. In contrast to the conventional IT wisdom of building systems to automate ride matching and fare calculation using structured forms, our initial phase of design revealed a preference for informal messaging, negotiation and caution in the sharing of specific location information.

Keywords
Agile ridesharing, dynamic ridesharing, designing participation, participatory design, HCI, technology probes, prototyping, community informatics, design thinking, iteration, agile software development.

1. Introduction to designing participation problems

For classes of problems and opportunities that manifest themselves at the level of community, one of the major challenges is to design and grow participation by the community itself. Growing participation is a key challenge for the viability of green initiatives, local community initiatives and virtual community initiatives. This paper begins with the premise that participation in community initiatives is a matter for design. That is, given well-conceived design interventions one can begin to grow community participation.

We have examined the problem of the high usage of single occupancy vehicles from the outer suburbs leading to congestion and pollution (Brereton et al. 2009) which has resulted in exploring the possibility of using mobile social software to overcome logistic and coordination problems in arranging to share rides. Ridesharing is a classic problem in designing participation and one for which we aim to find a good design solution.

Problems of designing participation have distinct characteristics. First, and by definition, the aim is to grow participation by a sufficient number of people in a scheme, because society will benefit as a whole the more that people participate. Second a common problem to be addressed is Hardin’s (1968) tragedy of the commons, the paradox of increased personal benefit (for example individual car use) resulting in decreased social well-being (congestion, environmental...
damage). The tragedy is that when a few individuals sacrifice their personal benefit and take public transport or share rides it does not have a significant impact on the problem, rather it is necessary to get many people to act at once, which is also the conundrum in dealing with climate change. This problem results in the third characteristic, the chasm of critical mass that is often difficult to cross.

How then does one approach such a designing participation problem? It appears to call for the most creative divergent thinking processes in order to explore all options, but then efficacy of solutions depends upon them fitting into the nitty-gritty of people's everyday lives and technologies. This latter requirement suggests an ethnographic approach to understand the nitty-gritty of what people do in their everyday lives. A third plausible approach is a participatory or co-design approach in which designers work with stakeholders in order to identify promising approaches and develop designs.

This paper discusses briefly the challenges that this design context presents to existing methods in ethnography, participatory design and IT design. The case study is then introduced to illustrate a designing participation method that draws upon these design methods and extends them to suit this context.

1.1 Challenges for Ethnography

Ethnography, a social science research approach to studying people and cultures has been advocated for its ability to uncover detailed insights about human activity (Hughes 1997) and for its ability to reveal hidden assumptions embedded in the conventional problem–solution design framework (Anderson 1994).

Ethnography draws upon observation, interviews, questionnaires etc to understand the particulars of daily life. Within ethnography, an ethnomethodological analytic stance seeks to uncover the locally organized character of action and interaction by studying 'what people observably say and do in situ' (Hughes 1997).

The challenge with respect to design is to incorporate ethnographic findings effectively into the design process. Quick and dirty or broad overview methods run the risk of observing only superficial aspects of behaviour (Crabtree et al. 2009). Detailed studies may deliver compelling insights, but the textual accounts of an extended ethnographic study still need to be absorbed and translated in some way by designers. Buur and Sitorus (2007) found that the format of video data as an ethnographic provocation was a more effective means of informing and ultimately convincing design engineers of user needs.

Drawn from the analytic traditions of anthropology, a detailed ethnographic analysis of a culture done for the purpose of describing that culture is in essence part of a different process that is separate from design. Separated in this way it can serve as but one lens or backdrop to inform design. By contrast, design with its mandate to intervene and change, benefits from understanding ethnographic and cultural implications of design moves in the midst of the design process. Design, commonly understood as a process of reflection in action (Schön 1990) wherein the designer reframes the problem as they explore it, makes moves and sees new implications, invites us to find ways to incorporate ethnographic data into the design process to enhance this process of design moving and seeing.

In this paper we explore how to interleave ethnographic work with design, so that ethnographic data can inform and inspire design prototypes, and design prototypes inserted into daily living environments can become part of the landscape of technologies that people use in the course of daily living.
The work builds on common practices in the Web 2.0 development community and on the notion of technology probes (Hutchinson et al. 2003), although in Hutchinson et al. original formulation, these were not designed for functional use.

1.2 Challenges for Participatory Design

Participatory design has as its fundamental tenet that those people affected by a design outcome ought to be included in the process of design. It owes its roots to industrial democracy projects in the 1970’s that sought to involve workers, as users of technology, in the design of new computerized technologies that they were using in their workplace (Greenbaum & Kyng 1992).

Participatory design in its early formulations was characterized by direct and lengthy interaction between designers and stakeholders, wherein stakeholders had a broad scope of participation and a degree of control over design decisions. In designing participation contexts, stakeholders are often many and varied and their motivations and contexts for using and participating in design are broad. The landscape of technologies in which design interventions operate is far more varied, networked and individualised (Brereton & Buur 2008). Moreover the design interventions serve to facilitate interaction between people, rather to engage people as users of a system. So, rather than planning the all-encompassing systems development project, where the focus inevitably shifts to the system itself, there is a call for methods that understand how to design to support people in their world. This view aligns with that of Suchman (2002, p.92) who argued that systems development should be seen as an “entry into the networks of relations including both contests and alliances that make technical systems possible”. Brereton and Buur (2008) have argued that participatory design needs to move towards iterative, experimental design explorations to provide necessary understanding of today’s complex contexts and practices.

2. Designing Participation by Designing in Use

The design approach employed in the case is an iterative approach drawn from the RAID (Reflective Agile Iterative Development) approach commonly found in social software development (Heyer & Brereton 2008; 2010). The RAID approach:

- Understands community practices through ethnographic fieldwork;
- Explores key design hypotheses by designing and deploying working investigatory prototypes for use by a segment of the community;
- Gathers fragments of ethnographic data from the prototype in use;
- Builds communities of use as the prototype is refined;
- Understands the factors that persuade or dissuade others from joining.

Figure 1. Designing Participation Method
Iteratively design a social technology, grow a community of users and refine the design within the context of policies and incentives.
The approach then uses the simplest functioning technology probes to explore design hypotheses rather than beginning with fully featured systems. Prototypes are deployed over an extended period, to understand how people use them in their daily lives to augment their natural activities. Prototypes have a simple functionality that aims to provide benefit to those who use them.

A traditional prototyping approach seeks feedback from “users”, who act as design informants in order to help designers design a product, often in focus groups or laboratory settings. In contrast an embedded prototyping approach aims for authentic use by people in their own contexts.

We describe a case study to illustrate how this process takes place and then discuss this kind of design thinking. We contrast this design approach with the standard IT system development approach wherein requirements are established up front and then major aspects of systems are developed followed by user testing.

3. Case study: Agile ridesharing with Mobile Social Software

3.1 Introduction to the Ridesharing Problem

Uptake of traditional carpooling schemes has been limited by the inflexibility of having to schedule ahead of time, the coordination problem of finding suitable partners and attachment to the privacy of the individual car (Galizzi 2004). In addition peoples’ daily plans vary due to flexible work hours, sickness, errands or meetings in different parts of town. An examination of dynamic ridesharing in Los Angeles, (Hall & Querishi 1994) found: that the greatest barrier to ridesharing for people with similar trip patterns is logistics, the ability to discover and coordinate with each other.

It appears that mobile social software could significantly ease these logistical problems and provide improved convenience and usability of ridesharing by allowing people to easily contact potential ride-sharers in their extended ride-share social network in real time through mobile phones. There is greater potential for ridesharing IF it can be spontaneous, easy to organise, if probability of finding a ride partner is high, if potential ride partners are known to be of good character, and if it is possible to get back home either through another ad hoc ride or through public transport. It is conceivable that if agile ridesharing was adopted on a massive scale, that one could ride in with one person and ride home with another waiting only a few minutes for a ride. On-demand shared taxi services could fill in where private transport was unavailable.

3.2 Design hypotheses for ridesharing systems

New mobile technology supported methods of organizing ridesharing (e.g., Gishigo, Avego for I-phone, Piggyback for Android, Zimride with Facebook) have begun to emerge, each with different approaches.

One system, Alpha, is based upon the philosophy that each unused seat in a car is a seat that can be sold, in the manner of a public transport system. The driver offers seats for sale along a route that they define, and adheres to the precept to not be even a minute late. Alpha’s design hypothesis is that people will sell and pay for rides, want punctual service and want an effective ride matching service.

A second system, Beta, offers rideshare options, either through the social networking software of Facebook or through their own system. Beta is built around a social networking philosophy with a hypothesis that social networks can be mobilized to help build the critical mass of people needed to get sufficient ride matches.
An assumption of both systems is that a significant role of the technology support is to provide automatic ride matching by matching rider to driver based upon origin, destination and travel times. From an information systems perspective, the power of information technology is to provide this kind of automatic data matching, so that a system can efficiently bring together people. However, as acknowledged by all rideshare system providers, aspects of privacy, safety, incentives, personal preferences and actively building a ridesharing community all need to be addressed.

In questioning the conventional problem-solution framework, our prototyping approach has set out to explore how people might want to communicate about ridesharing, while trying to make as few assumptions as possible about ways in which matching, community building, privacy and cost sharing might be addressed?

It is common to find that people do not respond to designs in ways that were predicted. Therefore, rather than undertake user studies to inform design requirements and then design a fully fledged system, we have chosen to implement a few basic features to test user response in the moment of travel. Thus we have undertaken an agile and iterative approach to exploring the design space in partnership with early users.

3.3 Exploring design hypotheses with a basic interactive prototype

A simple rideshare prototype was designed to operate using a common web browser, so that it could be accessed using all web-enabled phones, laptops and desktops. The prototype had a very limited functionality in that it only allowed people to send ride messages and information about seeking and offering rides. It was possible to either enter informal ride messages or to simply state the factual details about the ride in terms of origin, destination, journey start time and whether seeking or offering a ride. This strategy was taken in order to learn what it was like to define rides by entering ride information into formal fields and to allow expression of other information that did not fit into these formal fields. Figure 1 shows an example of the interface.

One limitation of the early prototype was that there was no prompt via email or text message when a ride was posted, so people had to keep looking at the system to see if new rides or responses were posted.

The prototype was used by a research group, who do not ordinarily share rides, and a few of their friends, 8 people in all. After seven weeks of usage, the ride information and messages were examined and the group convened to discuss their experience of using the prototype.
Figure 1a. Rideshare prototype showing the ride entry screen
The implemented prototype has been in use for approximately 12 weeks by 8 people who have made 71 posts to offer or share rides. There were 24 responses posted, and three shared trips resulted.
3.4 Findings from the design prototype in use

Formal vs informal information

Of the 71 posts,
14 contained only information in the formal fields
41 contained only an informal message
16 contained both formal and informal information.

The first 14 posts contained information in the formal fields only. In the beginning month of May people left the text message blank and tended to fill in a full address in the formal fields with street number and name. The behaviour could be characterised as learning how the prototype works and filling in what one is supposed to. However use of the prototype took off in June once people began to leave ride messages. The prototype implementation in fact privileged formal over informal information in that if the formal fields were filled in, the informal message was not available without further clicks. Once people realised this they began to leave only informal messages so that the informal message would show on the first ride screen. Informal information was very easy to post, as simple as entering a text message, and much less cumbersome than entering specific information in each field. As a result informal messages became the very dominant form of ride posting.

Informal messaging

Some example messages typical of the informal messages posted are shown in Table 1.
<table>
<thead>
<tr>
<th>Message characteristics</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Meeting Offer</td>
<td>Roamer: walk -Margaret street brisbane to Queen street for lunch</td>
</tr>
<tr>
<td>B Flexibility Constraints Walking/Meeting</td>
<td>Bio-Guy: &quot;Morning walk in—very flexible with start time. First meeting at 10am.&quot;</td>
</tr>
<tr>
<td>C Constraints Meeting Offer</td>
<td>Maidinmoggill: &quot;QUT Gp to kenmore. 4 hr parking tyranny. I'll be leaving at 11:30am for kenmore. Work in coffee shop til pic kids up in kenmore at 3. Then home to moggill. Anyone need meeting in coffee shop or ride to Kenmore?&quot;</td>
</tr>
<tr>
<td>D Flexibility Constraints Offer</td>
<td>Maidinmoggill: &quot;Leaving QUT Gardens Point for Kenmore and am parked under the freeway. I'm ready to go at any time, but need to get to Kenmore before 2:30pm. Does anyone need a ride?&quot;</td>
</tr>
<tr>
<td>E Open/Meeting Bio-Guy: &quot;Afternoon walk home&quot;</td>
<td></td>
</tr>
<tr>
<td>F Meeting Directed Flexible</td>
<td>Maidinmoggill: &quot;Child drop off at Kenmore at 8:50am Friday then to gp to meet Fiona at 9:30am. Or Fiona, I could meet you in chapel hill or kenmore?&quot;</td>
</tr>
<tr>
<td>G Request</td>
<td>Roamer: &quot;going home at toowong from qut gp. anyone sharing ride with me&quot;</td>
</tr>
<tr>
<td>H Request</td>
<td>Fredhead: &quot;Is anyone going to chapel hill from qut soonish&quot;</td>
</tr>
<tr>
<td>I Request</td>
<td>Hadi: &quot;Gordon park to city 8:30 am&quot;</td>
</tr>
<tr>
<td>J Meeting Staying home Maidinmoggill: &quot;Staying home on thursday. my contribution to congestion reduction and planet. Happy to meet in Moggill&quot;</td>
<td></td>
</tr>
<tr>
<td>K Ferry</td>
<td>Roamer: &quot;Toowong to QUT Margaret st by ferry ride. anyone interested.&quot;</td>
</tr>
<tr>
<td>L Bus</td>
<td>Roamer: &quot;qut to Eight miles plain going by bus at 1pm&quot;</td>
</tr>
<tr>
<td>M Mixed–mode travel</td>
<td>Maidinmoggill: &quot;Taking 444 bus to kenmore then drive to Moggill. Anyone need a ride to Moggill?&quot;</td>
</tr>
</tbody>
</table>

Table 1. Examples of informal messages sent using the ridesharing prototype

Rides or meetings

Several participants used messages to offer meetings as well as rides. Two participants walked to campus and did not have rides to offer, but liked to walk with someone and offered the opportunity to share a walk. (Messages A, B) Another offered the opportunity to meet at their home (although home address was not specified) or at a nearby coffee shop in the vicinity, due to the need to move the car from Campus parking before the meter expired. (Message C)

People expressed interest in sharing rides on all forms of transport, both public and private, which reflected their desire to meet as well as to ride. Posts invited shared trips by walking, bus, ferry and car.

Flexibility and constraints

Driver participants ride times were often constrained by the type of parking (early bird or metered) that they were using or constraints of needing to do school pickups, but otherwise they had some flexibility. (Message C, D) Others were very flexible and would adjust their travel time in order to share a walk or trip with others. Sometimes a meeting place was very flexible.

(Message F) The types of constraints were such that they would be cumbersome or could not be completely expressed in the formal fields. Moreover messages gave the opportunity to share some of the personal context of the ride offer or request (Message C, D, E, F).
Specificity

Although early ride posts were quite specific about places, this was attributed to people learning how to use the prototype. After the first 20 messages, it was rare to see any address given. People often only gave as much specificity as they felt was needed to open a negotiation about sharing. People either (a) knew that others knew where they lived, so didn’t need to give specific information, (b) were happy to make a small detour in order to share such that suburb level specificity was sufficient, or (c) were reluctant to give specific information in the general post, but happy to share in follow up private messaging during ride negotiation.

Offers and Requests

Messaging allowed people the ability to make an offer or request (Message G, H, I) rather than simply entering information into formal fields. By writing "Would anyone like a ride? Or afternoon walk home?" participants are able to make an offer more heartfelt and personal than simply entering travel information.

3.5 Barriers to adoption and prototype use over time

At first it was interesting to post messages and to see what other people were doing, but as the prototype had limited utility (since it didn’t send messages out beyond the website through email, text messages or social media) and after the group discussion on June 26th, posting of messages reduced. However the prototype remained operational for use.

In designing participation problems, where technology is being designed to support communication, prior work (Redhead et al. 2009, Brereton 2009, Heyer 2008) has found that lack of participation may be due to: difficulty using the interface; lack of function in the technology; lack of fit with personally owned technology; lack of interest or incentive to participate; lack of fit with lifestyle and associates, or due to an unimaginative interaction paradigm. It is important but difficult to establish causality without interviewing participants. The temptation is to keep modifying the interface in order to address interface problems, but it is always worth establishing the priority of interventions and understanding whether the key design proposition is viable.

At the group discussion barriers to adoption were investigated, and in particular, participants views were sought about how to address privacy and targeting of messages.

Some people found aspects of the interface confusing which lessened their participation. One participant wasn’t sure how to seek a ride, because they interpreted the “rides” button to mean click here if you are offering a ride. (See Figure 3). This difficulty in using the system was determined through interview.
Figure 3. Even a simple interface can be misinterpreted. One participant wasn’t sure how to seek a ride, because they interpreted the “rides” button to mean click here if you are offering a ride.

3.6 Design hypotheses and evolution of the prototype

Although a formal ride matching approach may have a role in a ridesharing system with a large number of participants, the initial prototype use established that informal messaging was a preferred mode of interaction. It is possible that informal messaging suits this stage of the prototype development and this stage of people’s experience in ridesharing, but that different preferred interaction styles may evolve as participation and the rideshare system grows or as people develop more experience in ridesharing and regular cohorts of sharers. The designing participation approach does support discovery and evolution of these interaction styles and it is important to recognise that different styles may suit different people at different times.

One of the most important roles for informal ride messaging may be that communicating about travel and meeting is not only useful for facilitating matches. It is also useful for extending friendship, sharing ones whereabouts with ones friends, and learning friends travel habits, even if rides are not shared. And this may eventually lead to travel sharing opportunities. As such, it may play a critical role in growing participation, because one can be a legitimate peripheral participant (Lave & Wenger 1991), even if one has no ride to share. By narrowing the problem-solution framing too quickly to the problem of making ride matches, rather than exploring the design space around shared travel communication, some possibilities for growing participation in travel sharing may in fact be overlooked. For example other studies have found that people may go out of their way for friends (Wessels 2010) and prefer not to charge them (Allen 2009) etc. Thus it is important to understand how people may wish to rideshare rather than to focus the design of a system around what technology is able to do well (i.e., automatically make ride matches and determine charges). An advantage of taking an iterative rough IT prototype approach is that a system can be grown around peoples expressed habits and preferences.

Iteration is widely recognised as an integral part of most design processes. It takes place at many levels of granularity. Schön’s (1990) reflective conversation with materials involved rapid cycles of iteration in the development of a design sketch and the better understanding of the design requirements, while Belotti et al. (2002) undertook iterative rounds of fieldwork in the evolutionary development of an email and information management system. Iterative
approaches to software engineering, such as agile methods (Beck 2001), are well established. The contribution of this approach is a case study of an evolving deployment of software within a growing community of participants with real time feedback of data from participants.

Our principal design hypothesis has become that ridesharing is best supported by a messaging system that supports sharing information among friends, neighbours and colleagues and about meeting and travel. It is important to recognise that this is not a scientifically proven hypothesis, but rather a hypothesis developed through early grounded exploration that is a promising lead on how to proceed, and no more.

Following an examination of prototype use and a discussion with participants, which included two people who did not use the prototype at all, priorities for the next evolution of the intervention were determined to be:

1. Extending the prototype so that rides were posted in real time via email and text messaging.
2. Allowing participants to control who could see their posts, rather than posting to everyone. The prototype had taken a starting strategy of rides being posted to everyone, because (a) the prototype was to be used within a group of people who knew each other and (b) all members knew that the information was public. However it was understood that this strategy would only work while the number of participants was small, in trialling the very early versions of the prototype.

Figure 4 below shows a modified interface that allows people to see, for each ride posted, exactly who can see the ride.

![Figure 4. A modified interface that allows people to choose who sees their ride posts](image-url)
The Designing Participation approach draws heavily upon the approach of RAID, reflective agile iterative development (Heyer & Brereton 2008, 2010; Heyer 2007), which is a collection of practices common in the development of social software systems that has been documented by Heyer and Brereton, although the authors make no claim on their invention.

RAID consists of three stages: design use and reflection, which revolve around a continuously usable exploratory prototype. In RAID a change log is used to monitor the evolving design and a question log is kept to inform data analysis and exploration. By paying attention to the evolving design and use the RAID approach helps designers to foresee and manage particular challenges in evolutionary prototypes such as those listed in Table 2.

<table>
<thead>
<tr>
<th>Deluge:</th>
<th>A rapid influx of usage exposing scalability issues.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accretion:</td>
<td>Developing ways to help participants manage contacts, artifacts that they develop in a system over time.</td>
</tr>
<tr>
<td>Drought:</td>
<td>Identifying and addressing problems of underuse through redesign and re-targetting the prototype.</td>
</tr>
<tr>
<td>Wearing in:</td>
<td>Improving usability by examining common usage patterns and helping to refine them.</td>
</tr>
<tr>
<td>Missteps:</td>
<td>Detecting and logging user missteps and revising the interaction design to reduce occurrences.</td>
</tr>
<tr>
<td>Discovery:</td>
<td>Learning from and capitalizing on unanticipated uses leading to new design features.</td>
</tr>
</tbody>
</table>

Table 2. Challenges of Managing Evolutionary Prototypes (Heyer & Brereton 2008)

The particular point of departure for the Designing Participation approach is that it aims to grow communities of use and to evolve the prototype hand in hand with growth of the community of use and to understand barriers to participation. However, it still holds at its core the RAID method.

4. Reflections on the Designing Participation Approach

In this discussion, we focus in particular on the way in which the RAID and Designing Participation approaches support design thinking.

One of the acknowledged challenges of design is to understand and imagine future use of a design that does not yet exist. Prototyping has long been used in order to make concrete aspects of a new design in order to facilitate imagining and further detailing of the design concept. The RAID and Designing Participation approaches use early, simple and yet functioning IT prototypes in real use contexts in order to understand aspects of use of a design intervention. Fragments of ethnographic data are gathered by the prototype and coupled with interviews and other data from the field. This combination of data can inform the design hypothesis. There are always aspects that are not observable, but embedded prototyping approaches take us much closer toward understanding designs in use and allow that use to inform design. One can argue that this is a natural extension of Schön’s depiction of design as seeing moving and seeing again into the distributed and mobile space, where the designer is able to see, move and see again, with the benefit of suggestions and concrete actions coming in real-time from the field in which the design is deployed. Thus we can argue this form of designing as a kind of evolutionary, distributed design thinking.

In contrast to standard user-centred design approaches that utilise approximations such as scenarios and personas (Cooper 1999), or that test prototypes in focus groups and laboratories,
removed from the context of everyday living, the RAID and Designing Participation approaches are able to gather fragments of data from the moment of use and to interview people about actual use experiences of interactive prototypes. Further, participants are able to interact with each other through the prototypes. The data fragments from the prototype use act as prompts that support recollection during interviewing.

It is important to clarify that data gathered through the prototype and through ethnographic work is used to inform and to inspire design evolution, rather than to make scientific claims about design efficacy. However, approaches to design that base their design evolution in data gathered through interactive prototypes might be considered to offer one form of a scientific approach.

Although social media have adopted these sorts of evolutionary design and development approaches, we believe that they have benefits in development of many IT systems. It is common for governments to specify functional requirements and to put out tenders for large IT systems such as ridesharing systems without having a good understanding of what exactly the design requirements should be and whether the resulting system will be successful in supporting shifts in community travel practices. In large IT systems design, the power of information and function is often prioritised over understanding the context in which people might share, discuss, negotiate and reveal that information. As a result the system requirements and design develop a life of their own independent of community needs (Shapiro 2006).

In developing a simple prototype that works across a range of technologies and platforms, the iterative prototyping process prioritises context of use and wide access over detailed development of a system to work on one platform. This has potential advantages and disadvantages. A clear disadvantage is that it is harder to develop a sophisticated and fully featured concept than when working on a single platform. In addition, the constraints of the existing landscape of technologies means that some kinds of revolutionary design are less likely. However, single platform views have less opportunity to embrace a wide range of users and to deal with the messiness of life and technological infrastructures that ordinary people have to deal with (Bell & Dourish 2006).

One disadvantage of evolutionary prototypes is that once deployed, and the more that the design evolves and is specified, the less flexibility the designer has to make large changes. There is a balance to be struck between providing utility in the prototype, yet for the design being sufficiently ‘open’, to be led by participants and the exploratory process (Heyer & Brereton 2010).

Having prototypes deployed over a period of time has particular advantages. First, people are able to use the prototype systems when it suits them, rather than in a trial devised to suit the timeframe of the research inquiry. When a prototype is continuously available and usable, participants can build trust and come to rely on it. Second, long term deployment reveals the variety of ways in which people bridge existing practices with use of the new system. Third, different people in different contexts get to hear about the prototype system over time and so we come to understand potential contexts, possibilities and communities of which we would not have been aware had we deployed for a short timeframe. Fourth and perhaps most insightful are aspects of non-use which are followed up by ethnographic study. When prototypes are tested in laboratories one does not have access to aspects of non-use and indifference that are demonstrated over time.
5. Concluding remarks

We have described a design approach that involves deploying simple interactive prototypes for use by communities in order to test the design hypothesis and to evolve the design in use. This paper has focussed only on the first stage of such a process, although other work in community digital noticeboards (Redhead & Brereton 2008, 2009; Redhead et al. 2009; Brereton 2009) and social mobile software (Heyer 2008) describes designs that have evolved over months and years with communities growing around them. A principal advantage of the approach, and the one that we aim to illustrate in this paper, is that it generates early data about design requirements, the design space and design possibilities in a grounded way through gathering fragments of data from use of the prototype in the field. The approach allows designers to question conventional problem-solution framings through prototypes that gather data. Through taking this approach a novel ridesharing prototype has been conceived that emphasises meeting and informal messaging in addition to sharing rides. The prototype has demonstrated that there is potential to support growth of participation in ridesharing by framing ridesharing in the broader context of travel sharing and social connection, although at this point this is a design lead rather than a proven hypothesis. The approach stands in contrast to a conventional IT design approach in which functional requirements are specified in detail, up front, before a system is implemented, and without a means to test whether the functional requirements are well specified.

Acknowledgments

We wish to acknowledge the participants in the rideshare work to date.
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Digital Learning, Digital Scholarship, and Design Thinking

Anne Burdick
Graduate Media Design Program, Art Center College of Design, Pasadena, California, United States

Holly Willis
Institute for Multimedia Literacy, University of Southern California, Los Angeles, California, United States

Abstract

Many in the Design Thinking community have advocated for the relevance of design methods and cognition in the face of global-scale challenges and complex contemporary issues. At the same time, another community—what this paper calls “new media educators”—has been advocating for a similar set of skills to address changes to learning and media-rich scholarship brought about by digital technologies. In spite of the apparent similarity of these dual efforts and calls for collaboration, participation and project-based learning, new media educators tend to associate media authoring skills not with design, but with digital tools. The focus on technology can eclipse the role of thinking and making; this paper examines this oversight and identifies opportunities for design thinking to be integrated into digital learning and digital scholarship initiatives.

To demonstrate the need for better communication between these two groups, the paper traces the ways in which the rise of digital culture has been a catalyst for the reconsideration of 19th-century educational models and even older print-derived models of knowledge and scholarship. It then posits four modes fundamental to design thinking that align well with the objectives of new media educators. The paper draws upon case studies in which educators and scholars have attempted to integrate multimedia authoring and design thinking, examining the incorporation of multimedia literacy into both a K-12 curriculum and a General Education curriculum, as well as attempts to create collaborative design projects within the digital humanities. After illustrating the alignment between the concerns of new media educators and the expertise and methods of design, and designating specific terms with which to frame the overlap, the authors query further potentials offered by the union of these two communities. Does this opening within teaching, learning and digital scholarship constitute an imperative for the design thinking research community to involve itself with the creation of emerging models for learning and knowledge production? The authors argue that it does, noting that the impact could be felt at an epistemic level for generations.

1. Introduction

Many in the Design Thinking community have advocated for the relevance of design methods and cognition in the face of global-scale challenges and complex contemporary issues. At the same time, another community—what we will call “new media educators”—has been advocating for a similar set of skills to address changes in digital education and scholarly discourse. As we will show, each community has championed similar abilities such as constructive thinking, problem-solving, collaboration, and multimodality, to name a few, yet new media educators seldom associate these abilities with design. Instead new media educators, from kindergarten
to the college level, tend to identify the changes with digital technologies, such as social media or computation. The focus on technology has eclipsed the role of thinking through making as it has been articulated within the Design Thinking community for more than 30 years.

Simultaneously, within education environments, “new media” has been a catalyst for the reconsideration of educational models relatively unchanged since the 19th century, and even older print-derived models of knowledge and scholarship. The initiatives range from the design of individual courses as instructors experiment with project-based learning, to enterprise-level decisions as academic infrastructures are reconfigured to accommodate digital media for teaching as well as research. The reconsideration of teaching and learning is spearheaded by diverse fields, from writing and composition programs to computer science, and it is often driven by a sense of urgency based on the palpable sense that the world is very different than it was even a decade ago, and concomitantly, the needs of students are different as well.

The willingness to rethink enduring approaches provides an opening for design thinking as educators and scholars cast about in search of innovative models that are a better fit. As we triangulate among digital learning, digital scholarship, and design thinking, we hope to show that design, as it has been theorized by many in the design thinking community (Cross 2006; Dorst & Lawson 2009) can account for the often unnamed modes of thinking new media educators hope to inspire. Further, practitioner-led design research is needed to inform the development of new models for digital scholarship that are underway. How might design thinking researchers mobilize a body of knowledge and expertise in order to approach this opportunity for deeply engaged collaboration? How might design thinking research help define a critical juncture whose qualities remain elusive yet whose effects are tangible?

2. Digital Learning and Design Thinking

Defining Digital Learning

Young people who have grown up with computers, video games, the Internet, and cell phones have been called “Digital Natives” by some scholars (Prensky 2001; Palfrey & Gasser 2008), and while other scholars have critiqued this term (Jenkins 2007), it conjures the sense of wholesale difference of younger generations from older ones. This cohort is believed to be genuinely different from previous generations in terms of social practices, learning styles, and even cognition, due to their early and constant engagement with information technologies. As a result, digital learning calls for an overhaul of pedagogy in order to accommodate learners who are bricoleurs: they can piece together information from multiple sources, are intuitive visual communicators, have strong visual-spatial skills and learn best through inductive discovery (Prensky 2001).

Regardless of the attributes and associated needs ascribed to so-called digital natives, a generation reared on media also needs literacies to understand these media forms. Alongside innovations in learning, then, have come calls for new literacies, including digital literacy, multimedia literacy, information literacy and so on (Bawden 2008; Jenkins 2006; Lankshear & Knobel 2008), informed by critical analysis. In 2005, the New Media Consortium helped to define 21st century literacy, noting that it constitutes

...the set of abilities and skills where aural, visual and digital literacy overlap. These include the ability to understand the power of images and sounds, to recognize and use that power, to manipulate and transform digital media, to distribute them pervasively, and to easily adapt them to new forms (The New Media Consortium 2005, p.2).

In many ways 21st century literacy sounds very much like designing.
Interpreting Design Thinking as a 21st century literacy

Design thinking identifies ways of knowing that can be applied throughout education at all levels, but, as illustrated above, it is in particularly close alignment with the needs and attributes identified by new media educators. Nigel Cross's use of the term “constructive” thinking, for example, which builds upon what Charles Sanders Peirce calls “abductive” reasoning, works from incomplete information and evidence and requires making a creative and intuitive guess. As such, abduction may be the form of reasoning that many of us use on a daily basis when we encounter a world that rarely supplies all the information we need. More significantly, however, abduction is a form of reasoning that can function best by making something, reflecting on what’s been made, and iterating. The intuitive aspect is transformed into an analytic component in an ongoing process of design thinking.

In addition to the cognition and expertise recognized by Nigel Cross, Bruce Archer, Kees Dorst, Brian Lawson, and others, models and metaphors from communication, interaction, and information design may provide a point of connection between digital learning and digital scholarship and as such provide a fruitful starting point for further research.

Borne out of the experience of designing, the following conceptual frameworks are based in specific practices and tested models:

**Interpretive, rhetorical, performative**

Communication design's foundation in visual rhetoric, semiotics, and visual narrative are essential when designing and interpreting the symbolic dimension of an interface, here understood broadly. This area of design thinking is directly applicable to notions of digital literacy and fluency as we understand that critical interpretation is as significant as critical practice.

**Situated, networked, contingent**

The designer's hands-on experience with the instrumentality, systemic embeddedness, contextual specificity, and social operations of both back- and front-ends of digital media can provide a useful frame of reference in the construction of new models. Indeed, this interplay forms the foundation for reconsidering a generic notion of “literacy” as a set of skills “acquired” and instead imagines literacy itself as situated, networked and contingent, and as such, something continually negotiated. The design thinking of interaction design specifically supports this constant emergence.

**User-Oriented**

A design perspective provides a shift from a technical tool-based orientation (which may be predicated on digital exigencies) to a user-oriented approach to interface and software design that takes into account not only how an application is used but also the kinds of subject positions, world-views, and models it affords. This user-orientation is closely aligned with learner-centered educational theories.

**Vital**

the conceptual, solution-oriented yet propositional (playful, speculative) aspect of thinking through the making of new media forms gives designers the capacity to offer new metaphors to conceptions of learning and authoring that are highly relevant to digital paradigms of teaching and learning.
Digital Learning and Design Thinking in the Curriculum

Successful endeavors in reimagining education for digital learners tend to manifest these four capacities. For example, “Quest to Learn,” a self-described “school for digital kids” recently founded for grades 6-12 by the Institute of Play in New York City, provides an example in which design thinking and digital learning coalesce. Principles from game design that promote innovation, discovery, strategic thinking, and play are core to the school’s curriculum, as is the recognition that contemporary students are immersed in media and technology.

In a recent interview in Big Think, the Executive Director of the Institute of Play, Katie Salen, who is a design professor and co-author of a book on game design titled Rules of Play, identifies how game design develops the abductive reasoning discussed by Cross. According to Salen, iterating and problem-solving in response to changing conditions is relevant now more than ever: “Technology is changing all the time. We have to constantly learn how to do new stuff every day.” Salen continues to explain how game design allows students to engage deeply with subjects, be motivated to develop content expertise, and to work on 21st century skills such as “collaboration, working in teams, complex problem-solving, systems thinking, being able to design and find resources” (Big Think 2010).

Salen indicates an understanding of the role of design thinking through reference to the situated and contingent nature of education broadly; in attention to the user interface; and in deploying design’s practices and metaphors as the foundation for the curriculum.

At the college level we also find that the rise of digital media has led some educators to consider the impact of design thinking on the curriculum. In a recent contribution to the International Journal of Learning and Media, Anne Balsamo argues that design constitutes “an important body of knowledge that should be incorporated into basic educational programs—in essence, as a ‘new liberal art’” (Balsamo 2009, p.5).

Indeed, Balsamo helped craft a curriculum intended to implement these ideas when, in 2006, she helped design a program at the University of Southern California called “Multimedia in the Core.” The idea was to offer all students at USC the possibility of authoring in new media forms and that the best place to do so would be within the General Education curriculum, which engages every student at USC. The goal was to reimagine the GE course through designing media—rather than to simply teach software or make projects—and to integrate the lab component such that the pedagogy, assessment and outcomes would all rely on design thinking. Once again, attention to design’s understanding of visual rhetoric, the situated and contingent nature of communication, user-oriented design and design metaphors proved foundational to the redesign of a curriculum attuned to new literacies.

The course-lab conjunctions were successful individually once they took place, but low enrollment levels prompted a redesign of the program. Students generally resisted the “extra” work associated with a GE course with which they felt little direct connection. Therefore the introductory lab sections are no longer yoked to specific GE courses but are offered as stand-alone experiences, and students are given more advanced support in the use of media in conjunction with higher level courses, where students see more incentive to engage with their research through the design of media-rich projects.

For both Quest to Learn and the Multimedia in the Core programs, educators realized that a new generation of students within a digital culture requires new ways of thinking and knowing. They also realized that these new ways of thinking and knowing center on an expanded notion of design thinking that includes 1) visual rhetoric; 2) a comprehension of situated expression; 3) a user-oriented approach, both to students and curricula, and in how students are taught
to engage others through their work; and 4) an attention to new metaphors for thinking and knowing, metaphors that derive from digital design practice.

3. Digital Scholarship and Design Thinking

Defining Digital Scholarship

If the four design thinking approaches highlighted above have proven useful in designing curricula for a new generation of K-12 and college students, they are equally pertinent in helping scholars across disciplines to re-imagine longstanding scholarly practices. Indeed, diverse scholars have responded to the capabilities of digital technology with new methods and new forms, as well as the creation of cyberinfrastructures more broadly. Scholarly discourse that was once restricted to printed texts is now being produced in a variety of formats, including short videos, information visualizations, and networked writing, while information architectures, often the province of IT departments, are becoming a focus for scholars as they realize that new tools bring new practices. Christine Borgman uses the term scholarly information infrastructure to encompass “the technology, services, practices, and policy that support research in all disciplines,” adding that these infrastructures enable “forms of scholarship that are information- and data-intensive, distributed, collaborative, and multi-disciplinary” (Borgman 2009, para. 2).

Scientific journals and research were quick to adapt to new digital paradigms, but only recently have we seen the development of what’s called the “Digital Humanities,” defined loosely as the application of computing to research and teaching in the humanities. While Susan Hockey traces instances of humanities computing to 1949 (Hockey 2004), it is perhaps the publication of books such as Borgman’s Scholarship in the Digital Age, Johanna Drucker’s SpecLab: Digital Aesthetics and Projects in Speculative Computing, and Matthew G. Kirschenbaum’s Mechanisms: New Media and the Forensic Imagination, all published within the last three years, that reflect the growing significance of the digital humanities.

To produce their digital scholarship, many humanist scholars began by self-authoring their work, including writing their own code and designing their own interfaces. But as projects have become more complex and as the technology has become more sophisticated, it has become increasingly necessary for these same scholars to partner with libraries or IT departments or to use existing commercial and open source applications and services. As a result, a number of digital archives, research portals, and multimedia authoring tools have been created that have not adequately addressed the epistemological trajectories being designed into their technological infrastructures or user interfaces.

A few scholars, such as Johanna Drucker, have taken notice. Writing in the Chronicle of Higher Education, Drucker insists that humanists must not cede the design of tools for scholarly inquiry to IT staff members. “For too long, the digital humanities, the advanced research arm of humanistic scholarly dialogue with computational methods, has taken its rules and cues from digital exigencies” (Drucker 2009, para. 13).

Clearly this is an area in great need of innovation. Conceptualizing the multi-modal and dynamic worlds of digital scholarship should be an ongoing, iterative process, one that incorporates design’s abductive reasoning as well as its understanding of users, semiotics, and the instrumentality of both interface and infrastructure. In this regard, scholarly digital projects provide an opportunity for practitioner-researchers and design thinking researchers to consider the role that design has to play in the generation and representation of knowledge. For as Drucker notes, “Knowledge does not exist outside of circumstances of use or independent of its material means of expression” (Drucker 2009, para. 12).
Digital Scholarship and Design Thinking in Humanities Research

Two digital journals explicitly recognize the importance of design thinking when conceiving new discursive models that are critically aware of their epistemic implications. *Electronic Book Review* and *Vectors Journal of Culture and Technology in a Dynamic Vernacular* each use a collaborative production model in which scholars, programmers, and designers work directly with one another to produce digital writing projects. Unlike most commercial and institutional sites on the Internet in which designers are service providers, these journals position their designers as co-practitioner-researchers.

*Electronic Book Review* is one of the longest-running journals of critical writing on the Internet. Since its earliest days, the production team—an editor, a designer, and a programmer—has researched how the affordances and constraints of the interface design and site architecture define the ideological boundaries of the literary journal through an ongoing cycle of iteration and reflection. According toconstitutes literary interpretation and knowledge. *Electronic Book Review* is an example of how thinking through making in the realm of digital scholarship can lead to new models that allow us to consider dimensions of designing—and design thinking—that go beyond utility and problem-solving and into the creation and interpretation of culture.

Another journal, *Vectors*, has had tremendous impact amongst humanities scholars for its experiments in digital writing. The editor, Tara McPherson, has a keen understanding that the nascent digital scholarship requires new ways of working and new modes of understanding that must be developed, practiced, and theorized. Therefore the journal runs a workshop each summer in which humanities scholars are exposed to a range of projects and issues in digital publishing. Importantly, the workshop also includes time for them to work side-by-side with designers and programmers. In the process, project teams develop a shared vocabulary, working process, and cross-disciplinary understanding that is manifest in innovative projects. Every member of the team is asked to contribute to the specifics of visual rhetoric, user experience, and the role of the interface in construing subject positions. In other words, every member of the team is asked to think as a designer. The result is a body of award-winning digital humanities projects that serves as research, provocation, and a point of reference for the field. In a recent essay on the digital humanities, McPherson echoes Drucker’s concerns about the foundational role scholars need to play in the design of software, noting that “it is imperative that we be involved in the design and construction of the emerging networked platforms and
practices that will shape the contours not only of our research, but of social meaning and being for decades to come” (McPherson 2009, 123).

This imperative can be taken one step further: design practitioners and design thinking have a key role to play in the construction of the emerging networked platforms and practices, as we have seen in the examples of EBR and Vectors, a role that is worthy of further research.

The time for practitioner-researchers to engage in the development of digital scholarship is now, while the field is relatively unformed. This sense of urgency has been articulated very clearly. Christine Borgman, for example, asserts in a recent essay for *Digital Humanities Quarterly*, “This is a pivotal moment for the digital humanities” (Borgman 2009, para. 1). She asks, “Can we seize this moment to make digital scholarship a leading force in humanities research? Or will the community fall behind, not-quite-there, among the many victims of the massive restructuring of higher education in the current economic crisis?” (Borgman 2009, para. 1). Similarly, Drucker insists that humanists currently face “a critical juncture” with regard to faculty interest in crafting digital tools, and calls on scholars to take seriously the task of imagining the future of digital scholarship.

4. Conclusion

If we are, indeed, at a critical juncture in education and scholarship due to the impact of digital technologies, it is worth asking, what will be the role for design? Design thinking researchers have valuable contributions and relevant expertise to bring to the new media education projects that are being produced at a variety of scales, from the classroom to the institution, from literacy skills to knowledge production. The alignment between the concerns of new media educators and the expertise and methods of design are a near-perfect fit, creating an opening—and an imperative—for the design thinking research community to engage with emerging models for learning and knowledge production.

Historically, the relationship between design thinking and innovation has centered predominantly on engineering, product development, and business. Digital learning and digital scholarship provide a space in which we can expand our definition of designing to include work whose outcomes may be less tangible but that are no less important: “social meaning and being.” There is work to be done—practitioner research and design thinking research—whose impact could be felt at an epistemic level by many for generations to come.
References


Design Thinking as a Form of Intelligence

Nigel Cross
The Open University, Milton Keynes, UK

Abstract

This paper re-visits the concept of 'design as a form of intelligence', first suggested by Cross (1990) and based on a development of Gardner's (1983) 'theory of multiple intelligences'. The premise of the concept was that there are sufficient significant features embedded in design thinking that, taken together, they constitute a form of intelligence that is different from, but comparable with, Gardner's other six (now increased to eight) forms of intelligence. Although the concept has re-surfaced occasionally in the last twenty years, it has not received the attention that perhaps it deserves. Recent extensions of the concept of design thinking have the potential to undermine the core concept of 'designerly ways of knowing' and therefore of the concept of design thinking itself. This paper re-states the concept of 'design as a form of intelligence' and identifies the progress that has been made in the past twenty years in understanding its key cognitive components. Significant aspects of this progress have arisen from the body of research in design thinking, including especially the DTRS series, but also from more distant but relevant work in the cognitive sciences.

1. Shifts of perspective

The series of symposia on Research in Design Thinking (DTRS), initiated in 1991 at the University of Delft by Cross, Dorst and Roozenburg (1992), and now here in its eighth version, has provided a broad base of research results and reflection on the nature of design ability, how designers think, and designerly ways of knowing. However, 'design thinking' has now also become such a common-place concept that it is in danger of losing its meaning. The new consensus seems to be that design thinking encompasses many forms of thinking and intelligence. The current extension of concepts of design thinking beyond the core design disciplines (so that managers, medics and administrators might all be 'design thinkers') is an indicator of the undermining and weakening of the very concept of design thinking. At its Business Week worst, design thinking becomes merely another way of making a profit. It is time to re-claim design thinking as a fundamental aspect of the discipline of design, something that pertains to the skilled, educated practice of designing.

The origins of a research focus on design thinking lie in the attempts to define design as a discipline in its own right in the mid-1970s and early 1980s (Archer 1979; Cross 1982). Lawson (1980) introduced the study of 'how designers think', and a little later Rowe (1987) produced his studies of 'design thinking'. Previously, a dominant view in design research had been represented by Simon's (1969) interpretation of design as a 'science of the artificial'.

The limitations of this previous interpretation were perhaps betrayed by Simon himself, when he likened the activity of a designer to that of an ant. He compared any creative problem solver, such as a designer, to an ant returning to its nest across a stony terrain. To an ant, the horizon is very close, the terrain is not all visible in advance, and it cannot foresee all the obstacles lying in its path on its way to its goal. All it can do is deal with the obstacles as it comes to them—working a way around or over them. The ant, like a creative problem solver, according to Simon, is likely to take what would appear to an outside observer, with much more of a global view, to be a circuitous route 'home' to the solution goal. What Simon tried to communicate by this metaphor was his view that the apparent complexity of the ant's (or designer's) behaviour is largely a reflection of the complexity of the environment (or design situation) in which it finds itself.
itself, whilst the underlying cognitive processes that control the behaviour may be relatively simple. So in this view, understanding designing is more about understanding design problems than about understanding design thinking.

This view was significantly challenged by Schön’s (1983) interpretation of professional ability as reflective practice. Probably the most influential study of a designer at work has been that reported by Schön. The influence of the study is largely due to it being set within his broader series of studies of professional practice (ranging from psychotherapy to management) that he used to establish his theory of reflective practice, or ‘how professionals think in action’. The study has also been influential because Schön’s analysis of what he observed is acute and sensitive; both designers and design researchers (those with personal design experience) recognise the veracity of the analysis. What is surprising is that such an influential study is based on just one, partial example of design activity—and even that is not a ‘real’ design example, but is taken from observing an experienced designer tutor a student in a university architectural design studio.

Schön established his theory of reflective practice as a counter to the prevailing theory of technical rationality, or the constrained application of scientific theory and technique to practical problems. He was seeking a new ‘epistemology of practice’ that would help explain and account for how competent practitioners actually engage with their practice—a ‘kind of knowing’, he argued, which is different from the knowledge found in textbooks. In his analysis of the case studies that provided the foundations for his theory, he began with the assumption ‘that competent practitioners usually know more than they can say. They exhibit a kind of knowing-in-practice, most of which is tacit.’ He identified a cognitive process of reflection-in-action as the intelligence that guides ‘intuitive’ behaviour in practical contexts of thinking-and-acting—something like ‘thinking on your feet’. At the heart of reflection-in-action is the ‘frame experiment’ in which the practitioner frames, or poses a way of seeing the problematic situation at hand.

So in the early 1980s there was a significant shift in perspectives on design thinking, from criticising the limitations of design cognition to recognising its strengths and potential. The emphasis changed from trying to formulate design as a science to recognising the merits of the natural, ‘intuitive’ processes of designing. This was well represented in the work of Davies and Talbot (1987), who studied the processes of a large number of outstanding designers. They summarised the characteristics that seemed key to making these people successful in dealing constructively with uncertainty, and the risks and opportunities that present themselves in the process of designing, as follows. ‘One of the characteristics of these people is that they are very open to all kinds of experience, particularly influences relevant to their design problem. Their awareness is high. They are sensitive to nuances in their internal and external environments. They are ready, in many ways, to notice particular coincidences in the rhythm of events which other people, because they are less aware and less open to their experience, fail to notice. These designers are able to recognise opportunities in the way coincidences offer prospects and risks for attaining some desirable goal or grand scheme of things. They identify favourable conjectures and become deeply involved, applying their utmost efforts, sometimes “quite forgetting” other people and/or things only peripherally involved.’ So, for outstanding designers, at least, design thinking is an absorbing, demanding, sometimes obsessional activity.

Cross (1990) drew upon the growing number of such studies and investigations into design activity and designer behaviour in order to clarify and categorise the nature of design ability. In this paper I summarised design thinking as comprising abilities of resolving ill-defined problems, adopting solution-focussed cognitive strategies, employing abductive or appositional thinking and using non-verbal modelling media. I identified these abilities as highly developed in skilled designers, but also suggested that they are possessed in some degree by everyone. I
went on to outline a case for design ability as a fundamental form of human intelligence, thus seeking to provide a much broader foundation for establishing ‘designerly ways of knowing’.

2. Design intelligence

The interpretation of design thinking as a form of intelligence was based on the work of Gardner (1983). Gardner’s view is that there is not just one form of intelligence (as conventionally identified in standard forms of ‘intelligence tests’), but several, relatively autonomous human intellectual competences. Originally, he distinguished six forms of intelligence:

• linguistic
• logical-mathematical
• spatial
• musical
• bodily-kinaesthetic
• personal.

Aspects of design ability seem to be spread through these various forms of intelligence in a way that does not always seem entirely satisfactory. For example, spatial abilities in problem-solving (including thinking ‘in the mind’s eye’) are classified by Gardner under spatial intelligence, whereas many other aspects of practical problem-solving ability (including examples from engineering) are classified under bodily-kinaesthetic intelligence. So in this classification, for example, the inventor’s competence is placed together with that of the dancer and the actor, which doesn’t seem appropriate. It seems reasonable, therefore, to try to separate out design ability as a form of intelligence in its own right.

We have seen many aspects of this ‘design intelligence’ emerge in the various studies reported in the DTRS series and elsewhere. For example, we have seen that good designers have a way of thinking that involves operating seamlessly across different levels of detail, from high level systemic goals to low level physical principles. Rather than solving merely ‘the problem as given’ they apply their intelligence to the wider context and suggest imaginative, apposite solutions that resolve conflicts and uncertainties. They have cognitive skills of problem framing, of gathering and structuring problem data and creating coherent patterns from the data that indicate ways of resolving the issues and suggest possible solution concepts. Design intelligence involves an intense, reflective interaction with representations of problems and solutions, and an ability to shift easily and rapidly between concrete representations and abstract thought, between doing and thinking. Good designers apply constructive thinking not only in their individual work but also in collaboration in teamwork.

The nature of design intelligence becomes particularly, and tragically highlighted in rare cases where it is impaired through neurological damage in the brain, such as through a stroke. One such case was reported by Goel and Grafman (2000), who studied an architect who had had a seizure, associated with a meningioma tumour in his right prefrontal cortex, a region at the front of the brain that is associated with high level cognitive functions. Before his attack, this person had practiced successfully as an architect. Goel and Grafman compared his post-attack design ability with that of a control participant, another architect with similar education and design experience, on being given a relatively simple task of re-designing a laboratory space. The sequences of design sketches that the two subjects produced are dramatically different. Each began by making a survey drawing of the existing laboratory and its furniture. The healthy control participant then produced a coherent series of sketches, beginning with abstracted considerations of circulation and organisation, then developing alternative proposals and refining the preferred one. The neurological patient produced three separate, basic and incomplete proposals, finishing with a ‘final proposal’ that was still inadequate and incomplete.
The differences in the thinking processes of the two participants become clear in graphs of the amount of time each devoted to different cognitive activities, as revealed by their ‘think aloud’ comments made during the experiments. The control participant focused initially on ‘problem structuring’, with periodical returns to this. He then moved to ‘preliminary design’ and on to ‘refinement’ and ‘detailing’. The graph of the control participant clearly shows a controlled but complex pattern of activities, with overlap and quick transitions between activities. In contrast, the neurological patient spent a huge amount of time on attempting ‘problem structuring’, and only small amounts of time on ‘preliminary design’ and ‘refinement’.

The experimenters reported that: ‘The patient understood the task and even observed that “this is a very simple problem”. His sophisticated architectural knowledge base was still intact and he used it quite skilfully during the problem structuring phase. However, the patient’s problem-solving behaviour differed from the control’s behaviour in the following ways: (1) he was unable to make the transition from problem structuring to problem solving; (2) as a result preliminary design did not start until two-thirds of the way into the session; (3) the preliminary design phase was minimal and erratic, consisting of three independently generated fragments; (4) there was no progression or lateral development of these fragments; (5) there was no carry-over of abstract information into the preliminary design or later phases; and (6) the patient did not make it to the detailing phase.’ In short, the patient simply could not perform the relatively simple design task.

In this unhappy case we can see exposed some of the considerable complexity that there is in normal design thinking, and evidence that the brain has high level cognitive functions that control or process activities that are essential aspects of design ability and that contribute to design thinking as a form of intelligence.

Studies of brain activities have identified specific areas of the right hemisphere of the brain as being active during design thinking. The two hemispheres of the brain, right and left, appear to have different cognitive specialisms. Neuroscience studies tend to confirm that the right hemisphere of the brain is more specialised in spatial and constructional tasks, in aesthetic perception and emotions. The left hemisphere is more specialised in language abilities and verbal reasoning. Damage to the left hemisphere often results in the loss of some speech functions, whereas damage to the right hemisphere, as we have seen, can result, amongst other things, in the loss of design ability.

It has been known for some time that damage to the right hemisphere can impair brain functions that relate strongly to intuitive, artistic and design abilities. This has been confirmed by studies of, for instance, drawing ability. One classic case is that of an artist who suffered right-brain damage. Although the artist could make an adequate sketch of an object such as a telephone when he had it in front of him, he could not draw the same object from memory and resorted instead to ‘reasoning’ about what such an object might be like, producing strange, clumsy new ‘designs’.

Several examples of the problematic behaviour and perception of people with right-brain damage were reported by Sacks (1985), including ‘the man who mistook his wife for a hat’ and who could not recognise a glove. When Sacks held up a glove and asked ‘What is this?’, the patient described it as ‘A continuous surface, ... infolded on itself. It appears to have five outpouchings, if that is the word ... A container of some sort.’ There is a weird logic to this reasoning, but no intuitive perception of the object and its obvious function. Of course, perceiving and creating relationships between form and function is a central aspect of design thinking.

Recently, Alexiou et al. (2009) undertook experiments comparing design thinking with more conventional problem solving activities (comparing ill-defined against well-defined problems), using functional magnetic resonance imaging of the brain during these activities. Their find-
ings suggest that designing and problem solving are indeed distinct kinds of thinking, involving distinct cognitive functions associated with distinct brain networks. They concluded that: ‘The discovered activation in the right dorsolateral prefrontal cortex for design versus problem solving is consistent with previous studies focussing on features of design and problem solving such as insight and the ability to perform lateral transformations and set-shifts. Additionally, the results are consistent with the view that design cognition essentially also involves evaluation and modulation of alternative goal states, or conditions of satisfaction, which may be supported by the anterior cingulate cortex. Compared to problem-solving, [cognitive activity in] design tasks recruits a more extensive network of brain areas. It is suggested that these brain areas work together in order to undertake semantic operations, evaluate means and ends of appropriate responses and representations, support the resolution of conflicts, and modulate decision making under uncertainty.’

These experiments provide evidence for the distinct location of design cognition within certain areas of the brain. This was one of the principal criteria that Gardner proposed for the recognition of a distinct form of intelligence. At the time he proposed these criteria, ‘potential isolation by brain damage’ as Gardner expressed it was perhaps the only way to identify such distinct centres of brain activity. As well as the continuing development of this kind of evidence, with specific attention to design cognition such as in Goel and Grafman (2000), we also now have much better ways of identifying specific centres of cognitive activity, again with some specific attention to design cognition as in Alexiou et al. (2009). We therefore now have a much stronger case for design thinking as a form of intelligence.

Gardner’s original set of criteria was as follows:

- Potential isolation by brain damage.
- The existence of idiots savants, prodigies and other exceptional individuals.
- An identifiable core operation or set of operations.
- A distinctive developmental history, and a definable set of expert, end-state performances.
- An evolutionary history.
- Susceptibility to encoding in a symbol system.
- Support from experimental psychological tasks.

In 1990, I concluded that ‘If asked to judge the case for design intelligence on this set of criteria, we might have to conclude that the case is “not proven”. Whilst there is good evidence to meet most of the criteria, on some there is a lack of substantial or reliable evidence.’ Twenty years later we do indeed have much more of that evidence, thanks especially to the Research in Design Thinking symposia, but also thanks to the general growth of design research with a focus on design thinking. This research (quite apart from DTRS proceedings) includes considerable work on the ‘core operations’ (e.g., Gero 1990, et seq.; Lawson 1994; Dong 2009), on ‘expert performance’ (e.g., Bucciarelli 1994; Lawson & Dorst 2009), on ‘symbol systems’ (e.g., Goel 1995; Purcell 1998), and especially on protocol studies and other ‘experimental psychological tasks’ (e.g., Cross 2001; Visser 2006).

Whatever the current strength of the case may be, viewing design thinking as a form of intelligence is a productive view; it helps to identify and clarify features of the nature of design thinking, and it offers a framework for understanding and developing design ability through design education. A view of design thinking as a distinct form of intelligence does not necessarily mean that some people ‘have it’ and some people do not. Design ability is something that everyone has, to some extent, because it is embedded in our brains as a natural cognitive function. Like other forms of intelligence and ability it may be possessed, or may be manifested in performance, at higher levels by some people than by others. And like other forms of intelligence and ability, design intelligence is not simply a given ‘talent’ or ‘gift’, but can be trained and developed.
A stronger re-formulation of the concept of design thinking as a form of intelligence could have the effects not only of re-establishing design thinking as key within the discipline of design but also of clarifying some boundaries and limits to the extensions of design thinking. Perhaps most importantly, it can also help to support the role of design as a fundamental, distinct aspect of education at all levels, and to assist design educators in formulating their aims, objectives and methods.
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Understanding how designers’ thinking and acting enhance the value of the design process

Sónia da Silva Vieira
FEUP, Porto, Portugal / TuDelft, The Netherlands

Petra Badke-Schaub
TuDelft, The Netherlands

António Fernandes
FEUP, Porto, Portugal

Teresa Fonseca
FAUP, Porto, Portugal

Abstract
One of the main purposes of design research is to understand how designers’ thinking and acting enhance the value of the design process and deliver value to design results. The present paper reports findings from an empirical research that aims to identify designers’ practices of value delivery across design disciplines.

Data collected during periods of observation and interviews provide insight into the characteristics and behavior of designers sharing working environment in four design consultancies established in the following design disciplines, graphic design, architecture, interaction design and engineering. The present study reports findings based on the categorization of interview transcripts.

Findings derived from this research are the priority values for decision-making in designing. These values integrate designers’ value systems and patterns of thinking and acting in the process of delivering value to final results. Results show variant and invariant designers’ priority values for decision-making across disciplines.

1. Introduction
The present research attempts to contribute to the understanding of how designers’ thinking and acting enhance the value of the design process and deliver value to design results (Eastman 2001; Akin 2001). As a process of thought, designing inevitably entails the designer making decisions (Akin 1995), either alone or through collaboration. Decision-making consists of two aspects, whereby the first aspect is to decide upon the own preference and the second is the choice made based on value judgment. The present paper attempts to provide insight into how designers use value judgment to make decisions. Research on value and decision-making in design are reviewed and followed by the description of the methodological procedure and results. Evidence is given to the priority values for decision-making across four design disciplines, namely, graphic design, architecture, interaction design and engineering.
The topic of values in designing (Lloyd 2009; Le Dantec 2009; Dong 2009) and variants and invariants in design cognition (Akin 2009) were discussed in the earlier DTRS 7. It seems appropriate to try to attempt to correlate both. In this research findings on the priority values for decision-making in designing are proposed as variant and invariant characteristics of designers’ thinking and acting across disciplines.

Ultimately, the inference and empirical evidence of such designers’ characteristics contributes to the later generic design-hypothesis (Visser 2009) with transdisciplinary knowledge on decision-making in designing.

2. Values and value systems

The notion of value has traditionally been defined by economic return or a measure of moral standards. Value spans a number of different disciplines such as philosophy, economics, psychology, marketing, music and design. Research approaches to value comprises three main dimensions, namely, economic value, human values and value systems. In the foundations and development of economic thought and market exchange, two general meanings of value were proposed: value-exchange and value in use (Smith 1776). Later, the study of human values emerged as an enduring tradition in the fields of psychology and sociology. The concept of value was given a more concrete meaning related to common activities. A wider notion later emerged that each individual creates a personal and flexible hierarchy of values (Allport, Vernon & Lindzey 1951). Currently, values are seen as guiding principles that rise above in specific situations and may change over time. Values guide the selection of information, steer the behavior and events as parts of a dynamic system with inherent contradictions (Bindé 2004). A value system is regarded as an enduring organization of beliefs concerning preferable modes of conduct or end-states of existence along a continuum of relative importance (Rokeach 1968). Contributions to research into values unfold in terminal values and instrumental values (Rokeach 1973) that along with important value components, namely, motivational, cognitive, affective and behavioral, as well as the influence of internal and external features (Rokeach 1968), guide individuals’ conduct and motivate action (Reich 1976).

3. Values and decision-making

In designing, as in any other activity, decision-making and deliberated expression of value-laden judgments derive from the need to take a stance and make a choice. Value in designing is defined as:

The designer or design team makes choices at every point in the design process and most of these are value laden. Every decision at each “choice point” will give priority to certain values over others (Marshall 2008, p.434).

Designers’ value systems guide individual and collective value judgments about the relative importance of the attributes for a certain result. These judgments most likely derive from motivational, cognitive, affective and behavioral-based decisions and preference is shown towards solutions that most reflect designers’ priorities (Lera 1980) in the given context.

3.1 Research on value in design

Studies have identified how designers’ characteristics and behavior ascertain different approaches to the design process framing the outcome and results (Badke-Schaub & Frankenberger 1999). Although emphasis has been placed on quality and value from a user’s perspective through user value theories and models (Boztepe 2007), few authors have tried to identify value in design (Austin 2005; MacMillan 2006; Langford 2007) from the designer’s point of view. Design researchers have been contributing studies on value issues such as, mechanisms
of value transfer in meetings (Le Dantec 2009), affect-in-cognition (Dong 2009), ethical thinking in designing (Lloyd 2009) and a plural value framework for a shared language supporting value management (Prins 2009). Such studies report results based on the analysis of meetings or approaches to value developed from experience. Although designers play an important role in adding value to products, services and experiences, little attention has been placed on the study of these activities on an empirical base. No transdisciplinary study has been presented on designers’ perspectives on value in design.

3.2 Research on decision-making in design

Studies show that most of the designers’ time is occupied making routine and novel decisions; therefore it is important to describe the conditions that surround these decision points (Akin 1995). Research in decision-making in design has been done that addresses single disciplines such as engineering design (Wallace 1995, Badke-Schaub & Gehrlicher 2003), architecture (Mackinder & Marvin 1982; Volker 2008) or industrial design engineering (Akin 1995).

Several research issues have been addressed, such as: methods and tools for decision-making (Wallace 1995); design decisions under uncertainty (Beheshti 1993; Daalhuizen 2009); context, task and institutional environment of decision-making (Little 1990); patterns of decision in design (Badke-Schaub & Gehrlicher 2003); comparative studies on consensus and single leader decision-making (Yang 2010); and philosophy based models for ethical decision making in design (d'Anjou 2010). Few report empirical evidence and transdisciplinary research was not done in more than two disciplines. Although some influential aspects of decision-making are acknowledged in these studies, such as: experience, use of information from previous projects, intuition, culture, personality, predicted or unforeseen elements of risk, chain of known and unknown design constraints, unknown design variables, interaction of alternative courses of action, validity of design concepts, design intentions, design values and strategies (Beheshti 1993), few empirical evidence is reported.

4. Values as Variants and Invariants

Research in design cognition has been supported by the assumption that, in different fields of design, cognitive processes have significant similarities and differences (Akin 2009). These characteristics have been addressed as variants and invariants in design cognition (Akin 2001). Invariants have been defined as variables of a conditional character, whereas variants have been identified as dependent variables (Akin 2001). The present study supports the thesis that in different design disciplines, designers’ value judgments share common and dissimilar characteristics. Thus, as designing is reflective practice (Schön 1988) this research entails cognitive processes and physical actions. From this study we propose variant and invariant characteristics of designer’s thinking and acting in value judgment across four design disciplines.

5. Research methodology

This case study-based approach is an exploratory research that aims to identify specificities and weaknesses on how designers’ think and deliver value in design across disciplines. The ultimate goal of this approach is to provide mechanisms to support an effective management of value in design. Research issues were assessed with field studies in design environments (Saldana 2009). Different sort of data was collected during the periods of observation providing insights into the characteristics and behavior of designers.

The present study refers to data collected by means of a structured interview addressing main topics regarding the context of design. Each interview was between 90 to 120 minutes. The selection was based on interviews that exhibited more complete descriptions of situations where the designer expressed the importance of certain values leading to a decision. The sample to
be presented comprises 16 selected interviews, four per case study. Each designer differs in background and activity as shown in Table 1.

**Table 1. Background and activity of the interviewees**

<table>
<thead>
<tr>
<th>Disciplines</th>
<th>Designer</th>
<th>Background</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CS1 Graphic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Graphic</td>
<td>Graphic designer</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Design</td>
<td>Producer</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Graphic</td>
<td>Graphic designer</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Graphic/</td>
<td>Graphic designer</td>
<td></td>
</tr>
<tr>
<td><strong>CS2 Architecture</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Architecture</td>
<td>Architect</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Architecture</td>
<td>Architect</td>
<td></td>
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<tr>
<td>G</td>
<td>Architecture</td>
<td>Architect</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Architecture</td>
<td>Architect</td>
<td></td>
</tr>
<tr>
<td><strong>CS3 Interaction</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Graphic</td>
<td>Experience designer</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>Graphic</td>
<td>Interaction designer</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>Multimedia</td>
<td>Interaction designer</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>Graphic</td>
<td>Interaction designer</td>
<td></td>
</tr>
<tr>
<td><strong>CS4 Engineering</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Aerospatial</td>
<td>Control design</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Mechanical</td>
<td>Control design</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>Electronics</td>
<td>Electronics</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>Mechanical</td>
<td>Software design</td>
<td></td>
</tr>
</tbody>
</table>

All interviews were transcribed for data analysis. Statements referring to designers’ value judgment for decision-making were selected. The selected statements were categorized and analyzed, first in interview prints, then secondly, using software for categorization and statistics. The coding and analysis of the interviews’ transcripts were discussed with the second author.

With the purpose to identify variant and invariant characteristics of designers’ value judgment in decision-making across design disciplines this study aims to answer to the following research questions:

*Which invariant characteristics across different design disciplines can be found in decision-making?*

*Which variant characteristics across different design disciplines can be found in decision-making?*

### 6. Findings

Five categories of designers’ value judgment for decision-making were identified across disciplines, namely, emotional, intuitive, rational, experience and constraint-based priorities as shown in Table 2. These characteristics encompass designers’ priorities as individuals with design-oriented value systems and issues that derive from the context of the design situation.

Sub-categories show the content of the priority values through expressions or succinct words. The priority values reported from this sample show issues related with designers’ thinking and acting while conducting decisions. Relevant aspects which determined decision-making in design reported in literature were also found, namely: experience, use of information from...
previous projects, intuition, culture, predicted or unforeseen elements of risk, chain of known and unknown design constraints, unknown design variables and design intentions.

The five main categories can be present in the same situation, and all, one, or a set of some can assert priority. The analysis of frequency revealed common and uncommon, similar and dissimilar incidence of priority values across disciplines.

**Table 2.** Priority values for decision-making across disciplines

<table>
<thead>
<tr>
<th>Main-categories</th>
<th>Sub-categories</th>
<th>Cs1</th>
<th>Cs2</th>
<th>Cs3</th>
<th>Cs4</th>
<th>Standard deviation</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emotion-based</strong></td>
<td>Interest, like what I do</td>
<td>5.13</td>
<td>2.68</td>
<td>5.71</td>
<td>6.14</td>
<td>1.54</td>
<td>4.92</td>
</tr>
<tr>
<td></td>
<td>The sensations to transmit to people</td>
<td>1.92</td>
<td>1.34</td>
<td>6.94</td>
<td>0.00</td>
<td>3.03</td>
<td>2.55</td>
</tr>
<tr>
<td></td>
<td>Feeling of uncertainty</td>
<td>1.92</td>
<td>2.01</td>
<td>0.82</td>
<td>1.81</td>
<td>0.56</td>
<td>1.64</td>
</tr>
<tr>
<td></td>
<td>Start seeing results</td>
<td>2.56</td>
<td>2.68</td>
<td>2.04</td>
<td>3.61</td>
<td>0.65</td>
<td>2.72</td>
</tr>
<tr>
<td></td>
<td>Challenging opposition</td>
<td>3.21</td>
<td>1.34</td>
<td>2.04</td>
<td>0.72</td>
<td>1.06</td>
<td>1.83</td>
</tr>
<tr>
<td></td>
<td>Personal and team emotional evaluation along the process</td>
<td>3.85</td>
<td>2.01</td>
<td>6.12</td>
<td>2.53</td>
<td>1.83</td>
<td>3.63</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>18.59</td>
<td>12.08</td>
<td>23.67</td>
<td>14.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intuitive-based</strong></td>
<td>Feeling that something is wrong</td>
<td>1.28</td>
<td>1.34</td>
<td>1.63</td>
<td>0.72</td>
<td>0.38</td>
<td>1.24</td>
</tr>
<tr>
<td></td>
<td>Feeling certainty about a choice without argument</td>
<td>3.21</td>
<td>2.01</td>
<td>4.49</td>
<td>2.89</td>
<td>1.03</td>
<td>3.15</td>
</tr>
<tr>
<td></td>
<td>Feeling of certainty in changing priorities</td>
<td>0.64</td>
<td>0.67</td>
<td>1.22</td>
<td>1.44</td>
<td>0.40</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Action driven experimentation</td>
<td>4.49</td>
<td>3.36</td>
<td>2.04</td>
<td>3.97</td>
<td>1.06</td>
<td>3.46</td>
</tr>
<tr>
<td></td>
<td>Individual or external sources of inspiration</td>
<td>3.85</td>
<td>6.71</td>
<td>6.53</td>
<td>7.22</td>
<td>1.52</td>
<td>6.08</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>13.46</td>
<td>14.09</td>
<td>15.92</td>
<td>16.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rational-based</strong></td>
<td>Know-how, specific knowledge</td>
<td>8.97</td>
<td>7.38</td>
<td>5.31</td>
<td>5.78</td>
<td>1.67</td>
<td>6.86</td>
</tr>
<tr>
<td></td>
<td>Project management</td>
<td>4.49</td>
<td>3.36</td>
<td>3.67</td>
<td>3.25</td>
<td>0.56</td>
<td>3.69</td>
</tr>
<tr>
<td></td>
<td>Design purpose, goals and direction of procedure towards the solution</td>
<td>10.90</td>
<td>9.40</td>
<td>8.98</td>
<td>7.58</td>
<td>1.36</td>
<td>9.21</td>
</tr>
<tr>
<td></td>
<td>Ethics</td>
<td>2.56</td>
<td>3.36</td>
<td>3.27</td>
<td>1.08</td>
<td>1.05</td>
<td>2.57</td>
</tr>
<tr>
<td></td>
<td>Users satisfaction</td>
<td>0.00</td>
<td>2.68</td>
<td>4.49</td>
<td>1.08</td>
<td>1.96</td>
<td>2.06</td>
</tr>
<tr>
<td></td>
<td>Design problem context, situation and circumstances</td>
<td>4.49</td>
<td>6.71</td>
<td>3.27</td>
<td>2.53</td>
<td>1.83</td>
<td>4.25</td>
</tr>
<tr>
<td></td>
<td>Redo, fine-tuning or reviewing</td>
<td>4.49</td>
<td>3.36</td>
<td>2.04</td>
<td>3.61</td>
<td>1.01</td>
<td>3.37</td>
</tr>
<tr>
<td></td>
<td>Undeveloped Knowledge</td>
<td>0.00</td>
<td>0.67</td>
<td>1.22</td>
<td>2.17</td>
<td>0.92</td>
<td>1.02</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>35.90</td>
<td>36.91</td>
<td>32.24</td>
<td>27.08</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The values represent priority levels across disciplines.
| Experience-based | Framed design choices | 7.05 | 2.01 | 2.04 | 2.17 | 2.49 | 3.32 |
| | Evaluation and association with results and processes from the past | 2.56 | 4.03 | 3.27 | 2.89 | 0.63 | 3.19 |
| | Looking for references | 3.21 | 4.70 | 2.86 | 1.81 | 1.20 | 3.14 |
| | Open mind for new solutions | 2.56 | 2.68 | 2.45 | 3.25 | 0.35 | 2.74 |
| | Experiencing the design situations, foreseeing the experience through simulation | 1.28 | 2.01 | 2.86 | 6.14 | 2.14 | 3.07 |
| | Forseeing difficulties | 1.28 | 2.68 | 2.45 | 3.25 | |
| Total | 17.95 | 18.12 | 15.92 | 19.49 | 0.83 | 2.42 |

| Constraint-based | Time limitation | 3.85 | 2.68 | 2.86 | 5.78 | 1.42 | 3.79 |
| | Financial limitation | 2.56 | 4.70 | 1.63 | 3.97 | 1.38 | 3.22 |
| | Technology conditions | 2.56 | 2.01 | 2.86 | 7.58 | 2.58 | 3.75 |
| | New policies limitations | 0.00 | 2.68 | 0.00 | 0.00 | 1.34 | 0.67 |
| | Client restrictions | 4.49 | 4.03 | 2.86 | 5.05 | 0.93 | 4.11 |
| | Cultural conditions | 0.64 | 2.68 | 2.04 | 0.00 | 1.24 | 1.34 |
| Total | 14.10 | 18.79 | 12.24 | 22.38 | 1.54 | 4.92 |

For comparison the statements frequency is presented in relative numbers based on percentage. In the following the definition of each main category is presented supported by an example of the selected statements.

**Emotion-based priority** is categorized when decisions are made upon the expression of arguments based on one’s circumstances, mood or relation to others. Sub-categories entail value judgment issues related to motivation, communication, uncertainty, seeing results, challenging opposition and emotional evaluation. An example of statement from the interaction design case study is given to the sub-category *The sensations to transmit to people:*

> Interaction, the initial part, the really raw part, what you feel in your guts, the sensation I want others to feel much before thinking.

The statement shows one emotion-based priority value for the creation of design solutions.

**Intuitive-based priority** is categorized when decisions are made upon the expression of arguments based on the ability to understand something immediately, without the need for conscious reasoning. Sub-categories entail value judgment issues related to risk, certainty, priority, experimentation, and sources of inspiration. An example of statement from the architecture case study is given to the sub-category *Action driven experimentation:*

> For example, when we visit the terrain in the beginning of the project, the initial idea we might have doing this visit is the most important one, some people have this idea and I think it is so much important as the opposite, living there for 2 or 3 days and understand how things work, but that first impact is important.

The statement shows the relative importance of the above mentioned intuitive based priority value enriched by an experience-based priority value of *Experiencing the design situation, foreseeing the experience through simulation.***

**Rational-based priority** is categorized when decisions are made upon the expression of arguments based on reasoning and logic. Sub-categories entail value judgment issues related
to know-how, project management, design goal and procedure, ethics, users, design problem context, fine-tuning and undeveloped knowledge. An example of statement from the graphic design case study is given to the sub-category Design problem context, situation and circumstances:

I try to fully understand the information they passed on to us and which will be our guideline. It’s just like a casting, when you are doing a casting for a commercial you have to know exactly what you want. We have to know exactly what kind of image we’ll use, what font we’ll use, what is the context, what is the epoch...several things like these.

The statement shows the relative importance between the above mentioned priority value and Design purpose, goals and direction of procedure as the rational-based priority values steering designers’ thinking and acting

Experience-based priority is categorized when decisions are made upon the expression of arguments based on practical contact with the subjects and observation of facts or events that derive into mature knowledge. Sub-categories entail value judgment issues related to framed design solutions, references, association with results from the past, open mind, foreseeing the experience. An example of a statement from the interaction design case study is given to the sub-category, Experiencing the design situations, foreseeing the experience through simulation:

My process is different and it’s related to people’s experience with things like: go in, coming out, touch, look, check the physical interaction, where are the eyes, where the body stands, etc.

The statement shows the influence of the above mentioned experience-based priority value and the rational-based priority value of Know how, specific knowledge.

Constraint-based priority is categorized when decisions are made upon the expression of arguments based on the limitations or restrictions that reframe the state of affairs. Sub-categories entail value judgment issues related to time, financial, technology, new policies, client and cultural conditions. An example of a statement from the engineering case study is given to the sub-category, Technological conditions:

Robotics is the state of the art and that is a key factor. Robotics depends on a lot of sensory parts, which is a specific area with a lot of new inventions made weekly that you want to try, to build, to see because it runs faster...if you can use these kind of sensors in this kind of robotics you can do away more.

The statements show one constraint-based priority values for the creation of design solutions.

A more detailed analysis shows variants and invariants of priority values across disciplines revealing characteristics of design thinking and acting as well as characteristics that most distinguish each one of the four design disciplines, such as non-specific and dominant issues in value judgment.

6.1 Invariants

It can be stated that the five main categories are priority values across designers’ self reports. The incidence of priority values across disciplines is shown in Figure 1.
Rational-based priority is a dominant category across all design disciplines, although with more emphasis in architecture and graphic design. Emotion-based priority in value judgments is more prevailing in graphic and interaction design disciplines. Constraints-based priority in value judgments is more prevailing in engineering and architecture. Intuition-based priority in value judgment is quite similar across disciplines. Experience-based priority in value judgment also shows similar incidence across disciplines with a decrease in the interaction design case.

The frequency in percentage of priority values per discipline is shown in Figure 2. The categories of priority values that show the highest variation of incidence among disciplines are emotion, constraints and rational-based priority.

Experience and intuitive-based priority values show only a variation of 3%. Intuition-based priority is higher when the constraints and experience-based priority are higher too (Engineering case). Emotion-based is higher when constraints and experience-based priority are lower (Interaction case). Rational-based priority is higher when emotion-based priority is lower (Architecture case). Intuition-based priority is lower when experience and emotion-based priority are even (Graphic design case).

The frequency in percentage of priority values in the 4 cases is shown in Figure 3. The general results show a dominance of 32% for rational based-priority, quite similar rate of 217% for experience, constraints and emotion-based priority values, and 15% of rate for intuition-based priority. Exception to invariants regards five sub-categories for further analysis.
In the following, variants of designers' value judgment across disciplines are distinguished. The observation and analysis of variant rates across sub-categories lead to variant priority values across disciplines. Rate analysis regards non-specific (0.00%), dominant (above 5%) and standard deviation (above 1.50) in the statements frequency deriving into characteristics that make distinctions among the four design disciplines.

Sub-categories of priority values that are absent in one or more design disciplines are shown in Figure 4. Such non-specific priority values are sub-categories such as: the sensations to transmit to people and cultural conditions that are absent in the engineering case sample; users satisfaction and undeveloped knowledge that are absent in the graphic design case sample due to the use of different terminology—graphic designers do not refer to the user, but the reader; and new policies limitations that are absent in 3 cases with exception to architecture—recent new policies regarding buildings energy certification demand for the creation of systematic knowledge and solutions towards a responsive design process.
However, these five sub-categories are still invariant through the architecture case. On the other hand, the sensation to transmit to people as a dominant value judgment shows standard deviation in interaction design, thus is a clear variant across disciplines.

Although not dominant some value judgment issues seem to be important, for example: new policies limitations, cultural conditions and users satisfaction, are equally important in the architecture case; undeveloped knowledge and users satisfaction are still important value judgments to the engineering case; the sensation to transmit to people and cultural conditions are still important value judgments to the graphic design case; and users satisfaction, undeveloped knowledge and cultural conditions are still important value judgments to the interaction design case. Such variance is shown in Table 3.

Table 3. Variant priority values across disciplines

<table>
<thead>
<tr>
<th>Sub-categories</th>
<th>Graphic design</th>
<th>Architecture</th>
<th>Interaction design</th>
<th>Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>The sensation to transmit to people</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Users satisfaction</td>
<td></td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Undeveloped knowledge</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>New policies limitations</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultural conditions</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
</tbody>
</table>

Sub-categories of invariant priority values that show incidences above 5 in one or more design disciplines are shown in Figure 5. Two value judgment issues are dominant in the engineering case, namely, technology conditions and foreseeing the experience through simulation. The other 3 disciplines show one dominant value judgment issue, namely: framed design choices in graphic design; design problem context, situation and circumstances in architecture; personal and team emotional evaluation in interaction design.

Figure 5. Dominance in invariant priority values across disciplines
7. Results and discussion

The following variant and invariant characteristics of value judgment in design across the four design disciplines can be asserted:

a. **Invariant priority values**,
   Five main categories of 26 sub-categories have been created from the interviews and they all show significant frequency across disciplines.

b. **Variant priority values**, 
   Five sub-categories are variant priority values namely, users satisfaction, undeveloped knowledge, new policies limitations, the sensations to transmit to people and cultural conditions, across disciplines.

c. **Variant incidence of invariant priority values**, 
   Non-specific and dominant priority values are asserted per discipline.

The inference of priority values in designers' value judgment for decision-making contributes to the knowledge of similarities and differences across designers and design disciplines. In spite of the diversity of designers value systems, commonalities and differences can be inferred from designers' reports of their actions related to value management.

A generic-design hypothesis was proposed in the past (Goel & Pirolli 1992) and recently augmented to a cognitively oriented generic-design hypothesis of “design as one, but in different forms” (Visser 2009). Several researchers attempted to demonstrate similarities and differences across design and non-design disciplines. Relevant aspects have been addressed such as, similarities and differences of cognitive processes in different fields of design (Akin 2001), differences in terminology across design disciplines, (Reymen et al. 2006), designers particular forms of knowledge (Cross 2006), the artifacts characterizing the design discipline as the variable underlying the differences across disciplines (Hubka & Eder 1987). However the later generic-design hypothesis claims for more and augmented empirical evidence and validation (Visser 2009).

Results derived from this research are proposed as contribution to the later generic-design hypothesis (Visser 2009).

8. Conclusion

Priority values for decision-making in designing are proposed as variant and invariant characteristics of designers’ thinking and acting. The research argues that design as a process of decision-making, integrates invariant priority values across design disciplines. These priority values may help to establish a kind of support to a better understanding of language between disciplines at the moment they know they have a common value system.

The empirical evidence of such characteristics contributes to transdisciplinary knowledge on decision-making in designing. The present contribution supports the notion of design thinking and acting as a cognitive frame that can be acquired and embedded through personal development and experience and is extensive to all the fields of human action. Ultimately, the research aims to contribute to the inflowing of designing in the field of management (Verganti 2009, Brown 2009), as an emergent skill to acquire.
Further work

Based on the findings of the present study, the research aims to answer to the following research question,

*How do designers deliver value to the design process and results?*

Further studies on the analysis of design meetings based on data collected in the same case studies will hopefully provide insights on how to cope effectively with value consistent and value inconsistent elements of designers’ thinking and acting.

Acknowledgements

The empirical study was feasible due to the support of atelier Henrique Cayatte, Ydreams, João Álvaro Rocha Architects and the Delft Center for Systems and Control. The authors gratefully acknowledge the opportunities to share their design environment and participation in this research. The research reported is funded by FCT-Portuguese Foundation of Science and Technology, which is thankfully acknowledged.
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Animal innovation: A window into design thinking

Andy Dong
The University of Sydney, Sydney, Australia

Emma Collier-Baker
The University of Queensland, Brisbane, Australia

Thomas Suddendorf
The University of Queensland, Brisbane, Australia

Abstract

Observations of animal innovations range from tool making by chimpanzees to elaborately decorated nests made by bowerbirds. Such behaviors raise fundamental questions about the evolutionary origins of design thinking. While none of these behaviors constitute what we would describe as design per se, specific cognitive mechanisms that make up what we describe as design thinking may exist in other species, even if they do not exist as a complete 'package' or to the same degree of skill as in humans. Animal innovations thus provide a unique window into the human faculty of design. In this paper, we discuss two cognitive characteristics, meta-representation and curiosity, and argue that they have a central role in the origins of design thinking.

1. The origins of design thinking

Designing is a paragon of a highly complex functional capacity in humans because it entails the capability to mentally imagine and plan out a material artifact de novo in the absence of any prior sensing or knowledge of that artifact.

By as early as 100,000 years ago, when the earliest evidence of symbolic design appears in engraved ochre (Henshilwood, d’Errico & Watts 2009), it is likely that early humans (homo sapiens) were modifying the world to suit their needs for survival; in other words, they were designing. By 70,000 years ago, they were making bone tools following deliberate production methods (Henshilwood et al. 2001) and using complex adhesive compounds to attach handles to tools (Wadley, Hodgskiss & Grant 2009). They were also beginning to create ornamental objects using, for example, shell beads (Henshilwood et al. 2004). These findings raise two important questions relevant to design thinking.

The first question is why human beings design many more artifacts than other animals. It has been argued that cultural preference for novelty can drive variation (Martindale 1990). The concept of culture is not exclusive to human societies though and has been attributed to chimpanzees (e.g., Whiten et al. 2001) and orangutans (e.g., van Schaik et al. 2003). Since culture is often defined by variations in patterns of behavior in the absence of plausible environmental explanations, an innate capability for representational variation must logically precede culture. Others have argued that sexual selection would have led to a reproductive advantage for those with creative skills (Miller 2001). Their explanation necessarily entails that females are the ‘choosy’ sex, and that males must display behaviors that females prefer. Males who are creative, that is, have the ability to produce an idea or behavior that is both novel and useful (Simonton 1999), would have a reproductive advantage. This advantage generated a selection for brain
functions that facilitate creativity, leading to runaway selection for creativity and hence increasing variety in cultural artifacts and practices. Thus, while social factors are recognized as an important extrinsic factor for novelty production, designing requires a cognitive capacity for novelty that cannot be pre-determined by social or environmental factors alone.

The second question, and the main concern of this article, is what set of design thinking skills are also skills animals possess to behave creatively and thereby produce innovations [1]. Creative outcomes can arise through a variety of behaviors. Not all are necessarily based on a mental representation of the external world and of processes acting on the world to achieve a desired outcome, which is a requirement of a cognitive view of design thinking; however, there is evidence of animal innovation not attributable to mimicry [2] or accidental discovery in nonhuman animals.

In this paper, we look to other species that exhibit creative and innovative behaviors as a way to identify the cognitive processes that may underlie human design thinking [3]. We define animal innovation as the cognitive mechanisms and social processes that enable nonhuman animals to produce novel and useful behaviors (creativity), and for social groups to then adopt these new behaviors or cultural artifacts (innovation). Ever since Masao Kawai published the first observation of animal innovation by the female monkey (macaca fuscata), Imo, who discovered the process of washing sweet potatoes (Kawai 1965), there has been growing attention towards the capacity of nonhuman animals to innovate. Animal innovations provide a unique window into the evolution of the human capacity to design in two ways.

First, innovations have been recorded for all great ape species, with which we share a common ancestor. Chimpanzees can introduce behaviors that are otherwise absent in other chimpanzee populations. They exhibit a wide variety of cultural variations in tool use, for example in their preference for using wood or stone hammers and anvils to crack nuts, even when both materials are available. Unique behavioral traditions have also been observed in chimpanzees, for example ‘rain dances’ (Whiten et al. 2001). Orangutans produce innovations in the way that they obtain food, make nests for sleeping and resting, recruit and modify objects for comfort and protection (such as leaf umbrellas), and produce signals for social communication (van Schaik, van Noordwijk & Wich 2006). Innovation processes in orangutans take multiple pathways including applying old knowledge to new problems and independently working out a solution to a problem (Russon et al. 2010). The high genetic similarity between humans and the great apes demands an explanation for the gradual, intermediary steps in the evolution of homologous cognitive skills underlying the type of design-led innovations exhibited by humans.

Second, innovations by species outside the human lineage, such as bowerbirds, have been recorded. Bowerbirds build elaborate bowers (nests) to attract females. The bowers may be up to 3m high and up to 4m in diameter, and are normally decorated with a diverse range of materials (Diamond 1986). The ability of the male bowerbird to build a nest of high quality and aesthetics (Wojcieszek, Nicholls & Goldizen 2007) correlates with its mating success (Coleman, Patricelli & Borgia 2004). The high-level of craft, the number of variables involved, the intraculture variation, and the ‘choosiness’ of the males in selecting materials to get different nest objectives ‘right’ suggests that the cognitive skills displayed by bowerbirds in bower-making appear similar to the kind of design thinking skills employed by humans while designing. If there is any overlap between the skills that allow bowerbirds to behave creatively and for humans to design, these skills are more likely the result of convergent evolution due to the distant relationship between bowerbirds and hominids. The skills most parsimoniously assumed to be homologous traits between humans and primates are the focus of this paper.

While a more complete discussion of the ‘package’ of cognitive mechanisms for design thinking based on biological evidence is treated elsewhere (Dong 2010), in this paper, we will discuss
two characteristics, meta-representation and curiosity, because of their central role in generating design situations and in framing those situations in alternative models.

Before proceeding, we wish to emphasize that our aim is not to conclude that only humans design and animals do not design [4]. Instead, we wish to draw together evidence to establish a cline for capabilities that are likely to have the most significant effect on design thinking. Because the definitions of these two capabilities may not be familiar to the design thinking research community, we first start by defining them and then present a discussion of why they are essential to the evolution of design thinking. Finally we compare these capabilities in light of innovations in nonhuman animals.

2. Meta-representation

Designing, from a cognitive viewpoint, has been characterized as the construction of representations (Visser 2006), and we thus require, in a strong cognitive definition of design thinking, that models of the artifact and behavior to realize the artifact are represented within the mind (Schön 1988). Mental representation of design artifacts and processes is essential for designing (Purcell & Gero 1998), and it is possible to design solely using mental imagery in the absence of external representations (Bilda & Gero 2007).

Such a definition presumes a mind that has symbolic, representational abilities. The study of the development of representational abilities suggests that humans progress through at least three stages (Perner 1991). The earliest stage is one characterized by a capacity for forming so-called primary representations only. These mental representations have a direct semantic relation to the world. The infant creates a single model of its environment that is constantly updated in light of new incoming information. In the second year of life, toddlers begin to go beyond the immediate present and entertain multiple models of the same referent. These so-called secondary representations are evident, for instance, in early pretend play, where the child holds both a representation of the world as it is as well as a representation of imaginary identity. Thus, a stick can become a sword or a horse, and yet the child is not mistaking the real object and the pretend identity. They do not typically (though exceptions prove the rule) actually eat their mud pies. At this stage in development, children demonstrate a variety of other evidence for secondary representational skills (e.g., mirror self-recognition, object permanence, insightful problem solving). Secondary representations are fundamental to our cognition as they allow us to entertain and compare multiple ways of seeing the same thing. In addition to primary representations of the world as it is, secondary representations allow us to imagine how the world was, will be, or could be. As Perner explains, “secondary representations are purposely detached or “decoupled” from reality and are at the root of our ability to think of the past, the possible future, and even the nonexisting and to reason hypothetically” (1991, p.7).

Secondary representation also allows toddlers to interpret the representational content of symbols. Only now do they protest when a picture book is read to them upside down (DeLoache, Uttal & Pierrouxsakos 2000). Indeed, they now appreciate that one thing (say a picture) can stand for another (say one’s house), and can use information from one to inform about the other. Thus, even 24 month olds can be informed about the true location of a hidden object by an adult pointing out its location on a picture or video of the hiding place (Suddendorf 2003). However, they do not quite yet appreciate how a representation represents. This skill only emerges around age three to four.

At this stage children begin to form representations of representational relations. This is known as meta-representation and is evident, for instance, in that children begin to appreciate that others might mis-represent the world. Children at this stage appreciate the representational relation between a symbol and its referent—even, for example, drawing a picture of themselves drawing a picture. This recursion is a crucial part of the human mind, and like the emergence
of secondary representation, is associated with a great range of new behaviors and capacities (Suddendorf 1999).

In short, having meta-representation means understanding that representations have an interpretation. This allows us to compare alternatives, and consider the veracity of various representational relations. This is a fundamental aspect of design thinking since it is at the root of developing alternative useful representations of the same imaginary object that is to be designed. Thus, one can, for example, mentally compare multiple objects that may solve the same design problem, and construct new design situations for which the object is more suitable. Perhaps most crucially, meta-representation is implicated in one of the key skills in design thinking—analogue reasoning. In making an analogy, the designer is making a representational relation between a designed object and its representation, wherein the representational relation can provide a ‘design solution’ to a familiar problem type. The designer could invoke the representational relation as the schema for a new representation, what is known as schema-driven analogising, or transfer the exact design representation in its entirety to a new context, what is known as case-driven analogising in design (Ball, Ormerod & Morley 2004).

There is considerable evidence of secondary representational skills in our closest living relatives, the great apes (Suddendorf & Whiten 2001; Whiten & Suddendorf 2007). Like human toddlers before the age of 4, chimpanzees, bonobos, gorillas and orangutans show some capacity for pretend play; they can recognize themselves in mirrors, solve problems through insight, and reason about the past trajectory of an object. Unlike monkeys and lesser apes, they appear to share a package of these fundamental representational capacities with humans. Given this distribution of secondary representational capacity, it has been argued that it is most parsimonious that great apes and humans have inherited this trait from their common ancestor some 14 million years ago (e.g., Suddendorf & Collier-Baker 2009).

Even our closest living relatives, however, have thus far failed to demonstrate a capacity for meta-representation. For instance, they have consistently failed tasks involving the appreciation of a mis-representation. Thus, this meta-representation appears to be a uniquely human trait. It follows that in this analysis, design thinking is uniquely human and must have evolved after the split from the line that led to modern chimpanzees over the last 5 million years.

3. Curiosity

We have good reason to believe that our insatiable ‘thirst’ for knowledge is what partially drives humans to undertake an extraordinary range of activities to gather information that explains the world around us. Yet, is this ‘thirst’ the same one that drives us to produce artifacts with an exuberant range of variation and sophistication? A wide range of developmental factors and traits could play a role in creating the potential to produce functional and aesthetic diversity and complexity in cultural artifacts (Simonton 2003), but we believe that curiosity is a central component to design thinking.

The emphasis on the role of novelty (neophilia and neophobia) in societies (Martindale 1990) reflects a tendency to downplay the fact that when variations occur, processes of learning and knowledge reproduction were instrumental in generating them. The education of designers requires that students acquire and reproduce the form of knowledge that is valued and cultivated within a discipline so that the student can perform design activities according to the written and unwritten rules of the discipline (Carvalho, Dong & Maton 2009). Since it is spontaneous variation which matters in the generative processes of design wherein a designer responds to the current design situation or produces a new design situation to give rise to an expansion or
projection of possibilities (Dong, McInnes & Davies 2005), the generative properties of associated cognitive mechanisms merit special explanation.

One possible reason for designers’ capability to give rise to new situations may be that the brain is innately predisposed “to seek and create novelty and change” (Mesulam 1998, p.1044). We define this predisposition as design curiosity. While curiosity can incite the goal of seeking out new information, the goal of design is not sated simply by the discovery of new (to the information-seeker) ideas or information-seeking behavior. The widely cited models of curiosity (Berlyne 1954; Litman 2008) simply avoid the issue of the type of feeling one obtains during discovery and invention (Csikszentmihalyi 1996) and that the goal of design is not mastering a subject. Beyond Berlyne’s model of perceptual and epistemic curiosity or Littman’s model of I-type and D-type curiosity, we have a ‘design curiosity’ that can only be sated by the realization (mental or material) of a novel and useful artifact. We can derive satisfaction from mentally imagining an artifact without building it, such as designing our dream home in our heads. In other words, there is an intrinsic curiosity that is satisfied simply by ‘thinking’ about designing.

The combination of curiosity and meta-representation would help to explain how humans loosen the rigid stimulus–response bonds and inhibit a pre-existing representation to try a new one. That is, to even have an ability to appreciate different representational relations, we also need to have an explanation for why the brain would expend the energy to generate new representations in the first place and how the brain evaluates representations to distinguish the mundane and superfluous representation and the novel and useful one. Curiosity may be a primary motivator in the mental activation of alternative representations that provide some advantage in functional or aesthetic utility. Humans consistently direct more attention toward the novel over the familiar when given a choice (Berlyne 1960). Curiosity encourages new ways to model the environment through exploration of novel stimuli and information-seeking behavior, and, for example, asking questions about a stimuli would be an important factor in developing meta-representation skills in children (Maw & Maw 1961).

Curious behaviors, such as investigating novel objects (Mayeaux & Mason 1998), are displayed by birds and advanced mammals, especially primates, but are generally absent in amphibians. Primates tend to be more curious about animate objects than inanimate objects (Jaenicke & Ehrlich 1982). Parker (1974) examined the response diversity of primate species by attaching a knotted rope outside of the animals’ enclosure and observing how subjects explored the object (including body parts used and actions performed). Great apes showed the greatest curiosity and tried out the most diverse range of actions in their object manipulations. This was replicated by Torigoe (1985), who examined 74 primate species. In what is perhaps the most comprehensive study of curiosity in nonhuman animals across species (Glickman & Sroges 1966), zoo animals were given novel objects in their cages. Primate species were the most ‘curious’ in terms of the number of responses to the novel objects, orienting themselves or contacting the objects more often and for a longer duration of time than the other animals. The most ‘interactive’ responses were reported for baboons and macaques who physically manipulated the objects by rubbing or stretching them, possibly to investigate the material potentials of the objects. Similar types of exploration of the properties of potentially useful materials are, of course, central to the study of materiality in design.

This curiosity may have been of critical importance in allowing species, particularly those with opportunistic lifestyles, to adjust to changing or impoverished environments. Animals invent a new behavior or use existing behaviors in a novel context as a way to adjust to a novel context or to respond to environmental stressors or ecological challenges. This is known as behavioral flexibility (Reader & Laland 2003). Clearly, their behaviors are not merely ‘new’, but they must also be ‘useful’ in order to have value and spread as innovations. There is evidence for creativity and innovation in many different species; however, the degree to which these behaviors show variation or complexity may rest in part on representational capacity, curiosity and behavioral
flexibility. Our closest living relatives show the curiosity and representational skills that are rudiments of the fundamental cognitive abilities that allow humans to design. Yet, even great apes appear to be lacking the full ‘package’ of capabilities essential to design thinking.

4. Concluding remarks

We have presented a basic model wherein two key aspects of design thinking, framing and creating situations, are supported by meta-representation and curiosity. The cline in representational capabilities and curiosity from the great apes to humans cumulated in the ability to radically change the world to suit our needs. Some of the cognitive skills that allow animals to innovate may be shared with humans, but perhaps to a different degree. Other cognitive skills may be of an entirely different quality. Identifying these will help us narrow the search for the origins of cognitive mechanisms underpinning design thinking.

We conclude with a brief comment about why we think this is an important question for the design thinking research community. When compared to our capacity for language, we know surprisingly little about the evolutionary origins of the capacity for design, yet, surely, this capacity would have been similarly crucial in shaping the modern world. The design thinking research community is particularly absent in the debate. In terms of the evolution of language, evidence for and theories of its origins are extensive. At present, knowledge about the evolution of design thinking is scant, but certainly design thinking is crucial to our survival today just as it was to our early ancestors.

Notes

1. Innovation is a behavior that is shown in some populations or individuals but not in others and the absence is attributable to lack of knowledge rather than state-dependent or ecological factors (Reader & Laland 2003).

2. While imitation is a key part of the social communication involved in innovation diffusion, the ability to imitate is itself part of a cluster of representational skills supporting innovation (Suddendorf & Whiten 2001).

3. Evidence that representational skills and curiosity are homologous traits shared with the great apes is emerging. However, evidence for representational skills is more complete (Suddendorf & Collier-Baker 2009) than for curiosity (Glickman & Sroges 1966).

4. A principal challenge in making this distinction is, of course, that there is no agreement on a ‘test’ for ‘designing’. Further, nonhuman animals may not ‘design’ because they simply have no need for this behavior.
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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 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:

\[
\text{WHAT} + \text{HOW} \rightarrow \text{RESULT}
\]

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.

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.

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:

\[
\text{WHAT} + \text{HOW} \rightarrow \text{VALUE}
\]

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.

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.

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).

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 to-
gether 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, deliber-
ately creating and maintaining a repertoire of frames in their offices, could inspire develop-
ments 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 ‘surprise’ (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 is-
sues 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 environ-
ment 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
frame

practice
```
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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Thinking About Interaction

Ernest Edmonds
University of Technology, Sydney, Australia

Tom Hewett
Drexel University, Philadelphia, USA

Abstract
This paper is concerned with the complex problem of interaction in design. Interaction is not best thought about in terms of action-response, rather, interaction needs to be understood from a systems perspective. As with human behaviour in general, it is often the case that something said or something seen, may go apparently unnoticed by the designer but have a significant influence much later on. In interaction design our thinking needs to take account of long-term influences as well as short-term responses. We can characterise many of the key issues of interaction design in terms of various forms of engagement. Instant engagement may be important in design for play but growing, long term, engagement is a more significant and larger scale problem for design in general. So, design thinking may often need to consider the complex and rather elusive issues involved in enabling and encouraging long-term engaging relationships. But, how is this to be done systematically? At least one approach to understanding and evaluating the various forms of engagement that people may have with designed artefacts has been developed. Recent results are described and some implications for the nature of design thinking are discussed.

1. Introduction
This paper is concerned with the complex problem of interaction in design. It is concerned with the development of a framework that can facilitate design thinking in this specific area. We, as human beings, interact with many things in our lives, and often with more and more things as we mature and change over time. This active and interactive world provides particular challenges to the designer because the key element of what is being designed is often an interactive experience. The complexity of human experiences with such systems makes thinking about interaction in design difficult. The most used term in relation to one or more properties of interactive systems is probably usability. Brian Shackel, in proposing an operational definition of usability, distinguished four components: effectiveness, learnability, flexibility and attitude. He explained that the last one was concerned that “... satisfaction causes continued and enhanced usage of the system...” (Shackel 1986). In this view, software design frequently requires consideration of likely human satisfaction. Indeed, if interactions are to persist over time we need to be interested in issues beyond “can they use it?” to “will they continue to use it?”

Thus we believe that interaction design is, or should also be, about design for satisfaction and “enhanced usage” as much as it is about ease of use. It is about design for the encouragement and enabling of use and therefore must be concerned with the dynamics of software in use. In discussing the aesthetics of the design of the 1925 Berlin bus, Werner Gräff said: “... and then we realise that the shape of a vehicle must be preserved when it is in motion. That the smoothest line is completely ruined when a bus goes jolting over uneven road surfaces on solid rubber tyres ... ” (Gräff 1926).

In this context, design thinking cannot just be about the breaking down of a problem into parts. Rather, consideration must be given to the dynamics of the software in use over time. It
is the totality of the design that matters, not just its functionality. Corbusier is often quoted in favour of a purely functional view: “A house is a machine for living in”. However, the quotation is normally made out of context. It goes on “Baths, sun, hot-water, cold-water, ... beauty...” (Le Corbusier 1923). This puts quite a different light on it.

In fact, design problems are often considered to be specifications of functional requirements (form follows function). In truth, however, other matters are often more significant as has been amply demonstrated, for example, by Apple with the iPhone and other products. This paper addresses issues relating to designing for interactive experience as against interactive function. We do not wish to downplay the significance of function, but rather we redress the balance between considerations of function and experience.

Taking on board this perspective suggests that interaction is not best thought about in terms of action-response at all. Rather, interaction needs to be understood from a systems perspective, each part or component is not just a part or component alone, rather it is in relationships with other parts and with the whole that must be minded. Sometimes optimizing a part or component will lead to a suboptimal system as whole. Another characteristic of systems is that they have a presence in time. As with human behaviour in general, something said, something seen on one occasion, may seem to pass by apparently unnoticed but have a significant influence much later on. One example of this in the thinking of designers has been called analogical reminding by Hewett and Adelson (1998). Analogical reminding is what happens when one or more design decisions made in dealing with complex interactions have been triggered by analogy with design decisions or influences from earlier contexts, situations or experiences. Thus in interaction design the thinking needs to take account of long-term influences as well as short-term responses.

Our goal here is to characterise many of the key issues in terms of various forms of engagement that characterizes human interaction with the world. Instant engagement may be important in play but growing, long term, engagement is likely to be more significant for design. So, design thinking may often need to consider the complex and rather elusive issues around enabling and encouraging these long-term engaging relationships. But how is this to be done?

First we need to reflect on experience and engagement with interactive systems and consider ways in which we can think about them in the context of interaction design for long-term engagement.

2. Reflections on Experience in Games and Art

There is a growth area in human-computer interaction research and practice known as experience design, as discussed, for example, by Shedroff (2001). This notion is particularly important to design thinking because it represents a collection of methods and approaches that concentrate on understanding audience/participant/user experience. It does not emphasise the design of the interface, as the early HCI work used to do, but looks instead at human experience and how the design of the behaviour of the system influences it. We can take the important example of the computer game as a relatively rich area, in which explicit design thinking about participant experience has received attention. The computer game arose from the technological opportunities that have emerged.

The design intention in a game can be and often is quite different to the design intention in an artwork. Both may involve the audience/player/user in intense interaction with a computer-controlled device (call it artwork or game) that is driven by some form of pleasure or curiosity. The human, confronted with the artwork (or game) takes an action that the work responds to. Typically a sequence of actions and responses develop and continue until a goal is reached or the human is satisfied or bored. The nature of play, as found in a game, is not infrequently
the subject of an artist’s interactive work and so game and artwork come together at times. Although this is no problem for artists, as recently as 2000 it was still a problem for curators. In the UK’s Millennium Dome (2010) all of the interactive art was shown in the Play Zone and none of it was included in the list of artworks on show. Exhibiting interactive art is still somewhat problematic, but the issues that the artist faces go beyond that because their practice has to change in order to deal with interaction.

The interesting thing we wish to do here is to use reflections on interactive art to go beyond games and examine the different types of engagement and experience that might be encouraged and that need to be thought about and taken into consideration during the design process. For example, in the context of interactive art, Costello has argued that the nature of play can best be understood through a taxonomy that she has termed a “pleasure framework” (Costello 2007). She has synthesized a collection of research results relating to pleasure into thirteen categories. She describes these categories as follows:

*Creation* is the pleasure participants get from having the power to create something while interacting with a work. It is also the pleasure participants get from being able to express themselves creatively.

*Exploration* is the pleasure participants get from exploring a situation. Exploration is often linked with the next pleasure, discovery, but not always. Sometimes it is fun to just explore.

*Discovery* is the pleasure participants get from making a discovery or working something out.

*Difficulty* is the pleasure participants get from having to develop a skill or to exercise skill in order to do something. Difficulty might also occur at an intellectual level in works that require a certain amount of skill to understand them or an aspect of their content.

*Competition* is the pleasure participants get from trying to achieve a defined goal. This could be a goal that is defined by them or it might be one that is defined by the work. Completing the goal could involve working with or against another human participant, a perceived entity within the work, or the system of the work itself.

*Danger* is the pleasure of participants feeling scared, in danger, or as if they are taking a risk. This feeling might be as mild as a sense of unease or might involve a strong feeling of fear.

*Captivation* is the pleasure of participants feeling mesmerized or spellbound by something or of feeling like another entity has control over them.

*Sensation* is the pleasure participants get from the feeling of any physical action the work evokes, e.g., touch, body movements, hearing, vocalising etc.

*Sympathy* is the pleasure of sharing emotional or physical feelings with something.

*Simulation* is the pleasure of perceiving a copy or representation of something from real life.

*Fantasy* is the pleasure of perceiving a fantastical creation of the imagination.
**Camaraderie** is the pleasure of developing a sense of friendship, fellowship or intimacy with someone.

**Subversion** is the pleasure of breaking rules or of seeing others break them. It is also the pleasure of subverting or twisting the meaning of something or of seeing someone else do so. The theories that contributed to this taxonomy are not discussed here. See more details in the Costello and Edmonds’ paper (2007).

### 3. Reflections on Engagement

Do people become engaged with an interactive system? Is that engagement sustained, and if so, how? What are the factors that influence the nature of the engagement? Does engagement relate to pleasure, frustration, challenge or anger, for example? Of course, designers can use themselves as subject and rely on their own reactions to guide their work. However, understanding audience engagement with interactive works over time is quite a different challenge and needs more extensive investigation than can be achieved through introspection alone.

There are many forms of engagement that may or may not be desired (Edmonds et al. 2006). For example, in museum studies people talk about attractors, attributes of an exhibit that encourage the public to pay attention and so become engaged. They have “attraction power”, in Bollo and Dal Pozzolo’s term (2005). In a busy public place, be it museum or bar, there are many distractions and points of interest. The attractor is some feature of the interactive system that is inclined to cause passers by to pay attention to the work and at least approach it, look at it or listen for a few moments.

The next question that arises is that of how long such engagement might last and we find that the attributes that encourage sustained engagement are not the same as those that attract. Sustainers have holding power and create “hot spots”, in Bollo and Dal Pozzolo’s term. So, presuming that the attractors have gained attention, it may be necessary to start to engage people in a way that can sustain interest for a noticeable period of time.

Another form of engagement is one that extends over long periods of time, where one goes back for repeated experiences such as seeing a favourite play or building often throughout one’s life. These relaters are factors that enable the hot spot to remain hot (or at least warm enough) on repeated experiences. A good set of relaters meet the highest approval in the world of museums and galleries. We often find that this long-term form of engagement is not associated with a strong initial attraction. Engagement can grow with experience. These issues are ones that the designer needs to be clear about and the choices have significant influence on the nature of the interaction employed.
4. A Process Model

Bilda et al. have developed a model of the engagement process in relation to audience studies with a range of artworks (Bilda et al. 2008). The process is illustrated in Figure 1.

Figure 1. Model of engagement: Interaction modes and phases

Note that the engagement mode shifts in terms of audience interaction from unintended actions through deliberate ones that can lead to a sense of control. In some works it moves on into modes with more exploration and uncertainty. Four interaction phases were identified: adaptation, learning, anticipation and deeper understanding.

Adaptation: Participants adapt to the changes in the environment; learning how to behave and how to set expectations, working with uncertainty. This phase often occurs from unintended mode through to deliberate mode.

Learning: Participants start developing an internal/mental model of what the system does, this also means that they develop (and change) expectations, emotions, and behaviours, accesses memories and beliefs. In this phase the participant interprets exchanges, explores and experiments relationships between initiation and feedback from the system. Therefore they develop expectations on how to initiate certain feedback and accumulate interpretations of exchanges. This phase can occur from deliberate mode to intended/in control mode.

Anticipation: In this phase, participants know what the system will do in relation to initiation, in other words they predict the interaction. Intention is more grounded compared to the previous phases. This phase can occur from deliberate to intended/in control mode.

Deeper understanding: Participants reach a more complete understanding of the artwork and what his or her relationship is to the artwork. In this phase participants judge and evaluate at a higher, conceptual level. They may discover a new aspect of an artwork or an exchange not noticed before. This phase can occur from intended/in control mode to intended/uncertain mode.

Comparing these phases with the pleasure framework discussed above, we can see that the categories may be most likely to be found in different phases. For example, discovery might be common in the learning phase, whilst subversion might be more likely in the later phases. In designing for engagement, the designer needs to consider where they sit in this space and what kind of engagement or engagement process they are concerned with.
5. Conclusion

So where has this discussion led us? By drawing from the HCI and psychological work on interaction we can begin to develop a critical language that can enable discussion of the design of interactive systems and can provide a framework that informs creative design practice. Whereas a painter, for example, might be able to think in terms of hue, texture and so on, the interaction designer also needs to think in terms of forms of engagement, behaviours etc. Colour, for example, is hard enough, but we know much more about that than about interaction and so the language of engagement and experience, in some form, within design practice involving interaction, becomes significant.

Interaction design is as valid as any other form. In working, the designer deals with the same issues and faces much the same challenges as in any other kind of design practice. However, each form and each medium has its own set of specific problems and this one is no exception. Interactive behaviour and engagement are key. For the designer, it is not necessarily a matter of coming to clear understandings, however. It might equally be a matter of providing the kind of challenge to our beliefs and assumptions that makes understanding even harder than we thought. That can be how deep engagement is encouraged.

We see that a range of audience experience issues are important for the interaction designer and that research into them is a significant part of the working practice. A range of these issues have been identified, including a set of pleasure categories, an articulation of a developing engagement process and different kinds of engagement over different periods of time. Designers are actively exploring both these factors and new methods that can be employed as part of practice in order to deal with them. It is suggested that researchers in HCI and, in particular experience design, might usefully consider these concerns to see to what extent they might contribute to the broader study of interaction, user and audience engagement.

Of particular interest from a creative design point of view, is that we can see the lists of issues that have been presented as the beginnings of a language with which to discuss the characteristics of interactive works, the intentions of the designers and the reactions of audiences. The work described in this paper, therefore, has the potential to go beyond its immediate implications for design practice and experience design research. It could be used as the basis for the development of a critical framework that extends design analysis to fully embrace interaction. The same framework will be valuable specifically in experience design.

There are some interesting questions for future work that arise from the preliminary analysis presented here. The most obvious one deals with the completeness or incompleteness of the list. What other factors are there that are not listed that will enhance user engagement in/ by the designed experience. Surely this is not an inclusive list. Another question that arises is how the various combinations of factors may differentially impact the designed experience. One of the implications of the position taken here is that various combinations of these factors may have different implications for the user experience. For example, two designers (or artists) with the same goals and intent may very well choose different subsets of these factors or add in something that we've not catalogued as yet. For example, at least one well-known artist chooses to have her work offend viewers as a way of creating engagement with the work. Similarly Shakespeare's Hamlet can be a very engaging experience without being a very pleasant one, while Beethoven's Ode to Joy movement from the 9th Symphony would be totally different in the hands of Schoenberg but, we suspect, equally engaging.

The arguments and examples reviewed in this paper suggest the beginnings of a framework for design thinking about interaction for sustained engagement. We suggest that a design thinker's own engagement should be with things that promote extended use and that this engagement requires dealing with systems rather than actions and responses. We argue that a design think-
er’s engagement should involve reflection on the full range of various forms of engagement over time. Further, a design thinker’s engagement, and that of others, hinges critically not only on initial attraction to a problem but also upon an identifiable set of processes by which we may be able to lead ourselves and others to deeper understanding of interaction, engagement, the design process and the designed experience.

Acknowledgements

The authors gratefully acknowledge the contributions made by the artists and researchers whose work contributed to the ideas developed in this paper and who are referred to in the references. Any errors in the contents of the paper are, nevertheless, the responsibility of the authors.
References


A Comparative Analysis of Sketching Interactions of Designers in Co-located and Distributed Environments

Ozgur Eris
Franklin W. Olin College of Engineering, MA, USA

Nikolas Martelaro
Franklin W. Olin College of Engineering, MA, USA

Abstract

This study is a comparative analysis of sketching interactions of designers in co-located and distributed environments. We are specifically interested in understanding more about the socio-cognitive variables that are associated with gesturing and co-creation, and how those variables are affected by collaboration technologies.

As a part of the study, we conducted experiments in co-located and distributed settings during which subjects responded to a design brief and collaboratively generated product ideas. Co-located sketching interactions were mediated with a whiteboard, and distributed sketching interactions were mediated with a half-duplex high resolution visual communication system. We analyzed the interactions according to a framework that is focused primarily on content creation, content manipulation, and gesturing.

We concluded that a “closed” visual-loop in which the gesturer can confirm if his/her gestures are being observed by the remote party is important for preserving the role of gesturing, and that half-duplex visual transmission of gestures in the context of sketching activity is only partially effective. Full-duplex transmission might be necessary. However, our results also suggest that “requiring” designers to take turns while sketching—an outcome of half-duplex communication—as opposed to merely providing them the option to do so can improve participation and collaboration.

1. Introduction

Ideation is a key dimension of design thinking. In team contexts, it is communication and synthesis driven, and necessitates the use of accessible design representations so that emerging concepts can be collectively manipulated and advanced. During early stages of ideation, physical representations such as freehand sketches and 3-dimensional sketch models play a critical role since they are highly fluid and accessible. However, fluidity and accessibility of such physical representations diminish significantly in distributed settings.

In order to manage this limitation, distributed teams can work with digitized versions of such representations, or directly create and manipulate digital representations within dedicated digital environments. However, these approaches can be problematic.

The first approach is problematic because it rarely leads to co-creation; it tends to result in digital documentation and sharing instead. Scanning hand-drawn sketches and sharing them with distant team members allows one to communicate early concepts, but it does little to support collaborative manipulation of concepts because of the inherent interaction barrier.
The second approach can be problematic because creating highly conceptual representations during ideation in the digital domain often falls short of providing the desired degree of fluidity (one is forced to think in the manner a given software package operates), or of supporting the kinesthetic component of creativity (one is forced to think “inside” the computer as opposed to physically interacting with the representation).

Ishii and Miyake made similar observations, and introduced the notion of “seams” in computer supported collaborative work environments. They argued that visibility of seams result in cognitive load for the users of the collaboration system (Ishii & Miyake 1991).

In this research, our goal is to study how distributed members of a design team can engage each other in the physical domain, where they work with familiar and tangible toolsets, while their actions are communicated in the digital domain in a seemingly synchronous manner.

2. Requirements for a Distributed Ideation System

We decomposed this goal statement into five requirement categories, which are articulated below. Some of the insights that led to these requirements are based on qualitative observations we made while executing industry-sponsored global design projects in an advanced distributed engineering design course the first author teaches. Others are based on the findings reported in the literature.

2.1 Enable and facilitate collaborative sketching.

Although the downstream phases of product development efforts such as analysis and decision making are somewhat supported by various collaborative CAD software, conceptual design activity remains relatively unsupported due to the unstructured nature of the cognitive processes it entails. Supporting distributed ideation presents a stronger need, challenge, and opportunity in this respect. Focusing on collaborative sketching is a good starting point since distributed ideation is often mediated by sketching.

2.2 Result in seamless interaction.

When creating early concept representations, designers prefer interacting with tangible and physical media such as pen, paper, whiteboards, markers, post-its, foam core, etc., since such media enable kinesthetic thinking and fluidity of action. Seamless interaction also means that interaction is synchronous and intuitive.

After conducting a series of case studies on distributed projects in industry in different contexts, Riopelle et al. has argued for the importance of the ability to work synchronously when engaged in complex tasks such as product development (Riopelle et al. 2003). Real-time interaction allows for synchronous editing of representations by all designers with minimum time delay. Time delay should be minimized since it causes the user to not only be unnecessarily aware of the digital environment, but also can frustrate and inhibit creative processes.

Intuitiveness of the interaction is related to the steepness of the learning curve. Since distributed work entails many interaction barriers by definition, interaction with the system should not require the mastery of additional and advanced skills. Therefore, any surface user should be able to pick up the tools and start “creating” in less than 5 minutes. Mastering advance features should not be a requirement for realizing the core functionality of the system.

2.3 Provide all designers equitable access to representations.

The system should not favor one or a set of users over others in providing access to the representations that are being developed. As commonly accepted, diversity of perspective is desirable
during ideation. Therefore, if some users have a higher degree of access than others, creativity can be inhibited. If representations are to mediate common ground as Visser summarizes when reviewing the role of representations in collaborative design work (Visser 2006), then it is only natural that each co-creator has equitable access to the representation in progress.

This requirement is particularly important for distributed work that involves sites with significantly different numbers of participants; if the issue is not managed, the site with the highest number of participants tends to dominate the activity and act as the gatekeeper to representations.

This requirement is also important for how access is controlled locally. For instance, the physical layout of the system should be such that it does not block some participants from interacting with the system because of their physical orientation to the system.

2.4 Provide direct support for gesturing in the context of sketching.

Gesturing is a primary and influential communication channel during design activity (Tang 1988, Bly 1989, Bekker 1995). When designers negotiate representations during sketching, they rely heavily on tacit information channels that work in conjunction with the sketching surface, and gesturing is one such medium. Therefore, the system should provide open channels of communication that capture and transmit gestures in the context of sketching.

Moreover, “proxies” to actual gesturing activity in the form of pointers or annotation indicators that reside solely on the sketching surface often fail to communicate the richness of human gesturing (Roussel 2001)—especially during complex cognitive activity such as designing. There is evidence that suggests overlaying “surrogate” gestures drawn with a pen-based system on a one-way video stream can be effective in enabling remote helper-worker pairs perform physical tasks (as in helper directing worker) such as the assembly of a simple artifact (Fussell et al. 2004). However, that approach would be highly problematic in the context of design activity during which shared complex representations are co-created and negotiated in real-time; sketching of the intended gestures on the shared design representation itself—even if a multi-layer approach was taken—would make the design representation very difficult to interpret and interrupt the activity. Therefore, it is important for the system to be able to communicate the actual gestures directly as opposed to via proxies.

2.5 Allow co-created information to persist within the environment at all sites.

In distributed design work, lack of persistence of co-created information often results in fragmented efforts as representations that have been created in previous discussions are often lost or not recovered in full detail in the absence of a shared physical environment. Also, any revisions that might have been made to representations during intermediate local asynchronous discussions are often not readily visible to the entire team, which limits its ability to synthesize what has been created at remote sites as a starting point for proceeding synchronous discussions.

This requirement highlights the need for a platform on which representations are not only co-created, but also persist, and reiterates the importance of connectivity and synchronization between distributed workspaces. A similar consideration was taken into account when the i-Room was developed as an interactive workspace prototype (Johanson et al. 2002).
3. System Development

We treated the above requirements as a starting point for system development. In conjunction with our own efforts, we reviewed existing commercial products and the literature to identify systems that have already been developed which might meet the requirements.

3.1 Review of Sketching Systems

Initially, we considered pen or touched based commercial sketching systems. Some of those systems are aimed at collaboration, have a relatively low interaction barrier, and can be networked to connect remote parties. However, none of them support direct gesturing in the context of sketching as described in Section 2.4.

During our review of research systems, it quickly became apparent that capturing the sketching activity on a local work surface via a camera and feeding that visual information to a remote location by projecting it onto the remote work surface so that a remote party can interact with it (and the remote activity would be captured and projected in a similar manner to close the visual communication loop) is a very promising approach as it has potential for meeting the first four requirements outlined in Section 2.

This visual connectivity paradigm was first explored in the form a prototype system called VideoDraw (Tang & Minneman 1990). VideoDraw relied on analog technology, and used inclined CRT displays which were positioned in front of the designers as sketching surfaces. There was a separate visual feedback channel that was dedicated to relaying the facial expressions of the designers. As intended, the cameras looking down at the sketching surfaces not only captured the sketching activity, but also the hand gestures of the designers as they interacted with the displays. Based on qualitative observations of a series of unstructured short design exercises, it was concluded that VideoDraw was effective in conveying hand gestures, providing opportunity for synchronous interaction, and allowing concurrent access to the sketching surface.

Tang and Minneman extended their exploration by implementing another version of this visual connectivity paradigm, VideoWhiteboard, by utilizing a vertical back projected screen as the sketching surface, and positioning the cameras behind it directly above the projectors (Tang & Minneman 1991). This allowed for a larger sketching surface and utilized an interaction framework users were familiar with, the whiteboard. However, since the cameras were positioned behind the screens, only “shadows” of users could be observed, and masking effects of the presence of bodies and low projector resolution were found to be limitations.

Ishii and Miyake differentiated between the physical “desktop” activity that takes place on a shared sketching surface and software applications users might run on computers in conjunction with such activity, and brought the computer application medium as an extra and distinct “layer” into the visual connectivity paradigm explored in VideoDraw by developing TeamWorkStation (Ishii & Miyake 1991). Their goal was to reduce the “seams” that exist between the physical sketching and computer support environments, and, consequently, create an “Open Shared Workspace.” Although TeamWorkStation was not evaluated in the context of design activity, it was found to be effective during a short simulated task on the remote teaching of a machine operation procedure. The shared desktop-computer surface was relatively small, and the resolution was reported to be a limitation.

TeamWorkStation was extended by ClearBoard, which had a new feature that relied on the capture of the local user’s image from behind the sketching surface and the projection of that image onto the remote sketching surface together with the image of the local sketching surface (Ishii & Kobayashi 1992). Observation of the functionality of this feature led to the notion of “gaze awareness,” which is the ability to know what part of the sketching surface the remote
collaborator is focused on. Clarity issues resulting from the tilt angle of the sketching surface and the lack of a means to document shared images were identified as limitations.

3.2 System Implementation

The studies reviewed above are promising, but had some common limitations. The prototype systems relied solely on analog technology, which constrained the size and resolution of the sketching surface, and the assessment of their impact on design interactions lacked detailed experimentation and analysis.

Therefore, we decided to implement a version of the paradigm by utilizing modern digital technology, develop a detailed coding scheme descriptive of the key interactions that take place during system use, and conduct quasi-controlled laboratory experiments with the prototype to understand if and how it supports the role of gesturing in a distributed setting as compared to the gesturing activity that takes place in a local setting.

The prototype distributed sketching system (DSS) we implemented uses a high-definition digital camera (1280 x 720) and a large (65” diagonally) high-definition plasma display at each site. The displays are positioned vertically and users draw on them with markers as they would on a regular whiteboard. The screens are covered with protective film, and a regular whiteboard eraser is used to delete marks.

The cameras are centered directly in front of the screens, and capture the content of the sketching surface, the user who is interacting with the surface, and any external objects the user might bring into the view of the camera. The local camera image is fed to the input of the remote display, and vice versa. In order to avoid visual feedback, only one camera is “live” at any given time, so turn-taking is necessary in order to “pass” the visual content between the sites. At the live site’s display, the most recent static image from the other site is displayed, so the information on the remote site is not lost. The user at the live site presses a “pass” button on a small control panel located to the side of the display when he/she wants the other site to be live.

The system also allows the user to save whatever is being displayed on the local sketching surface to a memory location. When either of the users pushes the “Save” button located on the control panel, whatever is on his/her sketching surface—including the image transmitted from the other location—is saved to one of the six memory locations. In order to retrieve a saved image, either of the users can push the “Open” button on the control panel at any time.

Also, each time the “Pass” button is pressed, the last static image from that site is saved on a server. Currently, those images are not made directly available to the users.

4. Experiment Design and Data Collection Methodology

4.1 Experiment Protocol

Six participants worked in teams of two during two 30 minute sessions. In each session, they were asked to develop a concept in response to a design brief. The first session was co-located, during which teams worked on a whiteboard. After the co-located session, we gave them a brief demonstration of the DSS, and asked them to use it for five minutes while sketching anything they wished. Then, they began the distributed session.
After the distributed session, we informally interviewed the participants and asked them to reflect on their experience, and followed up on their responses.

We videotaped the sessions and interviews by using multiple cameras in order to capture multiple facets of the activity, including gestures.

### 4.2 Sketching Environments

The sketching environments were located in the same room in a laboratory. The co-located environment was a 96” x 48” whiteboard that was mounted on one of the walls. The distributed environment consisted of two plasma TVs (57” x 32” each) that were mounted 5” from each other on another wall (Figure 1). Two large foam boards were used to visually separate the subjects from each other; although they could hear each other—as they would over a phone line—they could not see any part of each other’s work spaces without utilizing the DSS.

![Image](image1.png)

**Figure 1.** Images from two different distributed design sessions illustrating sketching and gesturing activity while using the DSS.

### 4.3 Design Tasks

Each design brief asks subjects to respond to a specific problem that a student is likely to run into while living in a dormitory. We formulated the design briefs based on the knowledge that the participants would be students. We wanted to ensure that they could make some reasonable assumptions when analyzing the problem statements outlined in the design briefs since time was limited. This can be seen as an artificial move, as problem framing is a critical dimension of designing. However, for the purposes of the study, we wanted them to ideate as much as possible in order to be able to collect data on sketching interactions.

The first task was to design and communicate a concept for a dorm room which alleviates conflicts resulting from roommates having significantly different sleep schedules. The second task was to design and communicate a concept for managing the dishes in a college dorm room kitchen. Photographs of typical dorm rooms and kitchens were provided together with the design briefs.
4.4 Participants

The participants were undergraduate engineering students who were all relatively familiar with each other since they all attend the same small engineering program. They all have had exposure to design process and ideation fundamentals. Five of the six subjects were not familiar with the DSS. One of them had worked with the DSS during a pilot exercise, which utilized a different task.

5. Analysis Methodology

We analyzed the data by using video interaction analysis techniques. We watched sections of the footage and reflected on our observations individually and as a research team. We also coded the entire dataset in order to deconstruct the overall design activity into a series of sub-interactions over time. We then performed statistical analysis of the coded data in order to compare designer behavior in the co-located and distributed environments according to the codes.

5.1 Inter-coder Reliability

We coded two 10 minute sections from co-located and distributed sessions that were particularly interactive. The co-author, who coded the entire dataset, was the primary coder. We used GSEQ software to compute a time-unit and an event-based Kappa value for each code category with 0.5 second tolerance and 80% overlap criteria (Bakeman et al. 2009). After our preliminary analysis, we discussed the disagreements, and developed and applied additional coding principles as necessary. In general, coding for gestures of any kind was more challenging than any of the other interaction categories. In some cases, it was difficult to distinguish between conversational, task related, and system related gestures. The two Kappa values are documented below ($\kappa_e$ for event-based and $\kappa_t$ for time-unit), and indicate high inter-coder reliability.

5.2 Interaction Codes

The interaction codes evolved over time during our initial analysis and discussions. Their descriptions and kappa values are documented on Table 1.

Note that half of the codes are concerned with actions (including gestures) of designers in the context of system usage. System related gestures are also design task related by definition, whereas non-system related gestures do not have to be. Although it is possible to categorize the gestures according to intent from a more general perspective (Bekker 1995), we wanted to utilize a task-relation distinction since conversational gesturing most likely does not have the same level of influence on design communication as task related gesturing.
Table 1. Interaction code descriptions and Kappa values.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>$\kappa_c$</th>
<th>$\kappa_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create System Content</td>
<td>Marking the sketching surface. Interval starts when marker makes contact and stops when it leaves provided it does not return within 1 second.</td>
<td>.70</td>
<td>.88</td>
</tr>
<tr>
<td>Delete System Content</td>
<td>Deleting marks from the sketching surface. Interval identified as above (eraser rather than marker).</td>
<td>.71</td>
<td>.91</td>
</tr>
<tr>
<td>Gesture at System Content</td>
<td>Gesturing at any content sketching surface by using the hands.</td>
<td>.73</td>
<td>.88</td>
</tr>
<tr>
<td>Task Related Gesturing</td>
<td>Gesturing directly related to the task. Involve subject's body but do not reference system content. Often made to act out a usage scenario.</td>
<td>.76</td>
<td>.89</td>
</tr>
<tr>
<td>Conversational Gesturing</td>
<td>Gesturing with hands during conversation that is not explicitly associated with task.</td>
<td>.73</td>
<td>.93</td>
</tr>
<tr>
<td>Verbalize</td>
<td>Speaking. Interval is determined by when speech begins and ends. Pauses less than 1 second are ignored.</td>
<td>.68</td>
<td>.94</td>
</tr>
<tr>
<td>Access External Content</td>
<td>Looking at representations that are not on the sketching surface such as objects, images or other printed material.</td>
<td>.65</td>
<td>.84</td>
</tr>
<tr>
<td>Annotate System Content</td>
<td>Underlining, circling, or bordering existing content on the sketching surfaces, often while verbalizing.</td>
<td>.64</td>
<td>.37</td>
</tr>
</tbody>
</table>

5.3 Statistical Analysis of Coded Data

We explored the coded data using two different units of analysis: the individual designer and the design team of two. For each interaction code, we computed descriptive statistics for the co-located and distributed settings. Moreover, we determined the cumulative durations for each interaction category, and calculated the incidence of the interactions per hour. We normalized the interaction durations by session duration since there was some variation in the length of the sessions (up to 5 minutes per session). Finally, we conducted paired t-tests between the co-located and distributed settings to test for differences in the coded interactions.

6. Results

Qualitatively, each team was able to finish the design task in each setting approximately within 30 minutes. Teams did not exhibit any significant difficulty in utilizing the DSS, and their transition from the whiteboard to the system was much smoother than we expected.

Statistical analysis of the coded data yielded the interaction trends that are plotted in Figures 2 and 3 when the unit of analysis was considered to be the individual designer.

When we compared the mean cumulative interaction durations in between the distributed and co-located settings, we observed the following differences: CreateSystemContent and DeleteSystemContent interaction durations increased ($p=0.09$ and $p=0.02$ respectively), whereas AnnotateSystemContent, AccessExternalContent, GestureatSystemContent, and TaskrelatedGesture interaction durations decreased ($p=0.06$, $p=0.04$, $p=0.03$, and $p=0.07$ respectively).
When we compared the mean incidence of interactions in between the distributed and co-located settings, we observed the following differences: DeleteSystemContent and Verbalize interaction rates increased (p=0.01 and p=0.07 respectively), whereas AnnoteSystemContent, AccessExternalContent, GestureatSystemContent, TaskrelatedGesture and ConversationalGesture interaction rates decreased (p=0.04, p=0.03, p=0.07, p=0.09 and p=0.10 respectively).

Figure 2. Mean cumulative interaction durations for the 6 subjects as a proportion of session time for co-located and distributed experimental settings. Error bars indicate standard error. n=6.

Figure 3. Mean incidence of interactions for the 6 subjects for co-located and distributed experimental settings. Error bars indicate standard error.
With the exception of Verbalize interactions, the trends are the same for the incidence and cumulative duration measures. When the unit of analysis was considered to be the design team of two, the trends were identical for each interaction category, but the statistical significance for most of the categories decreased.

7. Discussion

7.1 Content Creation and Deletion

In the distributed setting, subjects spent more time creating and deleting content, and had those interactions more frequently.

It can be postulated that the increase is due to any interaction barriers the DSS might have introduced. Although we observed some limitations, we did not observe significant interaction barriers—to the extent that interactions broke down and work flow was interrupted [1].

Also, we conducted an exploratory analysis by pooling the interaction interval durations, and could not identify differences in the mean durations of create and delete content interactions in between the two settings. If interacting with the DSS was problematic, it would have been natural for mean interval durations to be higher in the distributed setting (it would have taken longer to draw and delete content).

One explanation for this trend might be that the DSS provides more physical space for the subjects by allowing them to co-exist in the same location relative to the sketching surface; designers can simultaneously work on the same part of the sketch without interfering with each other. Also, during the debriefings, some subjects mentioned that they found it easier to contribute while using the DSS not only because they felt they had more freedom as to where they can in relationship to the sketching surface, but also because they had more mental and personal “space” due to that physical freedom.

Some of the subjects made similar observations when we asked them about the effect of both parties not being “live” simultaneously. The deliberate passing of “live” status from one subject to another (we found it natural to refer to this dynamic as a “tennis match” during the debriefings) seems to have given some subjects more room to plan and articulate their own contributions to the concept under development on the sketching surface while not being “live.” One subject used the term “parallel processing” when referring to this affordance. However, other subjects mentioned that they would have preferred being continuously “live” in order to achieve more synchronous communication.

It should also be noted that the total sketching area of the individual DSS stations was less than the sketching area of the whiteboard, which might have resulted in more deletion. However, that difference might be offset by the ability of each subject to access his/her own dedicated surface in the DSS.

There might also be task related effects. Although we tried to develop the task statements so that they would lead to similar levels of exploration through sketching, that is impossible to control. In order to compensate for this, we rotated the tasks in between the settings for the third experiment. However, we conducted an odd number of experiments, so one of the tasks was addressed twice in the co-located setting, and only once in the distributed setting.

Also, it can be postulated that the subjects became familiar with each other during the co-located session, and therefore were able to spend more time creating when they moved to the distributed session. However, as noted earlier, subjects were already familiar with each other prior to the experiment.
A much more interesting explanation surfaces when the behaviors of participants are considered individually as opposed to the aggregate outcomes. For the co-located sessions, the content creation ratios among the six participants were .34/.66, .59/.41, and .72/.28 for the three sessions respectively. For the distributed sessions, the ratios were .42/.58, .52/.48, and .54/.46. Clearly, in each group, the ratios became closer during the distributed sessions. Therefore, it can be argued that participation among the teammates was more even, and that more even participation resulted in more content creation overall.

### 7.2 Gesturing and Annotation

In the distributed setting, subjects spent less time gesturing (all type of gesturing) and annotating system content, and had those interactions less frequently.

Based on our observations and the reflections of subjects, this seems to be mainly an attribute of a general sense of being less connected to one’s teammate in the distributed setting, which is expected.

More specifically, we think the main limitation might be the absence of visual feedback during gesturing and annotation; if one cannot confirm that one’s gestures and annotations are being observed and understood by the other party, one is less likely to gesture and annotate.

However, it should be noted that gesturing and annotation activities did not vanish in the distributed setting, but they did decrease by 30%-50% in duration (task related gesturing duration decreased by approximately 80%).

In the co-located setting, we observed that subjects often made direct eye contact with the other party at some point while they were gesturing. This observation prompted us to conduct additional analysis of the gesturing activity in the co-located setting, and also allowed us to put Ishii’s findings on “gaze-awareness” in context (Ishii 1992).

More specifically, we further differentiated the gesturing durations according to the participants having eye-contact or not. Making that determination is difficult since it is not possible to decipher if subjects are looking directly into each other’s eyes. Thus, we made an approximation by focusing on and identifying the segments during which both subjects were looking directly at each other’s faces. If one subject turned his/her head away from the other (such small movements are clear) or the eyes were visibly not looking toward the other subjects face, we did not code the event as eye contact. We then calculated the proportion of the gesturing activity during which participants had eye contact at least once (in many gesturing segments, there were multiple instances of eye contact, but those segments were contacted as one overlapping instance). The results of that analysis are summarized on Table 2.

<table>
<thead>
<tr>
<th>Table 2. Proportion of gesturing activity during which designers had eye contact while sketching on a whiteboard (system refers to the whiteboard in the co-located setting).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gesturing Instances</td>
</tr>
<tr>
<td>Eye Contact Overlap (%)</td>
</tr>
<tr>
<td>62.1%</td>
</tr>
</tbody>
</table>

These results confirm our qualitative observations; participants made eye contact at least once during half of their gesturing actions. There is variation among the different types of gesturing. However, it is not surprising to see that there is less eye contact during the type gesturing activity that requires the gesturer to focus on external representations such as whiteboard content and printed material.
7.3 Verbalization and Accessing External Content

There was no difference in the total amount of time subjects verbalized. There was a very slight decrease in the frequency of verbalization in the distributed setting.

We do not have a very specific interpretation of this result. It can be postulated that this interaction category is correlated with most of the other interaction categories. For instance, if one creates less content, there is less material to discuss, and one often speaks while gesturing and annotating. Regardless, the finding demonstrates the relevance and criticality of the auditory communication channel in both settings since verbalization occurs for over 40% of a session per subject on average.

On the other hand, subjects spent considerably less time accessing external content in the distributed setting, and did so less frequently.

When we viewed the videos and plotted and inspected the coded activities over time, we observed that subjects tended to access external content simultaneously in the co-located setting. In other words, they were more likely to study the design brief and the images as a team. That might contribute to the increased external access durations since that behavior increases the chances of other types of interaction taking place around external content such speaking and annotating.

8. Conclusion

Direct half-duplex visual transmission of gestures in the context of sketching activity is partially effective in preserving the role of gesturing in distributed design interactions (as compared to gesturing during co-located interactions). Full-duplex transmission might be necessary to “close” the visual-loop by allowing the gesturer to confirm if his/her gestures are being observed by the remote party. In co-located settings, the closed visual-loop is often achieved through intermittent eye contact between designers while gesturing.

However, an outcome of half-duplex communication was that it “required” distributed designers to take turns while sketching as opposed to merely providing them the ability to do so. Participants who created less content than their teammates in the co-located setting increased their share of content creation considerably in the distributed setting. Therefore, “structured” turn taking might improve participation and collaboration during distributed sketching.

More specifically, structured turn taking can be effective in the sense that:

1. Each designer is strongly encouraged to contribute during his/her turn by the presence of an explicit turn taking paradigm.
2. Each designer is given physical and mental “space” to plan and articulate his/her contribution on his/her sketching surface when “out of turn.” This can lead to constructive parallel processing.
3. Designers have equitable access to the representation if turn taking is exercised democratically. In other words, each subject has uninterrupted access to the representation until he/she willingly ends his/her turn.
9. Future Work

This paper reported the preliminary results of our analysis of this dataset. We plan to perform the following additional analysis to arrive at a deeper comparison of sketching interactions in co-located and distributed settings:

1. Analyze the data to determine how often subjects gesture at or modify content that has been created by a teammate. This might lead to a more detailed understanding of co-creation during sketching.

2. Code the data for questions according to a framework which associates a specific questioning behaviour with design performance (Eris 2004), and explore potential relationships between gesturing and question asking in the two settings.

Finally, we plan to utilize what we learned in this study—especially with respect to gesturing—to redesign the DSS, and conduct additional experiments with more experienced designers.

Notes

1. In one session, work had to be paused when a subject inadvertently bumped a camera. The camera was repositioned and work resumed within 3 minutes. Although this could be viewed as an interaction barrier, the issue is more of an artifact of the prototype implementation.
References


How Tangible can Virtual Prototypes be?
On the Limits and Potential of Going Virtual

Gregor Gabrysiak
System Analysis and Modeling Group, Hasso Plattner Institute
at the University of Potsdam, Germany

Jonathan A. Edelman
Center for Design Research, Department of Mechanical Engineering
at Stanford University, USA

Andreas Seibel
System Analysis and Modeling Group, Hasso Plattner Institute
at the University of Potsdam, Germany

Holger Giese
System Analysis and Modeling Group, Hasso Plattner Institute
at the University of Potsdam, Germany

Abstract
Prototyping is considered to be an effective technique to iterate different design alternatives and communicate ideas to end users as part of the design thinking process. While prototypes of tangible objects enable end users to experience first hand whether the embodied concepts fulfill their needs, it is more difficult to achieve the same for the design of complex non-material systems. Usually, their inherent complexity cannot be represented by physical prototypes but only by conceptual models. In this paper, we propose the idea of virtual prototypes which allow intangible conceptual models to become tangible by means of simulation and visualization. The idea is explained referring to an existing approach of virtual prototypes for designing complex multi-user software systems. By transferring the notion of prototyping in domains dealing with inherently intangible concepts we strive to enable design thinking within these domains as well.

1. Motivation
Prototypes are an important element of the design thinking process. Different prototypes can provide different representations of design ideas and specific characteristics of each prototype have a major impact on the way people understand and react on the embodied design ideas.

Additionally, prototypes can help to establish a common understanding between design thinkers and end users as well as between design thinkers themselves. Furthermore, prototypes can facilitate discussion during divergent project stages and agreement in convergent stages of a project.

Prototyping typically aims at creating tangible representations of design ideas. Schön pointed out that ‘we have to externalize our ideas so that the world can speak back to us’ (Lim, Stolter-
man & Tenenberg 2008, p.9). Depending on how well end users can experience and perceive a prototype, they are able to judge and evaluate the design idea or even the rationale behind it. This, however, is quite difficult to achieve for designs or ideas concerning inherently complex intangible or non-material concepts, e.g., for the design of software systems.

Current prototyping practices of software systems development focus on the articulation of graphical user interfaces (GUI) using a broad range of approaches from paper prototyping (Snyder 2003) to evolutionary prototyping implementations that evolved based on evaluations till the prototype is suitable for production (Bäumer et al. 1996). However, these prototypes usually represent an individual and isolated end user's perspective on the system to create. Therefore, such prototypes are not suitable to elicit feedback about the underlying concepts of how activities are executed and intertwined or how an innovative software solution could support them. Instead, these prototypes mainly address usability issues. Thus, while the end users can judge whether the system is built right, i.e., usable for them, they can hardly answer whether the right system is built, i.e., suitable for the task it was designed for, since only a holistic view of all the intertwined perspectives could answer this question.

The goal of this paper is to discuss how prototyping in form of virtual prototypes [1] can also be effectively employed for design challenges dealing with non-material concepts, e.g., software-intensive multi-user software systems. We discuss the requirements and opportunities of such an approach.

Section 2 discusses prototypes as a possibility to communicate design ideas. Then, modeling, how it is used to describe abstract and intangible concepts, and its relation to prototyping is illustrated in Section 3. Section 4 provides a brief overview of the domain of multi-user software systems. Virtual prototypes and how they can bridge the gap between intangible concepts and prototyping is then discussed in Section 5. We also present our approach for complex software-intensive systems as an example. Finally, we end the paper with a discussion and some conclusions.

2. Prototypes

In Design Thinking, prototyping serves a central role. It is through the prototype that designers communicate and negotiate ideas among team members, users, and managers. Prototypes afford designers with a shared vision of their nascent projects, as well as enabling externalization of their private mental models. Indeed, it is the evolving series of shared prototypes that provides the glue which holds a project together, while grounding development in empirical feedback and data.

Early conceptual prototypes allow development and examination of many ideas, quickly and inexpensively. Critical function prototypes, on the other hand, are used for testing the viability
of an idea from an engineering perspective. They address basic functionality issues without having to build an entire system first. Finally, user prototypes are geared towards leveraging the knowledge and expertise of the end user. These issues are best explored before a product has been optimized for manufacture.

For Brown (2009, p.92), a prototype is ‘anything tangible that lets us explore an idea, evaluate it and push it forward.’ As presented in Figure 2, a design idea has certain properties depending on the design challenge. E.g., a design idea of a novel design for cups includes physical properties such as weight, size and form of the handle. To validate whether these properties are feasible, prototypes can be created. As Lim, Stolterman & Tenenberg (2008, p.10) argue, prototypes are manifestations of design ideas that ‘filter the qualities in which the designer is interested without distorting the understanding of the whole.’ Consequently, end users need to be able to recognize and interpret these relevant or filtered properties correctly to provide suitable feedback about them. Physical prototypes, as illustrated in Figure 1, can be touched, experienced and evaluated by domain experts or end users whose needs and expectations should be satisfied by the presented concept or solution.

Figure 2. A design idea is externalized and relevant properties are manifested.

In Figure 2, the property weight of the design idea was considered relevant while the size was ignored for the prototype that was created. Consequently, end users should recognize and interpret the weight' as relevant property to provide suitable feedback about the underlying design idea. Nevertheless, a physical prototype that has a weight also has a certain shape and size. Therefore, properties might be entangled in such a way that it is not possible to consider one specific manifested property without implicitly defining incarnations for others. E.g., a prototype of a cup can be made out of different materials. Each material has its own texture and weight. It is easy to quickly create a prototype whose weight feels right. It is also trivial to create a prototype whose texture feels right. However, it can become quite complex to build a prototype that suits both properties at once. Especially, since these two properties require a trade-off that needs to be well balanced. To avoid such undesirable trade-offs during the highly iterative prototyping, the creation of multiple prototypes emphasizing on different properties is usually more helpful and cost-effective than the creation of few prototypes which try to mimic the envisioned design idea in multiple properties simultaneously. Only when all properties of a possible solution are validated with the end users, the design thinkers can have greater confidence that they will design the right product (Buxton 2007).

As pointed out by Kyng (1995, p.46), 'most representational artifacts work so well not because they mirror that which is represented, but because they do not.' Instead, the representation captures a few intentionally selected qualities of that which is represented and nothing more. The right abstraction permits to discuss only the properties that really matter currently rather
than get lost in details that have not yet thought about. Furthermore, being able to discuss an envisioned solution at an abstract level provokes the people confronted with the prototype to fill in the missing details themselves or question the embodied design decisions.

2.1 Affordances of Prototypes

Gaver (1991) defines affordances as properties of the world that are compatible with and relevant for people’s interactions. This definition of affordances is also suitable to define the end users’ ability to interpret a filtered property correctly. Only if all end users (and designers) recognize and interpret a prototype’s property $p'$ as the manifestation of the design idea’s property $p$, they share a common understanding of this property.

Gaver also argues, that whether an affordance is perceived depends, among other things, on the observer’s experience. E.g., while an architect might be able to envision herself walk through a building she sees sketched or as an architectural drawing, somebody unfamiliar with architectural drawings might not be able to do so, let alone find the entrance of the envisioned building. This dependency on the end user’s individual experience or expertise implies three different choices to achieve tangibility for prototypes:

1. The first option is to build prototypes that offer an affordance by relying on concepts that everybody is familiar with (cf. Figure 3a). Nearly everybody is familiar with the concept of a door handle, thus, everybody could recognize the associated affordances. While it is desirable to create affordances in such a way, it is hardly possible for complex, not as commonly known concepts.

2. The second option would be to teach end users how to perceive new affordances which would otherwise be hidden for them. This can be done by, e.g., showing or teaching them how they can interact with a prototype or how they are supposed to use it. Consequently, the observers gain new experience which allows them to recognize the affordances again (cf. Figure 3b). However, a prototype that initially requires to be explained to all end users to enable them to evaluate the embodied concepts is infeasible for a high number of iterations, i.e., many potentially different prototypes.

3. A third option is to provide an interpretation of the prototype that eliminates the prerequisites a prototype might have. This can be achieved by providing transformations that allow to re-represent the relevant properties of the prototype in such a way that no specific experience or background is required to perceive them and to evaluate the underlying design idea (cf. Figure 3c). This is possible by explicitly relying on the commonly shared domain of expertise of the end users.

Consequently, the suitability of a prototype for an end user or a group of end users depends on the prototype’s prerequisites on the background of the person that needs to judge the prototype.

**Figure 3.** Designers have different possibilities of creating affordances that can be perceived intuitively.
3. Modeling

Modeling is an essential activity for all engineering endeavors. We capture existing systems in models to analyze and understand them or we use models to envision future systems and analyze them to ensure that they have the properties we require. Models are usually seen as an abstraction of the reality. By emphasizing certain aspects, the overall complexity decreases and can be dealt with. As indicated by Rothenberg (1989), modeling is a way of dealing with things or situations that are too costly to deal with directly. The construction of bridges may serve here as an obvious example. The engineers want to know whether the planned bridge withstands the expected load before they build it. To achieve this, they prescribe the planned bridge using models and analyze the models to predict the physical properties of the bridge.

According to Stachowiak (1973), models are abstract representations of existing or envisioned originals that can be characterized by three elements:

- Point of reference: A model is a representation of an original. Consequently, there is always a point of reference. Therefore, we have an abstraction function \( a \) which assigns a model \( M \) to the original \( O \) and a not unique interpretation resp. backward mapping \( i \) which assigns originals \( O \) to each model \( M \).

- Reduction: Not all properties of the original are represented in the model.

- Pragmatics: The model replaces the original only for a specific purpose.

As depicted in Figure 4, the reduction results in a reduced complexity of the model w.r.t. the original as several properties irrelevant for the purpose of the model are omitted. This reduction can result in omitting a property completely, but may also capture only a very rough representation of it instead. This is a critical prerequisite for many analysis or planning activities as otherwise the model would overwhelm the modeler due to its complexity. On the other hand, we have to note that also the model may have incarnations of properties that were considered irrelevant for the reduction. Thus, these superfluous properties do not reflect real properties of the original.

Furthermore, a model can be descriptive, if it abstracts from an existing original, or prescriptive, if the original is only envisioned. In the latter case, which is more relevant for design, the abstraction \( a \) permits to reduce what has to be specified only to those properties that are of interest. Consequently, the interpretation \( i \) is only correct if only the essential properties are deduced for the original. It would be incorrect to rate a model as unsuitable referring to its superfluous properties.

In several domains dealing with abstract and intangible concepts, e.g., software engineering or molecular chemistry, domain specific models enable modeling experts to externalize and communicate their knowledge or ideas. In such a setting, the involved experts will likely share the same interpretation (e.g., \( i \) in Figure 5) and, thus, can effectively communicate concerning the (potentially envisioned) original. If, however, end users are involved as well, a common in-
interpretation can usually only be achieved if the representation of the model mimics the original as intuitive and tangible as possible. Otherwise, unless somebody explains these models, the underlying modeling language, its elements and their symbolic meaning to the end users, they are usually not able to interpret these models correctly (i2 in Figure 5).

In different domains, modeling languages and notations that allow to describe concepts for their corresponding domain were established. Examples are BPMN [2] for Business Processes or the UML and its 14 types of diagrams [3]. Designers are able to externalize their (intangible) ideas as a model by relying on an appropriate modeling language and its agreed upon concepts.

![Figure 5. An envisioned original that is externalized as a model introduces prerequisites for its correct interpretation (i1).](image)

The creation of a prototype to externalize a design idea is obviously quite similar to the creation of a model prescribing an envisioned original. In both cases, somebody has an idea of how a problem might be solved and in both cases this idea is externalized to communicate it to other persons, i.e., other designers or end users. Also, the created artifacts do by definition not reflect all properties of the designer’s idea. Instead, properties are emphasized or ignored.

As mentioned in Section 2.1, Gaver (1991) argued that affordances might impose prerequisites to be perceived. Thus, the main difference between prototyping and creation of a model is the fact that end users need to be able to understand the employed modeling language and its notation to correctly interpret the content. Otherwise, models may only be used to communicate and share ideas among modeling experts.

4. The Domain of Multi-User Software Systems

One particular domain for which we are trying to solve this problem deals with complex multi-user systems. Essentially, two different kinds of systems can be identified. Either only one group of users interacts with the system, all of them in a similar fashion (e.g., Word Processors) or multiple users use the system in different ways, requiring different interfaces and capabilities for their individual tasks. An example for the latter is a Content Management System (CMS), where users enact different roles, e.g., Author or Publisher. Therefore, their usage scenarios are different, but still potentially intertwined. In case of a CMS, an author needs to write articles which are then published by a publisher. Usually, each role has a unique and distinct perspective on the system in terms of which activities it needs to perform and how it should achieve this. Consequently, information and requirements gathered from end users are rarely consistent, complete, or even correct (Pohl 1993). These often conflicting and inconsistent re-
quirements about the system from different stakeholders need to be captured, synthesized and validated to establish a common understanding.

A prototype to validate elicited or envisioned interactions of such a setting requires the creation of a single prototype that all end users can somehow experience and provide feedback about. This is usually not feasible, since it would need to mimic most of the system's functionality, properties and design decisions to provide the information expected by all end users.

Also, due to the rather high costs of creating such a prototype, it is usually not feasible to test many (alternative) prototypes, which would lead to better end user feedback (Tohidi et al. 2006).

Therefore, prototypes are not the standard way to address the design of such systems. Instead, to elicit requirements of complex systems, requirements engineers initially talk to the different groups of users, usually not only the prospective users of the software system (Alexander 2005). However, due to the inherent complexity of requirements for complex multi-user systems and the conflicting user requirements, instead of prototypes that present results of the synthesis in a tangible form, conceptual models of the requirements are commonly used to capture and validate the requirements and resolve conflicts. This holds for all domains dealing with complex multi-user systems. These respective models are not easy to understand, resulting in inconsistent and incorrect interpretations as depicted in Figure 5 (i,j). As discussed beforehand, whether the end users interpret a property correctly depends on their individual backgrounds. Even worse, the end user may interpret superfluous properties by mistake as relevant properties.

Practitioners usually solve this problem by annotating the models in natural language or interpreting them for the stakeholders in face-to-face sessions with them (Al-Rawas & Easterbrook 1996) [4]. Thus, the modeling experts have to create a common understanding, i.e., establish a common interpretation (ideally i) before details can be discussed. Consequently, the success of this establishment influences the communication between the designers and the end users. It is questionable whether the end users are able to provide the same feedback they would when confronted with a tangible model resp. prototype. Then, their own (intuitively correct) interpretation i would allow them to comment directly.

5. Virtual Prototypes

If we could enable end users to experience the consequences of these conceptual models and to comment on what they experience without being hindered to do so by their idiosyncratic formal representation, the employed conceptual models can be used directly as prototypes that enable qualitative end user feedback.

![Diagram](image)

**Figure 6.** An externalized model which imposes prerequisites on understanding needs to be transported back into the end users' domain of expertise.

To close the gap between the conceptual models on the one side and tangible prototypes on the other side, we propose to map the content of these complex models (which were created to
represent concepts of the problem domain on a more abstract level) back into the domain of expertise of the end users.

As argued before, each model can be considered to be a prototype, if the end users can understand its content. By simulating the content of the software-engineering models and representing them to the end users in terms of their effects in their domain, we can enable the end users to understand them. Such effects are usually based on interactions with the end users, actions like prompting the user or reactions to stimuli by the user. By creating such effects through simulation, we provide a common interpretation $i_{\text{common}}$ which can be perceived intuitively (cf. Figure 6).

Of course, for multi-user systems for end users with different backgrounds, each group of end users might need a different visualization of the model within their domains of expertise, similar to the effects observed by Sellen et al. (2009). Thus, consistent end user specific perspectives might be necessary. Similar to design thinking prototypes, different aspects can be emphasized or omitted. This also includes the possibility to adjust the virtual prototype's fidelity by employing different simulation and visualization strategies.

The feasibility of prototypes strongly depends on whether they can be created quickly and inexpensive. Considering the formal nature of the underlying models, virtual prototypes could be derived semi-automatically at virtually no costs. The only prerequisite for that to happen is that a domain specific transformation is defined that maps the available modeling elements and their effects within the end users' domain. After adjusting the software-engineering models by, e.g., omitting parts or emphasizing certain properties, they can be simulated and visualized accordingly.

5.1 Our Virtual Prototyping Approach

For the domain of multi-user business processes, we developed an approach of simulating and visualizing behavioral models specifying the actions and interactions of participants. To validate insights into the current state and prototype how it might be changed, end users can experience what these models specify within their domain. E.g., if a model specifies that a certain information needs to be shared between two users, the recipient might receive the information via (virtual) email within the visualization. Users can also interact with documents within the virtual prototype since all documents afford to be written and drawn upon (cf. Figure 7). The interested reader can find more information about this domain-specific approach from different perspectives. A holistic picture is presented in Gabrysiak et al. (2010a). While the visualization is illustrated in Gabrysiak et al. (2009), a discussion of the underlying software-engineering models and how these are derived automatically can be found in Gabrysiak et al. (2010c). The importance of flexibility, even when using formal models to specify insights, is discussed in Gabrysiak et al. (2010b).
Figure 7. A virtual prototype in a domain-specific visualization for multi-user processes.

One of the strengths of prototypes is the possibility to quickly create them in an inexpensive manner. The same holds for virtual prototypes, since these can be derived automatically for the underlying conceptual models. However, to achieve a common interpretation, these models have to be visualized in a way that can easily be understood by as many end users as possible. This requires the design thinkers to initially implement different kinds of visualizations, at least one for each considered domain. Only then it can be guaranteed that domain experts and end users are empowered to understand what is presented to them. However, the effort scales well, since such a visualization can be reused in other projects as well, apart from minor adjustments.

The two main functions of prototypes are the validation of assumptions about the problem domain gathered beforehand as well as the exploration of design alternatives. Thus, the quality of prototypes depends on their ability to provoke feedback from the end users in such a way that the design alternatives or assumptions embodied within the prototype can be evaluated. By providing such virtual prototypes, the last of the options described in Section 2.1 can be achieved. This is also the best options, since it is the most feasible one for complex systems with multiple users.

6. Conclusion

Using prototypes is important for the design thinking process, but prototypes are feasible only if they provide appropriate affordances that end users can perceive and evaluate. Only then, end user feedback can help to decide whether a certain design direction might prove fruitful. However, in domains dealing with inherently intangible concepts that are typically captured in domain specific models, this calls for a new prototyping approach.

We presented virtual prototypes as a means to close this gap and enable frequent high quality feedback by end users to be captured using virtual prototypes. We have chosen the domain of software engineering to motivate the need of virtual prototypes and to outline our approach. Especially within this domain, the problem of intangibility of complex systems and the underlying design decisions becomes apparent. However, the proposed concept of a virtual prototype
can be employed far beyond this domain whenever intangible concepts are captured in conceptual models. The only condition is these concepts need to have observable effects in the domain of expertise of the end users that can help to make them tangible.

Notes

1. Virtual prototypes should not be confused with Battarbee and Säde’s virtual reality prototypes (2002).

2. Business Process Modeling Notation (http://www.bpmn.org/)


4. This might also be one of the reasons why Neill and Laplante (2003) report from their survey, that 51% of practitioners rather use informal models than (semi-) formal ones (34%).
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Innovation Policy and Design Thinking

John S. Gero
Krasnow Institute for Advanced Study, Fairfax, USA

Abstract

This paper presents the basis for the connection between design thinking, innovation and innovation policy. It suggests that designing needs to be considered within a wider ambit than that of the designer and direct client and that much designing is for consumers who are not the direct clients of the designer. The paper draws the distinction between the producers of intellectual property, the innovators who use that intellectual property and who, through designing, generate products that are adopted by consumers. The relationship of these players is a social one in that many of their interactions are not direct but are indirect, and that these interactions affect their future behavior and the resulting phenomenological behavior of the system as a whole.

The paper presents the outline of an architecture of a system based on computational social science, to study the relationship between designing, innovation and innovation policy and the behavior of funders of intellectual property, producers of intellectual property, funders of innovators, innovators as designers and consumers of innovative products.

1. Introduction

Design research has largely treated designing as an activity involving a single designer or a team of designers commencing with requirements set by a client. The focus has been on the processes that a designer utilizes to generate a design. These processes are deemed to be examples of design thinking—that unique class of thinking that distinguishes designing from other human activity. The primary means of studying designing can be broken into two classes: computational modeling and cognitive studies, with the former predating the latter.

Computational models of designing have treated designing as an algorithmic process. The algorithms have been based either on conjectures about human designing behavior or on processes unrelated to humans. Examples of the former category include analogy and case-based reasoning processes. Examples of the latter category include evolutionary algorithms and neural networks. Computational models so far have drawn their inspiration primarily from either operations research or artificial intelligence (Asimov 1962; Buede 1999; Dym 1994; Gero 1991; Gero 2008; Pahl et al. 2007; Radford & Gero 1988).

Cognitive studies of designing have used an increasing array of approaches commencing with questionnaires and input-output experiments, with the primary method currently being based on protocol analysis (Ericsson & Simon 1993; van Someren et al. 1994). Future methods are likely to be based on cognitive neuroscience (Alexiou et al. 2010).

In all of this research aimed at illuminating design thinking insufficient attention has been given to the place of designing in the production of value in a society. Among a nation's goals are competitive leadership in the international marketplace and excellence in innovation and productivity. Innovation based on creative or at least superior design, a fundamental prerequisite for superior products and systems, is one of the keys for achieving these goals. The aim of this paper is to place designing within the context of innovation and the larger framework of innovation policy. The paper will only present an overall description of this framework.
To commence we draw the distinction between creation, designing and innovation as all three terms, or their derivatives, are often used interchangeably. We will use the term “creation” to apply to the generation of intellectual property that is novel, useful and unexpected. This intellectual property can be in the form of concepts found in research papers, licences, patents or designs (Boden 2003; Gero 1990; Gero & Maher 1993; Runco 2006; Sawyer 2006; Sternberg 1998). We will use the term “designing” to denote that activity that involves the production of consumable artefacts. We will use the term “innovation” to denote the introduction or uptake of intellectual property into products, processes or markets to create value from those products or processes (Archibugi et al. 1999; Edquist 1997). Designing may or may not be involved in the production of intellectual property but is always involved in innovation. The distinction between these three terms and what they imply is important as it is argued that the generation of products and processes is a separate activity from their introduction or uptake although the three are co-related (Hybs & Gero 1992). Innovation policy is any policy targeted at improving innovation.

We define “design thinking” as the process by which a designer creates an expected world different from the current world, operates within that world to produce a design and then brings the design in that expected world and the current world together. From this point of view the production of intellectual property can also be seen to be a kind of design thinking.

2. Designing, innovation and innovation policy

Designing is sometimes carried out for individual clients who are the end users of those designs, but mostly it is carried out for clients who are innovators producing artefacts for third parties here called “consumers”. Economic models of innovation have been developed along with computational implementations (Anderson 1994; Leydesdorff 2000; Moldovan & Goldenberg 2004; Nelson 2002). Recent research into innovation and innovation policy has produced interesting results along with models that are often untestable (Akintoye & Beck 2008; Allen et al. 1983; Archibugi et al. 1999; Branscomb & Keller 1999; Edquist 2005; Llerena & Mireille 2005). Currently there is no adequate, scalable, testable model of innovation policy.

The domain-individual-field-interaction (DIFI) model of creativity by Feldman et al. (1994) provides a framework through which we can explain the interactions between different players and the production of artefacts. Innovation clustering and the emergence of groups of innovations in geographic regions have been studied (Avermaete et al. 2003; Azagra-Caro et al. 2007; Cooke 2001).

2.1 Schumpeter

Schumpeter, in his landmark opus Capitalism, Socialism and Democracy (Schumpeter 1942), introduced a concept he claimed was a fundamental part of the foundation of capitalism and one of the primary causes of its success. He called this concept “creative destruction”.

... the same process ... that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism. ... the problem that is usually being visualized is how capitalism administers existing structures, whereas the relevant problem is how it creates and destroys them. (Schumpeter 1942, pp.83-84.)

This is a profound theory of innovation that, it is claimed, can form the basis of innovation policy. At this abstract level it draws the distinction between the evolution of products, processes and markets being treated as Darwinian systems and being treated as Lamarckian systems. In the Darwinian metaphor systems evolve with small changes and changes to the organism do not affect its genome or fitness function, where the genome may be thought of as the producer
of the organism and the fitness function is the way in which it is evaluated in some market. This form of evolution matches the notion of optimization. In the Lamarckian metaphor, changes to the organism cause disruptions to the genome with the resulting displacement of the previous organism. In addition to disrupting the genome there are also changes to the fitness function, ie, the value system used to evaluate the organism. This form of evolution matches the notion of designing and has the potential to produce transformation. Creative destruction as a model of innovation results in a transformation rather than incremental change. It does so by destroying what was there before and substituting it with another, more creative one, Figure 1.

![Figure 1](image)

**Figure 1.** (a) Original world, $S_o$, (b) new world, $S_n$, is additive in relation to the existing world, $S_o$; (c) new world, $S_n$, displaces part of existing world, $S_o$; (d) new world, $S_n$, displaces all of existing world, $S_o$.

An innovation policy for a system would be one that results in an improvement in innovation and would include this transformative behavior of the system. This class of behavior is an emergent, phenomenological result of the system rather than a direct consequence of entering data into formulas. It is claimed that the behavior of interest is phenomenological since we have no causal models that would form the basis of a computational implementation. So the question arises: how can such a phenomenological view be tested? The remainder of this paper outlines an approach to answering this question.

### 2.2 Modeling innovation and innovation policy

How can we model such an abstract concept in a manner that the contributions of the various inputs, phenomena and the resulting system’s behavior can be inspected and tested? We need to be able to build a “laboratory” where all the variables can be represented, where the resulting interactions between the variables can occur and the consequential, emergent phenomenological behavior made available. Once we do this we can then experimentally study the effects of variables on the production of transformative behavior and induce an innovation policy from this emergent behavior (Kuhn 1996; Thomke 2003).

To reify this we need to draw on a panoply of ideas and methods from the domains of:

- innovation theory
- creative production/design thinking
- computational social science
- social multi-agent systems
- situated cognition
- emergence.

Each of these domains will be briefly introduced and their contributory roles described.

**Innovation Theory:** the conceptual basis of innovation; of interest here is the theory based on creative destruction (Scherer 1984; Schumpeter 1942), later sometimes termed disruptive innovation (Bower & Christensen 1995; Danneels 2004). This provides the foundational ideas for the transformative behavior of systems. The significance of Schumpeter’s theory of innovation is that it implies not only that products are displaced but, more importantly, that these new
products bring new values with them that change the way all displaced and future products will be evaluated. We will describe how this can be modeled using ideas from situated cognition.

Creative production/design thinking: this requires processes that have the capacity to produce novel, useful and unexpected results; we will draw on the research in creative designing and design thinking to model this (Gero 2000; Gero & Maher 1993; Taura & Nagai 2005). We will describe how creative production is ultimately social (Csikszentmihalyi 1996; Feldman et al. 1994; Sosa & Gero 2005). Creative production is the progenitor of innovation.

Computational social science: this models social interactions and simulates the resulting social behavior through the use of computational agents rather than equation-based methods (Castelfranchi 2001; Casti 1999; Epstein 2007; Epstein & Axtell 1996; Gilbert & Conte 1995; Gilbert & Doran 1994; Hegselmann et al. 1996; Macy & Willer 2002; Miller & Page 2007). Computational social science provides the conceptual substrate for the development of this laboratory.

Social multi-agent systems: computational agents are encapsulated computer programs that respond and behave autonomously (Ferber 1999; Jennings & Wooldridge 1998; Weiss 2000; Wooldridge 2002). They can model any system that has goals, beliefs and methods or processes to move towards those goals. They can interact with their environment and other agents. Here they will be used to model different players in a system capable of innovation (Gilbert & Doran 1994; Sosa & Gero 2004; Sosa & Gero 2007). The internal state of social agents includes individual and collective components that gradually go from the individual to group structures such as pair, team, group, community, class, and finally to a society. Social multi-agent systems provide the implementation substrate for the development of this laboratory.

Situated cognition: this set of concepts holds that what you think the world is about affects what it is about for you, i.e., any system operates within its own world view and that world view affects its understanding of its interactions with its environment (Dewey 1896/1981; Clancey 1997). When we say an agent is “situated” (Smith & Gero 2005) we mean that it has a world view that is based on its experience—rather than using the AI meaning that it is embodied in an environment. Being situated is the fundamental construct that allows for the modelling of the changes of the value system brought about by creative destruction.

Situations are the result of being situated and may be thought of as the set of concepts and their relationships that embody the ontology of the world under consideration. This ontology includes the value systems that build expectations about the behavior of the world and are used to take decisions in that world (Gero & Kannengiesser 2004). Changing situations changes the value system of the world and can change the world itself (Gero & Kannengiesser 2009). Situations can change in one of three ways to produce a change in value system:

• concepts can be added or deleted;
• relationships between existing concepts can be added, deleted or modified in strength; or
• concepts can be substituted either for a subset of existing concepts or for all existing concepts.

Emergence: this is the notion that structures or behaviors can be found in a system that were not intentionally put there, ie, they emerged (Finke 1996; Gero 1996; Gero & Damski 1996; Gilbert 2002; Goldstein 1999; Holland 1999; Johnson 2001; Smith & Gero 2001). Computational social science, using multi-agent systems, often aims to demonstrate the emergence of behaviors such as acculturation, groupings, and diffusion, which are a systemic consequence rather than a direct consequence of causal knowledge embodied in predictive equations.
An innovation policy will be an emergent property of the behavior of the system based on the data produced by the simulations carried out in this laboratory.

3. Studying designing, innovation and innovation policy

This paper has argued that designing needs to be viewed within a broader canvas and that design thinking can occur not only at the level of the individual designer or design team but also may be part of the production of intellectual property. Further, designing plays a role in innovation by drawing on existing intellectual property to produce innovative artefacts that are adopted by consumers who are not the direct clients of the designer. Innovation is partly influenced by innovation policy and as a consequence there is a relation between designing and innovation policy. Section 2 has presented an outline of the tools that are required to study such a broad view of designing, innovation and innovation policy. This section briefly introduces the players that go to make up a system that has innovators, who employ designers, at its core.

3.1 Players

The primary players that inhabit this landscape and variously interact with each other are the following.

Producers of intellectual property: these are researchers in universities, research institutes and research centers of companies; designers who work directly for individual clients can also produce intellectual property.

Funders of intellectual property producers: these are government agencies and private foundations as well as the research arms of commercial organizations.

Innovators: these are companies that own, collect, license and purchase intellectual property and, through the deployment of capital, design products that claim to be innovative.

Venture capitalists: these are funders of innovators.

Consumers: these are the people and organizations that purchase the products of innovators.

In addition to the primary players there are secondary players that interact with the primary players, and include the following.

Marketers: these are people and organizations that are contracted by the innovator of a product to magnify its reach with consumers.

Amplifiers: these are people and organizations that are not associated with either the product or the innovator that through their commentary on the product amplify its reach. Typically they are columnists or reviewers in newspapers, journals, websites and blogs.

Gatekeepers: these are people and organizations that are not associated with either the product or the innovator that have the capacity to limit the notifications about the product. In physical stores they are the ones who decide whether to stock a product. Gatekeeping also applies to the dissemination of research results. In this case they are journal editors and conference program directors.
3.2 Objects

In addition to players who perform an active role there are objects that are the exogenous input to various players and the endogenous output of players and the system phenomenological behavior. The objects in this system are:

_Government policies_: typical policy instruments that affect innovation include taxation policies, financial policies, regulatory policies, educational policies and migrational policies.

_Research funding proposals_: producers of intellectual property generate funding proposals that they submit to funding agencies.

_Intellectual property_: this is the output of the producers of intellectual property.

_Venture capital proposals_: innovators generate funding proposals that they submit to venture capitalists.

_Products_: innovators produce products.

_Consumer behavior_: this is part of the system phenomenological behavior of unique importance as it is used to define the success or otherwise of products and is usually measured as the aggregation of the individual consumer’s purchase of particular products.

_System phenomenological behavior_: this is endogenous, collected and collated output from parts or all of the system and include emergent behavior.

Figure 2 shows the players and objects that go to make up the system. Of particular interest is how these players and objects interact with each other. For this we need computational social science modeling.

4. Computational social science modeling of designing, innovation and innovation policy

4.1 Agent modeling

A computational social science model of designing, innovation and innovation policy commences with the primary players and models each as a set of social, situated cognitive agents in an environment such as MASON (http://www.cs.gmu.edu/~eclab/projects/mason/). MASON is a fast discrete-event multi-agent simulation library core in Java, designed to be the foundation for large custom-built Java simulations. All agents embody situated cognition through
their ability to change their value systems based on their social interactions with other agents and the environment. All agents are social in that they respond to direct and indirect interactions with other agents. Direct interactions occur when one agent sends a message to another agent. Indirect interaction occurs when an agent either observes the behavior of another agent or observes some systemic behavior or some object in its environment. Each player agent can interact with and observe agents of the same kind of player as itself or other kinds of players. Each player has the ability to observe a limited range of objects.

4.2 Primary players’ direct and indirect interactions

The direct and indirect interactions among players and between players and objects generate the social model of the system through those interactions. The level and influence of these interactions are endogenous variables in this system.

Funders of IP: these directly interact with government policies and directly with producers of IP who generate funding proposals. They change their values based on both exogenous inputs such as government policies and the submissions they receive from researchers and indirect interactions with other funding agencies by observing what they fund.

Producers of IP: these directly interact with funders of IP through the submission of proposals and indirectly with other IP producers through observing which are awarded funding and by observing the source of the IP is taken up by innovators. They can also interact directly with innovators who can ask them to produce specific IP.

Venture capitalists: these directly interact with government policies and directly with innovators who generate funding proposals. They change their values based on both exogenous inputs such as government policies and the submissions they receive from innovators and indirect interactions with other venture capitalists by observing what they fund.

Innovators: these interact directly with venture capitalists and indirectly with consumers, other innovators and products. The indirect interaction with consumers is through observing consumer behavior.

Consumers: they directly interact with the product and indirectly with each other by observing each other’s behavior and with government policies.

The laboratory is now defined through this social modeling.

4.3 Innovation policies

Innovation policies commence as exogenous variables that influence the value systems of all the players. This laboratory can be run with varying innovation policies. As the social behavior of the system changes with changing value systems of the players based on the direct and indirect interactions of the players it becomes possible to capture that emergent behavior and look for patterns in it that have vectors (directions) associated with existing innovation policies. Those vectors can be used to produce new innovation policies. These new innovation policies can be treated as the feedback to the social model as a control system that has a phenomenological pathway in it.
5. Discussion

This paper has introduced the notion that designing needs to be viewed within a larger canvas than that of the designer or design team itself. It develops a framework that involves the producers of intellectual property that designers utilize to produce artefacts that are taken up by consumers. The activity occurs within a social interaction paradigm where all the players potentially interact with each other either directly or indirectly. An expansion of the space of players to include not just the designer and the consumer of the resulting artefact or product but also the producers of the intellectual property that designers make use of, the intellectual property producers’ funders, the organization of innovators, within which designers work, that uses the intellectual property, and their funders as well as knowledge of consumer behavior.

Within this framework it becomes possible to explore the effects of varying a large number of parameters without having a causal model as the effects are phenomenological and emergent. The phenomenological behavior is a consequence of changing situations within a situated cognition view and of social interactions between the players. Design thinking is located within two production entities: producers of intellectual property and producers of artefacts. Traditional design has focused exclusively on the latter and has taken the view that designing is a one shot process in relation to the requirements initially set by the client. Here, designing is a continuous activity that responds to and leads the consumers of designed products. The framework can be expanded to include innovation policies and their effects on the entire process.

Design thinking becomes an integral part of the entire innovation cycle.

Acknowledgements

This research is based upon work supported by the US National Science Foundation under Grant Nos. SBE-0915492 and CNS-0745390. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.
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Generalizing Design Cognition Research

John S. Gero
Krasnow Institute for Advanced Study, Fairfax, VA, USA

Abstract

This paper presents an argument for the need to have commonly agreed methods of researching design cognition. It introduces an ontologically-based coding scheme capable of being used to determine issues and processes in a design session independent of the design task, the designer or the design situation. This will allow for comparisons of results from different researchers. The paper further argues that a set of standard analyses of the coded protocol is required to allow for the comparison of the results across researchers.

The FBS ontology is presented as one of a number of useful general coding schemes. A set of standard analyses is described that has the potential to produce results that inform the development of both general and detailed understandings of designing. These standard analyses can be turned into an open source computational tool that can perform the analyses in a standard manner and produce results in a portable form.

The paper concludes with examples of the kinds of results that can be obtained and the comparisons that can be made with generalized methods of coding protocols and using general analysis methods.

1. Motivation

The development of a scientific understanding of design requires empirical data from designers designing on which to found and test models of designing. One method of collection of that data is through the study of design cognition. Most models of design assume that designing is a process, rather than being some mysterious activity, and as a consequence design cognition can be studied scientifically. For a field to progress researchers must build on the work of others. Progress in design cognition research has been hampered by the inability of researchers to build on the work of other researchers. This has been caused by a lack of commonly used methods and commonly agreed analytical tools.

Whilst there are many ways of viewing designing the claim is made that the fundamental issues and processes involved in designing are not uniquely related to any particular design task, designer or design situation (Asimov 1962; Coyne et al. 1990; Dieter & Schmidt 2008; Dixon 1996; Dym 1994; Eggert 2002; Eide et al. 2001; Ertas et al. 2008; Gero 1990; Gero 1991; Gero 2008; Hatamura 2006; Lawson 2005; Matthews 1998; Rychener 1988; Ullman 1992) and the issues and processes can be studied independently of the design being produced.

This is not to imply that there is only one way to carry out research into design cognition, rather it is suggested that within a research paradigm there is no commonly used approach to utilizing the source data and that without such an agreement it is difficult for one researcher to build directly on the results of another researcher and that this impedes progress.

Based on a survey carried out by the author there are four primary techniques currently available for studying designers: survey instruments; input-output experiments; protocol analyses; and fMRI-based cognitive neuroscience.
Surveys are not useful in cognitive studies as they are post-hoc and are unable to produce the level of granularity required. They are useful in other kinds of studies of design but not in cognitive studies (Murty & Purcell 2004). Input-output experiments treat the designer as a black box. Useful knowledge can be obtained using this technique but it does not produce any direct evidence for specific cognitive design behavior (Jansson & Smith 1991; Purcell et al. 1996; Purcell & Gero 1996). Protocol analysis is a technique that converts verbal utterances to data that can then be studied. Cognitive neuroscience provides a physiological basis for cognitive activities. Currently, our knowledge of design cognition is insufficient for fMRI-based cognitive neuroscience to provide a useful foundation. Research is still at the exploratory stage in using this technique (Alexiou et al. 2010).

Protocol analysis (Crutcher 1994; Ericsson & Simon 1993; Svenson 1974; van Someren et al. 1994) is a tool that has been used to study design cognition. It has produced results across a variety of domains (Adams & Atman 1999; Cross et al. 1992; Cross et al. 1996; Eastman 1969; Ennis & Gyeszly 1991; Gero & McNeill 1998; Kavakli & Gero 2002; McNeill et al. 1998). However, there has been a significant impediment with the application of protocol analysis in studying designing and this has been the lack of the means to compare the results of different analyses. This has been caused by the use of ad hoc coding schemes applied by different researchers even when tackling the same task. The use of ad hoc coding schemes has previously been recommended as a way of eliciting details from the domain (Ericsson & Simon 1993). This can be seen in the results published in Cross et al. (1996), where different researchers carried out protocol analyses over the same data set. Each research group used their own coding scheme and as a consequence the results are not comparable. Eleven years later in September 2007 a similar exercise was carried out, where different research groups were given the same data set and were asked to analyse it. In the intervening 11 years between the first and second exercise the same problem was still exhibited, namely that each research group used its unique coding method in the protocol analysis, and again it was difficult if not impossible to compare results (McDonnell & Lloyd 2009).

Given the claim that the fundamental issues and processes involved in designing are not uniquely related to any particular design task, designer or design situation, it should be possible to produce general coding schemes for protocol studies that address fundamental issues and processes; a general coding scheme is one that can be used across design domains and design environments.

Designing is not a unitary activity and it is unlikely that a single coding scheme will be capable of capturing all its nuances. However, as in all science, the claim is made that there is a regularity in designing that transcends any individual and it is that regularity that is being studied. An ontology is one means to provide a framework for that regularity. Depending on the focus that is being taken a number of potential ontologies could be constructed, however, very few general ontologies have been produced for designing.

One such exemplary ontologically-based coding scheme has been proposed based on the Function-Behavior-Structure ontology of design (Gero 1990; Gero & Kannengiesser 2004). In this ontology the codes are the issues and the connections between the codes directly map onto design processes, as a result design processes are a consequence of the ontology rather than a separate part of the ontology. The claim for the use of this ontology is based on the widespread reference to it in the design literature. Scholar.google indicates that the two papers, which outline the ontology, have over 900 citations between them. A Monte Carlo simulation of 50 selections from these citations, excluding self-citations, shows the breadth of the disciplines the citations come from, Figure 1. This is not claimed to be the only coding scheme capable of capturing issues and processes, however, it is a scheme based on an existing ontology that is referenced one order more often than other coding schemes. It may be possible to map one ontology onto another but this is not explored here.
In addition to a coding scheme that can be widely used, coded protocols need to be analyzed using either commonly agreed methods or methods that produce results that can be compared.

2. Protocol analysis

Protocol analysis is a rigorous methodology for eliciting verbal reports of thought sequences as a valid source of data on thinking. It is a well-developed, validated method for the acquisition of data on thinking (Crutcher 1994; Ericsson & Simon 1993; van Someren et al. 1994). It has been used extensively in design research to assist in the development of the understanding of the cognitive behavior of designers (Adams & Atman 1999; Atman et al. 1999; Atman & Bursic 1999; Badke-Schaub et al. 2007; Christensen & Schunn 2007; Cross et al. 1996; Ennis & Gyeszly 1991; Gercke et al. 2007; Gero & McNeill 1998; Goldschmidt 2003; Kavakli & Gero 2002; McDonnell & Lloyd 2007; McNeill et al. 1998; Purcell & Gero 1998; Purcell et al. 1996; Suwa & Tversky 1997; Suwa et al. 1998; Suwa et al. 2000; Tang & Gero 2002).

2.1 FBS coding scheme

The FBS coding scheme can be summarized, using the design terminology embodied in Figure 2, with the addition of the symbol R for Requirements. This produces six codes for issues, Table 1.

![Figure 2. The FBS ontology, labels are issues, numbers are resulting processes](image)

Table 1. FBS Codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>Requirements</td>
</tr>
<tr>
<td>F</td>
<td>Future</td>
</tr>
<tr>
<td>Bs</td>
<td>Be</td>
</tr>
<tr>
<td>Be</td>
<td>S</td>
</tr>
<tr>
<td>S</td>
<td>D</td>
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</tbody>
</table>
The processes are directly derivable from the protocol's linkograph. Linkography is a technique used in protocol analysis to study the structure of reasoning of designers (Goldschmidt 1990). It has been used to measure the productivity of designers (Goldschmidt 1995), study creative processes (van der Lugt 2000), and examine the goodness of ideas (Goldschmidt & Tatsa 2005). Linkographs can be of two kinds. A syntactic linkograph is based on the assumption, which is a weak assumption, that adjacent segments are related to each other and are therefore linked. This produces a graph of depth 1. A semantic linkograph is based on the notion that only segments that have a semantic connection are linked. Since each end of a link has an issue associated with it, a link consequently defines a process. Table 2.

Table 2. Processes from FBS Codes, the numbers in brackets refer to the processes numbered in Figure 2

<table>
<thead>
<tr>
<th>Design Process</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Formulation (1)</td>
<td>R→F, F→Be</td>
</tr>
<tr>
<td>Synthesis (2)</td>
<td>Be→S</td>
</tr>
<tr>
<td>Analysis (3)</td>
<td>S→Bs</td>
</tr>
<tr>
<td>Documentation (5)</td>
<td>S→D</td>
</tr>
<tr>
<td>Evaluation (4)</td>
<td>Be←→Bs</td>
</tr>
<tr>
<td>Reformulation I (6)</td>
<td>S→S</td>
</tr>
<tr>
<td>Reformulation II (7)</td>
<td>S→Be</td>
</tr>
<tr>
<td>Reformulation II (8)</td>
<td>S→F</td>
</tr>
</tbody>
</table>

3. Measuring protocols

With a single method of segmenting and coding protocols it is possible to have a unified set of measurements across all protocols.

A number of measurement techniques are employed to obtain information from the two data sets of the segmented protocol and its syntactic and semantic linkographs. It is on the basis of the information produced by these techniques that comparisons between the differences in design cognition can be made.

Standard Statistical Analysis

The statistical analyses can be used to compare the results of one protocol with another. Despite the extensive use of statistical analysis in traditional coding schemes, the ad hoc nature of the schemes does not allow for comparisons between different cases and across different domains. On the other hand, the ontological basis of the FBS coding scheme allows for comparative studies of the statistical results obtained from different cases of design protocols.

The dynamic nature of designing can be measured by using a window of a fixed number of segments and the statistical analysis carried out for that window as it commences at the beginning of the session, with its left edge at segment 1, and then moves a single segment over with the analysis repeated. The movement of the window a single segment at a time is repeated until the window’s right edge hits the last segment of the protocol. For each window position an independent calculation is carried out and assigned to the central segment of that window. Putting the result of calculations together, a dynamic model is produced that shows the changing values of the issues and processes in the course of the design session.

Markov Models

Designers’ strategies in terms of processes can be assessed by producing Markov models of the transitions between segments (Kemeny & Snell 1960; Norris 1998). A Markov model describes the probability of moving from one state to another in a stochastic system. This gives
us the probability of a particular issue following another particular issue. This provides the
foundation for cognitive insight in terms of the transitions of cognitive tasks. We can do the
same for linkographs. The dynamic Markov model can be generated using the same windowing
technique as described for the general statistical analyses.

Cluster Analysis
If we remove all the links in a linkograph and only consider the nodes, we obtain nodes in a
two-dimensional space. Treating each node as a point in the X-Y plane we can statistically de-
scribe a linkograph in terms of the mean values of X and Y—that is the centroid or the average
position of all the nodes, and their deviations in the X and Y axes.

The total number of nodes indicates the level of saturation of a linkograph. Normalizing this
number against the number of links will be the link index as described by Goldschmidt (1995).
A higher mean value of X implies that more nodes appear at the end of a session and a lower
value suggests that more nodes are present in the beginning of the session. A higher mean
value of Y indicates longer linking lengths. The standard deviations show how concentrated the
nodes are clustered around the means.

First passage model
A first passage model (sometimes called a first passage event model) (Kemeny & Snell 1960)
measures the average number of segments that a designer traverses before returning to the
same issue. This is a measure of the designer's focus on an issue. It can be measured within a
single protocol as an overall measure or by dividing up the protocol to determine changes in
behavior during a protocol. As a measure it can be used to compare different protocols.

Entropy models
Further understanding about the behavior of designers can be obtained by examining the
information content of their protocols. Shannon entropy (Shannon 1948) can be used to mea-
sure the information in a linkograph or a subgraph of a linkograph. In Shannon's information
theory, the amount of information carried by a message or symbol is based on the probability
of its outcomes. The more stochastic a system is, the more informative is the definition of its
state. By measuring the entropy of semantic linkographs from different design sessions, Kan
and Gero (2009) argued that there is a potential relation between the productivity of design
activities and the entropy of their corresponding linkographs. Using the same idea about in-
crementally sliding a window along the design session, the dynamic entropy of the session can
be measured. The dynamic entropy only takes the structure of the linkographs into account
and currently ignores the codes in the segments. It is hypothesized that information entropy is
related to fixation, commitment, divergence and convergence in designing.

4. LINK0grapher—a measurement tool

4.1 LINK0grapher
The production of the coded segments from the verbal and video protocol is a labor-intensive
task, as is the production of the linkograph. Attempts have been made to automate some of the
manual tasks. However, these have not yet produced a successful automated or even a semi-
automated approach. The manual analysis of the coded segments and the linkograph is also a
labor-intensive task. With an agreed set of analysis methods it becomes possible to consolidate
the analysis methods into a single computational tool that takes as input the coded segments
and the linkograph of a protocol and produces the results of the analysis in a portable form.
LINKOgrapher (Gero et al. 2011) is one such consolidated measurement tool that carries out the following:

- Standard statistical analyses
- Issues distribution
- Dynamic issues distribution
- Process distribution
- Dynamic process distribution
- Markov model generation
- Dynamic Markov model generation
- Entropy model generation
- Dynamic entropy model generation
- Drawing of linkograph

### 4.2 Typical results from LINKOgrapher

LINKOgrapher outputs its results in both graphical and numerical forms. Figure 3 shows a screenshot of the interface with its graphical output. Figures 4 to 7 show typical graphical output of some of the results from a protocol of 1,280 segments.

**Figure 3.** Screenshot of LINKOgrapher tool showing interface and graphical output.

**Figure 4.** Typical tabular statistics presented as an image.

**Figure 5.** Dynamic issues showing the distribution of design issues across a protocol of 1,280 segments with a window 1/10th of the length of the protocol.
Figure 6. Dynamic processes showing the distribution of design processes across a protocol of 1,280 segments with a window 1/10th of the length of the protocol.

Figure 7. Dynamic entropy showing the distribution of entropy across a protocol of 1,280 segments with a window 1/10th of the length of the protocol.

The graphical form of the results provides opportunities for qualitative analyses. Associated with each measurement, in addition to the graphical output, is a numerical result with which further statistical analyses can be carried out.

5. Discussion

The lack of any common approach to the analysis of protocols of designers designing has limited the utility of the results. Although each researcher and research group can draw conclusions from their own results and make those conclusions available in a qualitative form this does not allow one researcher to build on the results of other researchers. It prevents the direct comparison of results.

Two classes of commonality are required for any empirical field to progress: commonality of representational description and commonality of measurement.

Commonality of representational description: requires an underlying ontology that provides a framework for the knowledge in the field being studied. This does not imply that there is a unique ontology for a field, only that without any ontology it becomes difficult or even impossible to describe the activities and events in that field in a form that can be understood and used by others. Any field will have multiple ontologies to capture its richness and the richness in the cognition of the researchers. This is largely lacking in design cognition research.

Commonality of measurement: is more usual in design cognition research but even here there is a lack of commonly utilized measurements. Whilst most researchers use descriptive statistics to provide a robust measurement very few use these statistics to attempt to describe the dynamic nature of designing. Even fewer use dynamic statistics or other richer measurements.

Through the use of a common ontology with a common measurement it is possible to make direct comparisons between results from different research programs. Figure 8 shows the comparison of design issues distributions in two disparate domains: architecture and soft-
ware, where both protocols were analysed using a common ontologically-based coding scheme to code the protocol and a common measurement.

Figure 8. Comparison between architects and software designers of the distributions of issues.

Figure 9 shows the comparison of design process distribution in two disparate domains: architecture and software, where both protocols were analysed using the same common ontologically-based coding scheme and the same common measurement, which then makes direct comparison possible.

Figure 9. Comparison between architects and software designers of the distributions of design processes.

With commonly agreed analysis tools it becomes possible to disassociate the analysis from the researcher, from the task and from the environment of the task. This will have the effect of allowing results from the following situations to be compared:

- cognitive behavior differences between professional designers and student designers
- cognitive behavior differences between novice and expert designers
- cognitive behavior differences due to the use of tools and the use of different tools
- cognitive behavior differences due to design education
- cognitive behavior differences between individuals and design teams
- cognitive behavior differences due to gender
- cognitive behavior differences when designing in different disciplines.

For any science to progress it must build on the work of others in the field. Design cognition is currently hampered by its inability to do this.
Acknowledgements

This research is based upon work supported by DARPA under Grant No. HR0011-08-1-0024 and the National Science Foundation under Grant Nos. SBE-0750853, EEC-0934824 and CMMI-0926908. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation. Many of the measurement tools were introduced by Jeff Kan in his doctoral thesis (Kan 2008). LINKOgrapher has been designed and programmed by Morteza Pourmohamadi. The assistance of Dr Jeff Kan in the production of some of these results is appreciated.
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The Design-Psychology Indispensable Research Partnership

Gabriela Goldschmidt  
Technion—Israel Institute of Technology, Haifa, Israel

Petra Badke-Schaub  
Delft University of Technology, Delft, Netherlands

Abstract  
This paper distinguishes between Design Thinking and Design Thinking Research, which is the locus of exploration of design cognition, or the cognitive aspects of designing. Laying in the intersection between design studies and cognitive psychology, we consider research in this area to be essential to a better understanding of design thinking, learning and practice, and consequently to developing effective design interventions and support tools. In this overview paper we outline major contributions of design cognition research in the areas of creativity, visual thinking, reasoning, learning and teamwork in design. We conclude that collaborative research by designers and cognitive psychologists has a potential to further our understanding of design cognition more than can be expected of the Design Thinking method.

1. Introduction  
In this paper we wish to make a case for the indispensible role of cognitive psychology in the study of designing. This line of research is undertaken under the auspices of Design Thinking Research, a field of study that has been active for over 30 years now. We find it necessary to emphasize the profound difference between Design Thinking Research and what has lately acquired the acronym ‘design thinking’, which is an overarching approach and methodology for innovative problem solving. It stretches the term ‘design’ to include almost any type of problem solving, mostly for the purpose of providing a competitive edge due to innovativeness, be it of a product, system or service. We briefly survey Design Thinking and Design Thinking Research, and then proceed to present a framework of cognitive processes and examples of studies pertaining to design processes that lean on cognitive psychology and thereby illuminate designers’ thinking in a way not possible without the psychological input.

2. Design Thinking and Design Thinking Research  
Design thinking is not a new term. However, lately it has become a household term (or dare we say buzzword?) in good currency among designers and business innovation promoters around the globe. In its current incarnation Design Thinking denotes a method meant for general use in the process of devising novel solutions for products, spaces, services (including ‘experiences’) or systems. More than anything, it is a business strategy (Lockwood 2009; Martin 2009; Verganti 2009). In California’s Silicon Valley Design Thinking is even referred to as a movement: The Design Thinking Movement. It pertains to a method that is used and taught, and one is perforce reminded of The Design Methods Movement in Britain in the 1960s. The raison d’être of these ‘movements’ was then and is now to improve design processes such that the outcome be the best possible. However, the scope and methodology differ considerably and may actually be contradictory in the sense that Design Methods were about breaking away from intuitive design practices, and Design Thinking embraces intuition and associative thinking, albeit in a systematic manner and with a focus on users.
The Design Methods Movement sought the ‘scientification’ of design by developing prescriptive optimization models, mostly aimed at achieving better products as a result of efficient methods. By comparison with the current Design Thinking Movement, the Design Methods Movement was not as business oriented, and not so focused on innovation. Today’s Design Thinking is motivated by an innovativeness imperative. It is based on observations of user behavior within a social setting, and the process of problem solving is always carried out as team work. It is about ‘how-to’s: How to identify, define, and solve design problems? However, this does not contribute to our understanding of the underlying cognitive processes related to designers’ activities, which is the focus of this paper. It does not explain what the particular knowledge that designers posses is (Cross 2006; Lawson 2004; Visser 2009), how a synthesis of “new ideas from seemingly disparate fragments” (Brown 2009, dust cover) occurs, or how designers convert ideas generated by a team into implemented solutions. Surely, even the most sophisticated observation methodology cannot answer these questions, at least not at the cognitive level. It is here that Design Thinking Research—as opposed to Design Thinking tout court—becomes relevant, and in particular that branch of research which involves cognitive psychology as a way to access designers’ thinking and activities, at both the individual and team settings.

2.1 Design Thinking Research

The Design Methods Movement was unsuccessful because as it turned out, designers were reluctant to use the prescriptive methods they were offered, which were perceived as rigid and inflicted with too much rote work. Moreover, there was no evidence that the use of these methods led to better results than those achieved using mostly intuitive methods. It was at this point that design researchers realized that in order to have an impact on how design is carried out it was necessary to better understand how designers actually think and this led, in the early 1980s, to the emergence of Design Thinking Research (Pahl et al. 1999). Pioneering work in this direction was published even earlier, by Eastman (1970) and Akin (1978). Significantly, both researchers used protocol analysis as a primary methodology that allowed them to fathom designers’ thoughts. For an overview of publications on that issue including the transition years into Design Thinking Research, see Bayazit (2004).

2.2 Research methods

As thinking is a human process that is not observable, already one century ago heavy debates took place on how to investigate these processes in a scientifically rigorous way. The first described and implemented attempt to gain access to human thinking was proposed in Wundt’s method of introspection. This method was soon thereafter heavily criticized as being unscientific by the founder of behaviorism Watson (1920), who proposed instead that thinking aloud could provide direct access to inner sub-vocal speech via external verbalization. A transcript of such a verbalization is called a protocol.

Protocol analysis

Protocol analysis was ‘imported’ into Design Thinking Research from psychology, wherein it was pioneered earlier in the 20th century and used as a primary research methodology in problem solving research by, for example, the Gestalt psychologist Karl Duncker (Ericsson 2001). As had become clear already in the 1980s, protocol analysis is a research methodology that is particularly well suited for the study of short-term (up to a few hours, usually less) design activities, a time-frame appropriate for cognitive explorations. Protocol analysis has its drawbacks of course, but has gained increasing acceptance not only in design but in the behavioral sciences in general (Ericsson 2003), not the least due to the seminal work of Ericsson and Simon (1984/1993). The issue of non-verbal data is still largely unresolved, and because often there is a lot of graphic output in design sessions, this is a matter that awaits advancement. Remaining problems notwithstanding, protocol analysis (and retrospective verbal reports) has
amply proved to be a useful tool that provides access to problem solvers’—in this case designers’—thinking processes’ patterns. Cross et al. (1996) have both summarized the work done in Design Thinking Research with protocol analysis, and contributed to its solidification and continuation by dedicating to this methodology a workshop and ensuing publications. However, protocol analysis can only gather data; its interpretation has to be carried out by the researcher. Here psychology comes into play, providing theoretical background for interpretation. Thus, it is possible to go beyond the description of phenomena and come up with explanations.

Further methods such as studying thinking processes of great inventors and designers by analyzing biographical records (for example the design process of the first power engine flight machine by the Wright Brothers) are unfortunately not very common, with a few welcome exceptions like Cross and Lawson (2005).

3. The essentials of Design Thinking

Design Thinking Research is a wide and rich field of study, in which various issues related to cognition occupy a central position. This is not surprising, as design thinking is obviously part of human thinking in general. Some examples of influential publications in psychology that were used by Design Thinking Researchers include Holyoak and Morrison (2005) and Wertheimer (1959) in problem solving and reasoning; Sternberg (1999) in creativity; Finke, Smith and Ward (1992) in idea generation and fixation; Kosslyn (1994) in mental imagery; Gentner and Stevens (1983) and Klimoski and Mohammed (1994) in mental models; de Groot (1946/1978) and Ericsson and Charness (1994) in expertise; Wickens et al. (1997) in human factors; Erez and Somech (1996) and Stempfle and Badke-Schaub (2002) in team performance; and Resnick (1987) in education. Needless to say, this is a very partial and certainly non-conclusive list.

Why is there a need for studies of the design process at the cognitive level? Design thinking is a cognitive process that can be defined as goal-oriented information processing, including different partial processes as depicted in Figure 1. The search for information and the generation of solutions, often described as divergent thinking, refers to the widening of the problem and solution space(s) and represents a major proportion of what is investigated under the topic of design creativity. Another key characteristic of design thinking is its visual component. Mental imagery is a cognitive process necessary to build and adapt a mental model during the complex solution process. Reasoning processes are essential, as the different steps in the development of solutions are driven by evaluations of what is carried further and which ideas, information, etc. may be disregarded. The ability to structure (and restructure) is a prerequisite for the further development of design strategies, where there is a crucial difference between expert and novice designers.
Whereas these cognitive processes are part of the individual design process, they are detected in modified forms in the group context wherein many different additional processes take place; however, a strong theoretical underpinning of the empirical data regarding teamwork is still missing. In the following sub-sections we present some of the major contributions to the study of design thinking processes at the cognitive level.

### 3.1 Design creativity

The motivation behind this line of research is to discover what needs to be done in order to augment creative design outcomes. Early research dwelt mainly on work procedures, especially in teams. Variations of brainstorming methods have been tried out (e.g., van der Lugt 2000) but this did not seem to have a large enough effect on the outcomes. Similar results were obtained in non-design teams and with different kinds of tasks. Groups produced fewer solutions to a given problem and these solutions were rated less creative than when individual responses were randomly combined into groups (Dunette et al. 1963; Taylor et al. 1958). Although this result is not new, brainstorming is still a frequently used method in design practice.

A lot of research today centers on visual stimuli that are purposefully shown to designers at the outset of their work or later on in the process (e.g., Casakin & Goldschmidt 2000; Pertulla 2006). It turns out that whereas in general exposure to varied stimuli produces a positive effect, i.e., a higher creativity or innovation score, converse results are obtained when the stimuli are examples of solutions to problems similar to those to be solved. In such cases researchers argue that designers are unable to divorce themselves from features of the examples and in fact they experience fixation (Cardoso & Badke-Schaub 2009; Jansson & Smith 1991; Purcell & Gero 1996). An exception is the case of novice students, who benefit from exposure to case-images close to the ones they are asked to undertake (Heylighen & Verstijnen 2003); however, cases may be different than stimuli in the form of single (or even multiple) images.

Other parameters that affect creativity are different non-visual stimuli, the environment (McCoy & Evans 2002), and of course, personality traits (MacKinnon 1962) and neurological processes regarding memory, but we shall not expand on those in this paper.
3.2 Visual thinking in design

The psychological literature on visual thinking and perception (e.g., Arnheim 1969), mental imagery (e.g., Kosslyn 1994, Shepard & Cooper 1982), analogy and metaphor (e.g., Gentner 1983, Holyoak & Thagard 1996), to mention just a cursory selection of relevant areas and writers, is of the essential. Designers of tangible objects (e.g., architects, industrial, visual communication and fashion designers, mechanical engineers) have to deal with form, shape and physical properties of objects and therefore it is not surprising that they make extensive use of visual thinking, which is also manifest in the representations they make and the images they entertain, externally and internally (mental imagery).

A potent representation mode is the freehand sketch, which has been in use by designers for hundreds of years and is still in good currency, despite the wide availability of digital drawing tools. The rough sketch has important cognitive advantages: it can be produced very fast practically anywhere and under all circumstances; has flexible stop rules; is only minimally rule-bound; and is reversible at any stage. The sketch is also tolerant to error, incompleteness, inaccuracy and lack of scale (Goldschmidt 2008). Thus sketching is an excellent mode of providing feedback while at the same time a sketch may be a locus of unexpected cues and discoveries (Do & Gross 1995; Suwa & Tversky 1997). Therefore, in addition to sketches that are made for the sake of communication and specification, sketches are actually thinking-aids (Ferguson 1992) which are extremely economical in cognitive resources and therefore highly effective in advancing the design process (Goldschmidt 1991).

In addition to producing visual representations, designers are also avid ‘consumers’ of visual images which are used as sources of inspiration (Curtis 1986; Eckert & Stacey 2000; Keller et al. 2009; Lasdun 1976), and particularly as bases for analogy in the process of solving design problems (Bonnardel & Rech 1998; Casakin & Goldschmidt 2000).

3.3 Design reasoning

Boiling down the variety of empirical results of research about designing there are three main patterns of design thinking and reasoning that have been repeatedly found in different studies.

Many designers create a solution idea already at the outset of a design project, which they then adapt to the constraints of the problem by reframing the problem. Designers tend to not clarify the task in detail at the beginning of the design process, but do so during the process. Dorst and Cross (2001) refer to this phenomenon as the co-evolution of the problem and solution spaces (see also Maher & Poon 2008).

Closely related to this procedure is a second pattern, namely the corrective adaptation of ideas in the course of the elaboration of the first concepts (Günther & Ehrlenzpiehl 1999), instead of a generative variation of ideas.

The third strong finding is the opportunistic approach of designers to the development of solutions (Ball & Ormerod 1995; Guindon 1990, Hayes-Roth & Hayes-Roth 1979; Visser 1994). Systematic design methods instruct designers to hierarchically decompose the problem. However, even when they plan their processes, designers deviate from their plans and react in an opportunistic way. This is presumably because designers’ intuitive reasoning processes are associative, wherein one thing leads to another until a design proposition is solidified or an evaluative examination is concluded. Goldschmidt’s theory of linkography (e.g., 2003) which analyzes design reasoning is based on this premise.
3.4 Learning and development of expertise

Design educators have taken great interest in issues of design pedagogy, as there seems to be a consensus that studio-based education, although it is universally recognized as the main locus of design learning, is far from perfect. We hardly know what strategies work best and whether they have a long or short-term effect. The educational challenge of the studio is formidable—the transfer of different types of knowledge and skills (Uluoğlu 2000) and learning by doing, by reflecting, and by obtaining critical feedback (Schön 1987). Questions of learning style crop up (Durling et al. 1996) and the emotional stress related to studio learning must also be taken into account (Austerlitz et al. 2002). Most studies that address design education have not addressed cognition directly, but this line of work is extremely important and we believe in its potential to arrive at findings that will eventually help plan better studio education. Research in the field of expertise and its acquisition yields further insights into the learning processes of designers, but it will not be addressed here.

3.5 Teamwork in design

Many of the issues relevant to teamwork are not directly related to cognition, and we shall not discuss them (i.e., interdisciplinarity, leadership, management, cultural differences, co-location vs. other modes, and many more); but since teamwork, despite shortcomings (Brooks 2010), is the order of the day in most design disciplines, we choose to highlight two cognitive issues that pertain to teamwork in design: shared mental models, and cognitive conflicts. These are also topics on which the authors have collaborated in the past, and therefore they serve to highlight the benefit of collaboration between design researchers with a design and a cognitive psychology background, respectively.

Shared mental models in design teams

During the design process the designer has to develop a mental model of the process and the product which, at the beginning, is unclear, fuzzy and incomplete. Even so, in a team situation individual mental models need to be communicated in order to reach a common understanding among team members regarding the product vision and further procedures. There are different ways to communicate and develop shared mental models, and in design making visual representations is one of these ways. In an empirical study the effects of joint sketching by members of a design team on the outcome were looked at. The assumption was that as opposed to individual sketching, joint sketching would enhance the sharing of mental models. Results have shown that this is the case only when sketches are actually used in the team deliberations; the mere production of joint sketches is not enough (Neumann et al. 2009). This accentuates the complexity of creating a shared mental model which, in design, has essential visual representation components that are not necessarily present in other lines of teamwork. In this area the designer author learned to conceptualize idea formulation and framing in design and the dynamics of its evolution in terms of mental models. Furthermore, the newly acquired conceptual framework has already served as the basis for two successfully completed theses, supervised by this author (Eshel 2010; Surasky 2010). On the other hand, the psychologist author has learned more about the centrality of visual representations in the forming of mental models, and particularly shared ones in design group settings.

Cognitive conflicts

Cognitive conflicts, at least in design teams, serve to increase the innovativeness of the ensuing product. Findings from an empirical study conducted by the authors support the notion that teams whose work scores high on innovativeness were in fact those who experience more cognitive conflicts (Badke-Schaub et al. 2010). The conflict behavior style of these groups was mostly competitive and compromising, and not collaborative, as might have been expected. In fact collaboration was the conflict behavior style boasted by low ranking teams. In contrast
with these findings the collaboration between the authors, design researchers with a design education in one case and psychology in the other, was a fruitful process. The psychologist learned about assessing design ideas and the designer learned about conflict behavior styles and their measuring methods. Back to the research findings, those confirm once again how intricate teamwork is. As far as cognitive issues are concerned, conflicts—it turns out—are not to be shied away from as they are actually beneficial to the design outcome.

4. Concluding remarks

We see designing as a cognitive activity comprising thinking processes such as searching for ideas, generating solutions, evaluating information, considering and producing visual representations, and developing strategies while learning and building up experience. These processes are modified and moderated in specific contexts such as in a team situation.

However, designing entails more than cognitive processes. Designing also deals with uncertainty, which may affect thinking processes in a positive way challenging a person with a higher tolerance for uncertainty; on the other hand uncertainty can be detrimental to the thinking process of a person who has, in general or in a particular situation, a low tolerance for ambiguity, which might lead to anger or anxiety and these emotions often increase risks and failures. The social and cultural settings are also very important ingredients of designing. Designers must interact with users and other stakeholders, and in this sense designing is a process of negotiation. Consequently a broader exploration of the designer as a complex human system is called for.

Let us return to the underlying premise of Design Thinking Research, which maintains that in order to best support design activities we must gain a better understanding of how designers actually think. Further understanding of the thinking processes of the designer is especially important as it has turned out that personality traits and capabilities such as intelligence or spatial abilities failed to predict which designers would produce more successful work. Furthermore, in order to teach students how to design it is of major relevance to find out how to arrive at good solutions. Design Thinking Research complements the ‘how to’ approach of Design thinking. The latter is valuable because of its appeal to the business community and as such, it helps gain attention and esteem for design and designers. But it does not advance knowledge and it does not help to make the next step. It is therefore most important to draw a clear distinction between Design Thinking and Design Thinking Research, a distinction that is not always made.

Although decades of design research have garnered significant findings, we still do not know enough about what happens in the designer’s mind. The Design Thinking method-movement cannot be looked to for answers as it actually is about doing rather than about thinking. This is why collaboration between design researchers with a design background and cognitive psychologists is so important (for the sake of clarification we should note that we understand cognitive psychology as an integrated approach, also including emotional and motivational aspects). It is hoped that both disciplines will rise to the challenge and seize any opportunity to help further our understanding of design cognition and its implications for successful design learning and practice. In a broader perception of design and designers, we consider design cognition to be the most important component.

Acknowledgements

The first author gratefully acknowledges support by a grant from the fund for the promotion of research at the Technion. She would also like to express her gratitude for the stimulating intellectual environment at the CDR, Stanford University, which hosted her when this paper was written, while on sabbatical there.
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**Design Basis:** Insights about Design Thinking from the perspective of Decision Analysis

B. Christopher Han  
Stanford University, Stanford, CA

Neeraj Sonalkar  
Stanford University, Stanford, CA

Micah Lande  
Stanford University, Stanford, CA

Malte Jung  
Stanford University, Stanford, CA

Larry Leifer  
Stanford University, Stanford, CA

**Abstract**  
Design and decisions are both integral to the human experience. Interest in both topics is great as evidenced by a growing body of research surrounding each. In this paper, we explain how the study of decisions offers insight into our understanding of design for researchers and practitioners alike. Specifically, we draw from the field of normative decision making, called decision analysis, for a novel perspective to some basic questions relating to design, such as “what is common to all design situations?” Decision analysis may appear to be an unlikely source for insight into questions in design, but as discussed in this paper, decisions and design are similar in many respects. Both are artificial or man-made, and Herbert Simon’s phrase concerning the study of design as the “science of the artificial” fits the study of decisions as well. As such, design and decisions may be viewed as fraternal twins. Analogous to examining twins separated at birth to shed light on each other’s inherent traits, we present how a decision-analytic concept known as the decision basis suggests a similar one for design, called the design basis. Knowing the decision basis helps a person think through a decision situation, especially in the framing stage, and contributes to the quality of the decision made. Likewise, we contend that establishing the design basis helps a person think through a design situation (design thinking) and help guide design activities (design doing), ultimately influencing the quality of what is designed.

The concept of the design basis, which represents what is common to all design situations, is relevant for both design research and practice. This paper is meant to be a substantive start of a progressive conversation rather than a completed piece of work. As such, we raise more questions than we answer within these pages, and it is our intention to trigger a fruitful conversation with the reader.
1. Introduction

Design and decisions are like fraternal twins—different yet sharing essential attributes. Both are artificial, to use Simon’s sense of the word, and each is a product of human intention (Simon 1969). Given the apparent similarity, we turned to decision analysis (coined by Howard in 1963) to gain insights into design thinking. We first provide a brief background on the relevant aspects of decision analysis (abbreviated as DA) to situate the investigation.

Decisions lie at the intersection of thought and action. Decision analysis offers conceptual tools and methods to help a person think through a decision and achieve clarity of action (knowing what to do). In order to have high quality thoughts about a decision situation, DA underscores the important role of distinctions. Forming distinctions is the most elemental cognitive act (Varela & Maturana 1980), and it is the building block to more complex thoughts. Some of the key distinctions in DA are captured in the decision basis.

The decision basis represents components that are common to all decision situations (Howard 1966). Those components are preferences, alternatives and information. In other words, what you want, what you can do, and what you know. Added to this is the decision frame as all decisions are preceded by the framing of the decision.

Decision analysis, it should be pointed out, is part of normative decision making as opposed to descriptive decision making. “Normative” is concerned with how people ought to make decisions, and “descriptive” speaks to how people actually make decisions. They represent two separate, but related, bodies of research. One helps inform the other, especially the descriptive research on decision traps, which describes cognitive biases that often befall even the most attentive minds (Tversky & Kahneman 1981). As evidenced empirically, thinking through difficult decisions can be tricky.

Thinking through the decision basis helps a person clarify and understand his decision situation. As the name suggests, it forms the basis of any subsequent analytical work, such as mathematical modeling of the decision that may be necessary to achieve clarity of action. Drawing on his extensive experience in decision research and consulting Howard states that, at times, just thinking clearly through the decision basis (such as generating a new alternative) may be enough to help a decision maker know what to do. In the way that the decision basis helps a person think clearly about his decision situation, what might help a person in the design context?

Clear thinking may not be a sufficient condition to creating high quality design, but it is a necessary one. This is because the work of design is infused with cognitive activity. Some amount of thinking precedes, follows, or runs parallel to design actions. So, clearer the thinking, better the design activity. The rest of this paper presents the concept called, design basis (Han 2009).

2. Design Basis

Design basis refers to the basic components that are common to all design situations. These are: 1) the frame, 2) preferences, 3) alternatives, and 4) state of knowledge. We elaborate on each one by one.

Frame

Every design situation has a frame. Prior to starting any design activity, it is helpful for the designer(s) to think about the framing of the design situation. One may ask, “What is it that we’re really trying to do?” For example, in designing the PhD experience, a graduate student
may frame it as “striving to win the Nobel Prize” or “establishing a foundation for a life-long career in research” or even “just getting to three signatures as quickly as possible”.

A design frame is different from a design point of view (POV). In a rudimentary sense, the frame is associated with the design situation whereas the POV is typically associated with the designer (and/or stakeholders). A designer can select from different frames of the situation while maintaining the same POV.

It is important to recognize that the initial frame may not be the most appropriate one (Schön & Wiggins 1992; Valkenburg & Dorst 1998), so the individual or the group should ask himself or one another probing questions relating to the frame at hand. This conversation should make explicit any assumptions held by any person and then proceed to define the boundaries of the design situation. For example, is the aim to tackle “world peace” or “peace in the U.S.” or “peace in California”? This is a matter of scope. Also, is peace defined as the absence of conflict? What is included and excluded in conflict?

Some might describe these probing questions as helping designers define the problem space. That characterization is acceptable so long as the space is recognized to be multi-dimensional. Thinking through the number and type of dimensions is part of the framing. Clarity of the design frame is essential to the quality of subsequent design activities.

A frame is common to all design situations. The next component of the design basis is the preferences of the person(s) involved.

Preferences

Preferences refer to what we want. For a designer creating something for oneself, the primary concern is with his own preferences. However, if the designer is creating something for a client—whether an individual or a group—the preferences of others matter.

At this juncture, the issue of uncertainty becomes germane. When designing something for someone else (called client), there is a degree of uncertainty about the client’s preferences, since it cannot be assumed that one person can know wholly what another person wants with absolute certainty. This issue challenges the designer to take steps to sufficiently understand the client’s preferences while avoiding biases or making false assumptions. As a related note, descriptive research in behavioural decision making suggests that one may also be, at times, uncertain of one’s own preferences (Ariely 2008).

Knowing that preferences should not be assumed to be wholly known, it behoves the designer(s) and client(s) or stakeholders to engage in a conversation about preferences until sufficient clarity is achieved. The operative point here is sufficient clarity for the design situation, not absolute clarity. This typically involves making preferences as explicit as possible through iterative communication.

Sometimes a designer may believe that the client does not know what he truly wants or that the client’s preferences need to be elevated to a higher standard (namely, the designer’s own). Whether a designer believes that projecting one’s own preferences on others is acceptable or even desirable, it may be best done with the others’ consent or, at minimum, awareness.

Preferences are a component common to all design situations whether they are those of the designer and/or the client. We now turn to the creation of alternatives, which is another important component of the design basis.
Alternatives

Alternatives refer to what we can do. This is the aspect of design that is most associated with creativity, since it deals with the realm of imagination or the pursuit of finding out what is possible. Here, also, uncertainty comes into effect and the primary source of this uncertainty is ignorance, or the absence of knowledge. We do not use the word, ignorance, in a pejorative sense; it is merely pointing to the human predicament of not knowing all that we want to know about something.

Imagine that an omniscient being is given a design problem. For such an all-knowing being, designing would be less about the creative process of inventing a solution and more about matching the optimal solution (that is already known by the omniscient being) to the stated problem. Once the problem is known, so is the solution. Put another way, as soon as the omniscient designer understands what the client wants with sufficient clarity, he immediately knows how to create the best design. There is no need for learning. Since omniscience is not a human attribute, a designer will always encounter the problem of uncertainty (epistemic uncertainty) to some degree and encounter the necessity for learning.

On the topic of learning, the process of creating an alternative even with the a priori belief that it will later be scrapped (as in prototyping) is useful precisely because it affords the opportunity for the designer(s) to learn. This underscores the importance of reflection during design (Schön 1983) as a means to learning. Countless alternatives may be created and thrown away in the process of design prior to converging (deciding) on one, best alternative.

Creating alternatives is a component common to all design situations. The final component of the design basis relates to the state of knowledge of the designer.

State of knowledge

What a designer knows at the time of the design situation influences the quality of the design activity. It is helpful to make explicit what is known and unknown at the start and throughout the course of designing. The unknown yet relevant areas of the design situation can be a focus of attention in the early prototyping phase when learning is essential. One might call this the known-unknowns. Hence, awareness of one's state of knowledge and thinking about what is most valuable to learn can guide the prototyping process.

Some might argue that thinking about the knowns and unknowns might be “too much thinking” and can hamper creativity. It is certainly not our intent to prescribe a preponderance of thought at the cost of action. What we are contending, however, is that the designer must be able to distinguish when thinking before doing is helpful and when it is not. And this requires at least a modicum of thought.

The biggest challenge to learning during design activity stems from the intractable problem of the unknown-unknowns—the thing which one does not know that he does not know. Since, by definition, one cannot generate a thought to know an unknown-unknown, what can a person do? This is where we introduce another useful distinction—thoughtal-action.

3. Thoughtal-Action

Thoughtal-action, and its complement actional-thought, exists at the intersection of thought and action. Consider the following Venn diagram showing thought and action in Figure 1.
There is a circle containing thought and the rest of the space is no thought; there is also a circle for action and the rest, no action.

There are thoughts without action, such as daydreaming, and action without thought, like breathing. Then there is thought with action, or actional-thought (Howard 1988). These are thoughts that are geared towards achieving clarity of action. In other words, actional-thought helps a person to arrive at a specific action through conscious and purposeful thoughts.

\[ \text{actional-thought (Howard)} \]

\[ \text{thought} \quad \cap \quad \text{action} \]

\[ \text{thoughtal-action (Han)} \]

The overlap between thought and action has another important distinction—action with thought. These are actions that are geared towards generating new thoughts—thoughts that one may not have had if not for those actions. This is called thoughtal-action (Han 2009).

The term thoughtal-action can be a label to all kinds of action that many designers are already using in practice. These actions may not appear on the surface to be related to the design situation, but somehow provides the designer with a way to encounter new thoughts. For instance, one designer may draw ideas from engaging in dance, whereas another from taking exploratory hikes through nature. Whatever the specific action may be, the category of actions that are intended to generate new thoughts relevant to the design situation is known as thoughtal-action. Future empirical research may shed more light on what types of actions influence our ability to generate new thoughts.

4. Summary and outlook

We presented in this paper the concept of the design basis as one answer to the question of what is common to all design situations. The design basis serves as a cognitive tool for designers that can guide high quality thinking about the design situation and facilitate clear communication among stakeholders. We also introduced the distinction of thoughtal-action and suggested that it is a way of generating thoughts about the unknown-unknown through action. What those relevant actions may be is a matter of empirical research. As stated in the outset, our intention has been to trigger a fruitful conversation with the reader and we hope that we have done so.

We raise a few more questions as we conclude and offer a cursory response as a way of fueling the conversation. The first question is: “what makes design difficult?” While some design experts may testify that design is not difficult (to them), we observe that design expertise is not uniformly demonstrated by everyone even if all people possess the innate potential for it. Without attempting to provide a comprehensive answer to this question, we contend that one significant reason that design is difficult is uncertainty. Uncertainty of various kinds relating to
the world we live in (epistemic uncertainty) as well as uncertainty about preferences in others and, perhaps, even oneself.

Another question we ask is “how does one recognize high quality design activity?” This is separate from the question “how does one recognize high quality design?” which refers to the “thing” that is designed whether it be a tangible product, a service, or an engineered system. We do not yet have an answer to this question. Research on this topic, especially on design interactions, is on-going by several colleagues at the Center for Design Research at Stanford University.

In the field of decision analysis, which inspired several ideas presented in this paper, there is a distinction concerning small “d” decisions and big “D” decisions. A small “d” decision is a decision that can be analyzed, however complex it may be. An example is HP’s decision to acquire Compaq. It is certainly a very complex decision, but it can be modeled. A big “D” decision, on the other hand, is one that a person chooses not to analyze, because it is such a transformative decision. Transformative here means that the person is not the same as a result of the decision. An often cited example is the decision about whom to marry. It does not make sense, from our perspective, to make a marriage decision via a model measuring the attributes of each candidate. Furthermore, love defies measuring. Bringing this notion to the context of design, is there such as thing as a small “d” design and a big “D” design?

We propose that a big “D” design is where the designer is creating the design (the thing) with only his own preference in mind. A good example is an artist who designs a work of art without any concern whether there might be a customer for it or even whether others might appreciate it. In contrast, a small “d” design is where the designer considers all of the practicalities of designing the thing as well as his own preferences and motivations. There is often a client or customer for small “d” designs, and design practitioners likely spend the most of their working hours on these.

We look forward to building on what we presented in this paper and to the conversations with the design thinking research community.

Acknowledgements

We kindly thank the Hasso Plattner Design Thinking Research Program for the support that made this work possible.
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What kind of thinking is design thinking?

David Jones
Just Knowledge, Sydney, Australia

Abstract
Design thinking is an emerging discipline. We can clarify the way the term is used by distinguishing between the modes of thinking employed by designers of tangibles, and the modes of thinking employed by people ‘designing’ solutions to intangibles like so-called ‘wicked problems’. This contrast can help us name what is distinctive about the cognitive processes at work in designing intangibles. What is similar to the thinking of designers of tangibles? What is distinct? And what new dimensions does the context of wrestling with intangibles add to thinking as a ‘designer’? Design thinking in the context of intangibles is (in part) a peculiar form of what Arthur Koestler called bisociation. I offer a heuristic of this mode of thought in the context of design work on intangibles.

Finding our bearings with design thinking
Designers, academics and business writers have talked about design thinking. No stable consensus about the term has emerged yet [1]. This ambiguity is (in part) the consequence of using ‘design thinking’ for an emerging discipline and for traditional design.

I want to propose a way to clarify what we mean in either case. I hope this clarity serves a focused enquiry into what is distinctive about ‘design thinking’ in the contexts of the current discussion: i.e., the worlds of organizational intangibles like strategy, culture and ‘wicked problems’, rather than that of designing tangible products.

The key shift is from the design of tangibles to the ‘design’ of intangibles. The common link is the intuition of an overlap in the cognitive and social processes of practitioners in both contexts.

We could preserve ‘design thinking’ for the new context. After all, that is where the term has gained greatest currency. However, this might suggest there is nothing distinctive about the thinking employed by designers of tangibles. Whatever either group does, it involves ‘design thinking’. So, how can we clarify what we mean?

In this paper I will refer to:

- **DT-T**—those modes of thinking characteristic of designers of tangibles
- **DT-I**—those modes of thinking characteristic of ‘designers’ of intangibles
Whatever this lacks in elegance, it can serve to clarify the layers of ideas associated with design thinking. We might also gain perspective on how the discussion has evolved:

1. Designers working with tangibles employ (aware or unaware) certain modes of cognition as they proceed from ideation to a physical product [2]. I am calling this DT-T.

2. People grappling with intangibles like ‘wicked problems’ have intuited some analogy to their own work and asked [3]:
   a. How does a designer think when she works with wood, etc?
   b. What do these ways of thinking (DT-T) have to offer to those grappling with intangibles, such that we can talk of another mode of design thinking (DT-I)?

3. Wrestling with DT-I leads to asking:
   a. What ways of thinking does a person working on intangibles need that designers of tangibles don’t need?
   b. What are the unique dimensions of DT-I provoked by working on intangibles?

The discourse about design thinking assumes that the thinking processes used to create physical products are insightful for people grappling with intangibles like strategy. The world of business and organizations is a world of people and actions, and great designers are renowned for their sensitivity to human needs and context. So why hasn’t design thinking figured more in management thinking?

Western intellectual culture privileges abstract and analytical thought over other modes. On occasion there have been appreciative accounts in intellectual history of practical skills and wisdom (e.g., Aristotle). But the applications to organizations have remained unexplored. A buoyant confidence in the competence of analysis to dispel ambiguity (or assure profit) has not encouraged the idea that rich insights could be gained watching architects or artisans. Ironically, a managerial mindset might even now domesticate ‘design thinking’ rather than be challenged profoundly by it.

At the other end, designers generally have not seen the need to reflect epistemologically. And why should they? The orthodoxy of intellectualism continues to divorce the so-called practical from the intellectual [4].

What qualifies me to bridge this gap?

First, my own disciplinary background bridges the analytical tradition (microbiology) and wider fields of ‘thinking on thinking’ including epistemology, sociology of knowledge, philosophy of science, systems theory, and hermeneutics. I want to suggest that DT-I can be enriched by better understanding heuristics, an idea ubiquitous in these fields.

Second, my professional life has been immersed in these questions as a principal in a firm highly regarded for its pioneering work in DT-I [5]. For the past 5 years I have recruited, placed and mentored designers trained in various modes of DT-T as they moved into working on complex intangibles. I began to use a simple heuristic to explain the movements of mind that were present and distinct in their creative acts. The more I used the frame, the more it revealed the distinctive characteristics of this mode of thinking; not only in contrast to ‘non-designers’, but also to the thinking of designers working with tangibles.
Locating design thinking

My sense of the territory of DT-I is formed around two ideas—abduction and bisociation—and the distinct application of bisociation to design. Together they suggest my visual heuristic.

Abduction—pinning down the focus

The concept of abduction (Peirce 1878; Hintikka 1999) names the cognitive act in design thinking. Abductive logic has been defined as:

- seemingly unrelated facts (i)
- ...brought together by an intuition of connectedness... (ii)
- ...that results in a hypothesis—the inferred “explanation” of the facts (iii) [6].

Although the language of abduction derives from the discourse of logic [7], the term takes us to the heart of the creative act. The idea of “seemingly unrelated facts” fits neither deduction nor induction well. The act of connection (ii) is an intuition: a wondering or guess. But it is not a leap from nothing to nothing. Polanyi describes a movement from the “tacit” to the “focal” (Polanyi 1962, pp.55, 311). The experience seems to lack dimension in effort or intent except for the events that triggered the guess-worthy question. We choose a point of focus (or it chooses us), not to reduce reality, but to pin down the topic.

Abduction by itself does not yield design. To borrow from physics, abduction is the inchoate but essential point of nucleation: like an atomic nucleus, it is the centre of everything, but there is nothing there when you pull it apart! It is not a first step in design. It is an ‘everywhere step’.

Bisociation—teasing it out

Arthur Koestler coined the word bisociation for the ‘moment’ at the centre of the creative acts of the human mind (Koestler 1970, p.36 passim). Koestler’s ‘moment’ was an act dimensioned not by time, but by the experience of its unity. For Koestler, creative thought arises from a collision between two matrices of thought or behaviour.

While bisociation takes many forms [8], Michael Polanyi [9] named perhaps its archetypal form in his theory of knowledge. Our existing “subsidiary” or “tacit” awareness is drawn out to a new “focal” awareness, and something happens to make a new emergent reality. Insofar as design thinking can be said to follow a process, it might be described in Koestler’s terms as a trajectory of ‘movements of mind’ as much kinaesthetic and emotional as cognitive. The movements are visceral and seamless, though distinguishable.

These images of movement and trajectory lend themselves to a visual heuristic suggesting interactions that give rise to and occur within some new sensing and thought that may now unfold as intention or direction (Figure 1):
Intent is critical to design thinking, whether DT-T or DT-I. The movement of design, left to right in my heuristic, derives its momentum from intentionality. Staying on track during the design processes—even discovering the track—relies on intent. But generating intent is not design thinking.

Bringing aspiration into 'collision' with what is tacit in the mind is what generates the particular places of design thinking (Figure 2) [10]. We can think of design as occurring in four 'places' of the mind, each richly cognitive, emotional and aesthetic:

Western epistemology has privileged places #1 and #4 (Figure 2). Science made research and hypothesis-testing its core methodologies. This is mirrored in the predilection for analysis and planning in management thinking. Design is distinct in the value it assigns to places #2 and #3. Design arises from the possibility that life "can be other" than it is [11].

Intentionality (#2) and synthesis (#3) have been the poor cousins of productive thinking since the ascendancy of technical rationalism (Schön 1987, pp.3, 34 passim). Yet many studies have shown that generative science does not proceed according to its lineal caricature [12]. It is profoundly intuitive and aspirational. Likewise aspiration (#2) and synthesis (#3) are intelligent acts carrying their own logic in the place where ‘what is’ and ‘what might be’ dialogue with one another.
What do heuristics offer design thinking?

A word on heuristics

Heuristics are part of our mental toolkit. Though increasingly mentioned, they may be little understood [13]. I use ‘heuristic’ to mean a scaffolding in our minds that we appropriate or invent. As we cultivate fluency with the heuristic, it enables us to recognize patterns fast. A tight definition matters little. What matters is noticing how heuristics are the tools we use at the edges of generative thought.

The inherent feature of a heuristic is the ‘problem-finding’ role it plays when we grapple with a need for which no solution has arisen. This indeterminacy is shared by all design thinking, whether DT-T or DT-I. The challenge of DT-I is that the design is of knowledge itself. There are no pre-existing boundaries. The only boundaries are those that will be imagined and imposed by the mind that brings order to the topic.

Laying a heuristic over a subject simultaneously has three effects on the user:
1. Recognition—yes/no, this situation is one of these kinds.
2. Comfort—some pieces of the puzzle suddenly settle into place.
3. Movement—the dialogue of design begins and carries you forward with its own momentum.

At first the heuristic enables a general sense of fit. Then it begins to work on the subject:
4. Sorting—the mind has a way of deciding what is ‘in’ or ‘out’ as it careens through the vast storehouse of tacit knowledge and possible interpretive patterns.
5. Platform—the mind has a place to stand, alternatively easing the mental load to free it to see more, and providing a pointer to the next move.

Heuristics are like conversation partners. They talk back to us. Heuristics offer stabilizing points in the dialogue, in effect asking, “So what belongs here, then?”

I have assisted designers trained in DT-T move to working on challenging intangibles. Nothing has matched the impact of heuristics. Designers of tangibles know how to visualize a finished product. It is another thing to visualize a strategy or culture, or to sculpt a brilliant way forward for a ‘wicked problem’. Using heuristics is a core feature of thinking in design and in the disposition of designers. The ability to proceed provisionally and with iteration is central, but the mind only deals with so much [14]. The challenges of ambiguous contextual knowledge require prodigious feats of cognitive agility, moving quickly between overview and details, deconstructing and re-conceiving whole systems in the mind. It can only be done with heuristics.

A heuristic does for a DT-I designer what material media does for a DT-T designer

DT-I is not a new way of thinking. What is new is the scale of the intangibles to which design is being directed. The prevalence of knowledge work and ‘wicked problems’ has overtaken the competence of analysis and planning (Negroponte 1995; Buchanan 1992). There is a new scale and urgency of reflective discourse about how to effect innovation in enterprise systems and cultures. Paradoxically, this focus on intangibles is now making design thinking explicit.

Craft design has been sustained by a tacit, apprenticed mode of skill and knowledge development. But that mode of learning is unavailable when the subject matter of the design is knowledge itself. The key difference is this: in craft design, the media itself carries the process [15]. Timber, for example, holds its own secrets through space and time. A craftsperon encounters the information held in the timber itself—its grain, texture, and mood—and learns from it as
she works it. Likewise with tools: a particular chisel interacts with woods in certain ways. If a culture lost its craft, one day someone would discover chisel and wood, and the craft would return. Designers of tangibles experience this dialogue with the materials at hand, and in activities like sketching that serve as proxies for materials.

These interactions with material media have been formative in the development of DT-T design thinking. But the cognitive game changes as the design practice moves away from dialogue with physical material. The new ‘media’ is cognition itself activated by the collision of aspiration and knowledge in an intangible context. The DT-I designer still needs tools, but now they are distinctly cognitive tools: heuristics.

Heuristics for DT-I designers are the thought equivalents of what DT-T designers typically hold in their hands. With nothing in her hands, so to speak, the DT-I designer still needs some medium to support her dialogue with ambiguity and intent. She needs some way to walk around the problem space. A way to reframe knowledge. This is the role and value of heuristics.

**The modes of DT-I design thinking**

A heuristic holds open a shared space for conceptual prototyping. It makes discussable the dimensions of a context and the knowledge bound up with it. A heuristic enables collaboration and co-design of the intangible. A need exists then for a heuristic for DT-I itself, enabling us to think well about design thinking.

The heuristic below (Figure 3) enables the DT-I designer to locate herself, the problem, and reflective conversation in the experiences of abduction and bisociation:

![Figure 3. Four modes of thought in design thinking](image)

The heuristic makes several allusions about the work of DT-I:

- The heart of the process is the place where two things collide (the bisociative core).
- The nature of the ‘collision’ is an iterative dialogue between intention and finding meaning in tacit knowledge and ambiguous contexts.
- Each iteration suggests an expandable terrain; there is more to see by venturing along the arcs or axes of the heuristic.
- Each iteration suggests movement toward something that will emerge.
- A designer becomes skilled in choosing a heuristic that levers and keeps open the space she wishes to explore and her options in making.

The scope of the design thinking process is determined by the extent of movement out from what could be simply a satisfying guess (abduction). But a ‘guess’ is unlikely to satisfy stakeholders in large enterprises with vast social, fiscal and legal responsibilities. Nor should it. Each place of design thinking across this bisociative space is fractal, fluid and rigorous. How
well a designer explores the design space and sustains her presence and attention is directly proportional to the power of the heuristic devices she chooses.

**Mode #1: Heuristical thinking**

The huge challenge of a DT-I designer is to get mental traction with intangible mental substrates. The ambiguity of the subject matter—the intrinsic complexity of human systems—unearths a kind of fractal character to design thinking. The further a designer pushes into the realm of the tacit, the more she discovers a patterning of knowledge within knowledge. Each fractal changes the whole fabric of cognition. The interpretive frames that arise within her are an extension of how she senses each problem space. If she imposes patterns too strongly, she kills off what is possible. The persistent practitioner becomes uncommonly sure-footed in making her way through cognitive indeterminacy. Even the decision to 'stop' requires some heuristical sense of 'good' or 'enough'.

The further a DT-I designer moves along axis #1, the further she moves into systems thinking. Whenever we grapple with knowledge, we require our minds almost simultaneously to apprehend and process what is being presented (the conditions), and to make decisions about it (the consequences). If the effort to apprehend the conditions is large, there may be little capacity to formulate the consequences [16]. This is the critical role of systems thinking in designers [17]. Systems capability allows the designer to reduce large and/or complex spaces to dimensions that are manipulable on the mind's table—like the way a war room table enables a General to see and plan moves. The design mind cannot hypothesise in an oceanic swirl—islands of terrain must emerge.

**Mode #2: Aspirational thinking**

Sustained design thinking requires a strong desire for something different. This is the heart of the game in strategic environments. The design space opens around the sense that it is untenable to remain "here, now". An intuition emerges as to some desired future state. We sense that the present can be transformed by our design intervention: that we can make something—an idea, a system, a body of knowledge—sufficient to carry us from "here" to "there".

The activity and methodologies deployed are determined by the amount of effort required to locate, secure and cultivate intent. It comes down to how unknown or novel the design space is, and how much confidence we require to present our proposed solutions.

Designers deal in hope. The bisociative move has no more necessary trajectory than an abductive guess. Hope provides the impetus. The task requires the designer to articulate the intent of clients and the aspirations of customers, and to engage these with her own hopes.

**Mode #3: Synapical thinking**

DT-I designers dwell in the collision between aspiration and situation. As with all the activities of design thinking, this is a richly textured, fractal fabric. A designer must:

1. Cohere aspirations with realism in vision
2. See the connected layers of relevance between emerging designs and context
3. Dwell in the tightening nexus between her own aspiration and the antecedents of design as the parts of the puzzle begin to form a whole
4. Integrate these emotional and cognitive terrains into an emergent hypothesis.

These movements of mind—synthesis—take place as an undifferentiated whole. Few words express the nature and effort of this cognitive work, yet we need to incisively differentiate this mode at the level of fractal cognitive moments. This led me to reach for the term "synaptic" in
hope that its meaning might now be filled with others' rich observations of this phenomenon [18].

**Mode #4: Hypothetical thinking**

Guessing has not stopped since bisociation began. A kind of prototyping has been taking place even as the designer’s mind sorts, discards and selects among her heuristic stock. In a sense, it is all guessing. But we accord a privileged status to the guessing we do after synthesis. This guessing has gained our confidence.

The designer’s cognitive path veers from educational convention. Most people were schooled by examinations to ensure we got the right answer. Experts are respected for precision. Managers who engage in the space of design thinking can find the iteration and provisionality unnerving. Designers, however, become accustomed to the inner feelings that accompany venturing to express something they know they will revise.

Hypothesising takes courage. A DT-I designer must be prepared to expose her thinking product to the world. She puts it out there with the expectation that it can be broken. This is also true of a DT-T designer. But the personal risk is lessened for the designer of tangibles because the “putting out there” is accompanied by a conspicuous move from visualisation and conversation to a physical medium. The DT-I designer, however, puts forward (little more than) the naming of a new possibility within an ambiguous setting of need, context and aspiration.

The DT-I designer engages in one of the most culturally challenging moves in the organizational arena. Her task is to expose and break thoughts as much as to present them. But managerial mindsets are unaccustomed to generative conversations. The managerial mindset is enmeshed in a culture that demands certainty as a prerequisite for action, no matter how fictive that ‘certainty’ may prove to be. We should not underestimate the courage required of DT-I designers.

**The challenge of presence in design thinking**

The DT-I designer needs to be present in hope: a professional and intelligent optimism that sustains focus on the outcome. When she is cultivating intent, it is done with feet on the ground and a view to delivering results. When she is making, she is guided by the situated reality she has steeped herself in; she keeps a constant eye on the purposes to be accomplished. This ‘fractal presence’ has a curious side effect: DT-I designers become adept practitioners of “getting above their own thinking”. It becomes a natural modality.

The complexity and business realities of the contexts of DT-I work involve multiple stakeholders. Collaboration plays a central role in the sociology of DT-I designing. The designer can only develop the disposition and craft of DT-I by engaging with others who hold intent or experience of the complex problem space. At its heart of design thinking is the practice of generative conversations grounded in visual representation of complexity.

Design resists being reduced to a managerial rationalism. The hard-headed contexts of strategy and wicked problems must not obscure the priority of such human sensibilities as wonder, curiosity, integrity, and even humour [19]. How else could one ‘indwell’ an intangible design space, or guess a way forward?

All enterprises need convention. No one can or should sustain complete freedom from definition. But convention atrophies into conformity and control. This paper has outlined a heuristic frame for thinking about design thinking in the context of intangibles. It allows us to converse in a productive tension between innovation and control. It makes distinctions discernable. It
names skills and experiences that can be addressed in curriculum and professional development. The usefulness of the heuristic lies in the possibilities of reflective practice.

Acknowledgements

I am indebted to the talented designers it has been my privilege to recruit and learn from in Second Road, to Second Road for playing at the leading edge of design thinking for over two decades, and to Mark Strom for clarity.

Notes

1. This spectrum is represented by Lawson 2006 (first published in 1980); Martin 2009; and Lockwood 2009. Some of the classic literature in Design Thinking will be found not to be in the libraries and bibliographies of design at all, but in fields such as language e.g., Ricoeur (1977) and sociology e.g., Berger and Luckmann (1966). My own theorising began with these "non-design" writers and their concerns, but found voice in the design arena through the philosophy of Richard Buchanan and his pioneering work bridging the humanities, rhetorical theory, and design in the School of Design at Carnegie-Mellon University, Pittsburgh. Buchanan was arguably the first to comprehensively theorise about design as a mode of thought that applied beyond the ideation and production of tangible products. His "Rhetoric, Humanism, and Design" (1995) and "Design and the New Rhetoric: Productive Arts in the Philosophy of Culture" (2001) have become standards. Richard will no doubt detect the traces of his own thought here, and of our conversations since 1992. Buchanan's work was itself inspired by the philosopher Richard McKeon (e.g., McKeon 1987).

2. An extensive review of the literature related to how designers think when they are engaged in the design of tangibles can be found in McGarry 2005.

3. The history of interest in design thinking is more complex than I have sketched. This is unsurprising for the effort amounts to trying to qualify a human cognitive capability that is broadly used, yet marginalized in the western intellectual traditions. Interwoven strands include design educators like Richard Buchanan grappling with the cognition of design, design theorists seeking a better understanding of physical design processes, and management theorists writing about ways to commodify and leverage innovation. In parallel, journalists and others draw attention to a possible nexus between the commercial success of 'designer' businesses such as Apple and their penchant for elegant product design, and their iconoclasm toward management orthodoxies.

4. There are rare exceptions. Mark Strom is one—a published historian and academic, a long term practitioner of design thinking in corporate contexts, and a fine woodworker. Mark referred me (pers.comm.) to a kindred spirit of his, Matthew Crawford, a motorcycle mechanic and self-confessed 'petrol-head' with a PhD in philosophy, (see Crawford 2009; Strom 2007).

5. Sydney based firm Second Road has largely been without peer in bringing design thinking to highly complex 'wicked problems'. The founder of Second Road, Tony Golsby-Smith, was a visiting professor at the School of Design, Carnegie-Mellon University, and the insights of Richard Buchanan are clearly present and developed in Tony's (1996) article on "Fourth Order Design". See also Golsby-Smith 2007.

6. I believe that I drew this definition from writings by Jaako Hintikka but have been unable to re-locate the source.

7. Kikuchi and Nagasaka's work (2003) "On the Three Forms of Non-Deductive Inferences: Induction, Abduction, and Design", is an example of the use of formal logic in these domains that most designers are accustomed to regard as far less rule-bound!

8. For example, paradox is a bisociation of opposites. Hence Niels Bohr's exclamation, "How wonderful that we have met with a paradox. Now we have some hope of making progress." Moore 1966, p. 196.
9. Polanyi 1962, p. 55 passim. Polanyi and Koestler frequently use the study of break-through creativity in science to frame their understandings of generative cognition. It is not surprising that I find them deeply sympathetic resources for reflection on design thinking.

10. Jenkins (2010, p.18) explains: “The Ancient Greek rhetoricians used mental short-cuts or organising devices to help them develop rich arguments and explore multiple perspectives. The word they used for this was topoi, or places ....suggesting devices one could use to create a mental ‘topography’ of a subject matter”.

11. The phrase “can be other” originates with Aristotle. Known for crystallizing the principles of logic, Aristotle was clear that the methods of logical analysis belonged to enquiries into things which “cannot be other than they are”, i.e., where no change is involved. Things which “can be other than they are” lent themselves not to logic, but to rhetoric: the discipline of framing a coherent and compelling argument. Each mode of enquiry was in effect an alternative road to the truth. Design follows the ‘second’ road. For an application of Aristotle’s insight to design thinking, see Golsby-Smith 2001, pp.199-206.

12. Studies and debates around design thinking are still in the stage of paradigm formation, such as that explored in, and triggered by, Thomas Kuhn (1970). Kuhns’ work on scientific revolutions was forged in an environment of an intense flurry around the sociology and cognition of science, hotly fueled by Popper’s trenchant positivism (Popper 1962). These disputes remain relevant to distinctions we need to make around design cognition, and showed up in writings about cognition and epistemology such as MacIntyres’ (1977) paper “Epistemological Crises, Dramatic Narrative and the Philosophy of Science” Lakatos and Musgrave (eds) proceedings on Criticism and the Growth of Knowledge, and more books, such as Paul Feyerabend’s blistering manifesto, Against Method (1975). It is reasonable to expect a similar turmoil around design thinking, with the notable difference that the Design Thinking debate is being played out in blogs and the popular management press.

13. The term is used in many fields. In psychology, heuristics tend to be mental rules of thumb: the cognitive equivalent of computer algorithms for decision-making (e.g., Hutchinson & Gigerenzer 2005). In business, Roger Martin (2005) uses the concept expansively, referring to heuristics as “rules of thumb that narrow the size and scope of mysteries”, and including as examples the law of gravity, the invention of perspective in drawing and of the colour wheel in painting, and the capacity to repeatedly write hit tunes. My own view is closest to that of Einstein’s 1905 usage (Ter Haar 1967, p.92). As John S. Rigden (2005) observes, “Einstein’s ‘revolutionary’ paper has the strange word ‘heuristic’ in the title. This word means that the ‘point of view’ developed—that is, the light particle—is not in itself justified except as it guides thinking in productive ways”. A heuristic that has been extraordinarily productive in just that way, and ‘sticky’, with spinoffs into multiple disciplines, is the particle/wave/field heuristic that Kenneth Pike introduced from tagmemic linguistics (appropriating terminology from physics). See Young, Becker and Pike 1970, p.120 passim. Strong heuristics require a proportionally strong appetite to acquire the necessary understanding or facility for them to then transform thinking capability. Many students of Richard Buchanan refer to the four-pointed heuristic he requires them to learn—perspectively derived from Aristotle’s Four Causes—as “the cross of pain”.

14. Herb Simon’s (1969) work around design cognition reflects a theme that occurs in writings from his first book on administrative behaviours—the idea of limits to our cognitive processing capability, and the effects of those limits on how we perform in decision making. It holds well for symbolic cognition, which even if not all that a designer must do, is certainly a big part of what they must do in corporate contexts.

15. Schön (1987, p.42) speaks of “a reflective conversation with the materials of a situation”.

16. “Working memory is limited in capacity; estimates vary between about three and seven chunks of information that can be held simultaneously. In the process of problem solving, any or all of these chunks can be replaced with information from long-term memory or by new sensory inputs. Cognitive-processing resources must be used to retain information in working memory for more than about three seconds.” (Ware 2000, p.368).

17. Understanding the relation between systems thinking and design thinking requires that we distinguish between systems thinking and systems theory. Systems thinking is a capability to think comprehensively
about a complex matter. A typical application would be a large socio-technical system like taxation. Systems theory covers the various explanatory frameworks or systems archetypes that offer some methodological coherence to the task of tackling such a large system. In this respect, system thinkers and designers are confronted by similar concerns. As design has been turned to use in social spaces, their concerns have overlapped. However, I do not regard design thinking as a sub-species of systems thinking.

18. I am indebted to Timothea Horn (pers.comm.) for hinting at this serendipitous naming. The suitability of referring to the fusions that take place in the heart of the bisociative collision space as “synaptic” derives from its etymology, from “synaptein”, which Sir Charles Scott Sherrington and colleagues coined from the Greek “syn-” (“together”) and “haptein”, (“to clasp”) (Wikipedia 2010). It also has strong analogical usages, e.g., the notion of place where bisociative collisions occur bears a resemblance to the synapse as “the site at which neurons make functional contact” (University of Alberta 2002, emphasis mine).

19. The strength of a heuristic is not limited to what falls inside the frame—a heuristic will always “infer” something about what has been excluded from its content, but not from its interpretive reach. This paper has only covered the “content” of the heuristic, and in these closing paragraphs alluded to some of the essential concomitants of DT-I, such as collaboration and visualization, and to the disposition of a designer enacted by their cognitive immersion in the four modes I have described. In this latter area, my heuristic strongly aligns with Warren Bergers’ (2010) observations about designers’ dispositions to question, care, connect and commit.
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Designing Perception-Action Theories: Theory-Building for Design Practice

Malte Jung
Stanford University, Stanford, USA

Neeraj Sonalkar
Stanford University, Stanford, USA

Ade Mabogunje
Stanford University, Stanford, USA

Banny Banerjee
Stanford University, Stanford, USA

Micah Lande
Stanford University, Stanford, USA

Christopher Han
Stanford University, Stanford, USA

Larry Leifer
Stanford University, Stanford, USA

Abstract

Like many other design researchers we entered the field of design research with backgrounds in analytical engineering and science—the “sciences of the natural” as Herbert Simon put it. But we were also designers at heart, wanting to change existing conditions for the better. When trying to combine these two perspectives we were faced with a dilemma. We had the option of doing scientific research as observers detached from the situation; or doing social science research with a situated understanding but without changing the situation itself for the better; or be designers and actively change the situation without being considered as doing research. The dilemma we faced was between studying a design situation and changing it, while bridging the gap between generalizability and situatedness of our understanding. It is a dilemma unique to the practice of design research.

We explore an argument that theories and theorizing in design differ from those in the natural and social sciences. We propose that those actually grounded in the experience of perception and action fare better at being relevant to practice and understanding.
1. Introduction

Design research and design practice need a new kind of theory. We need theory that speaks to design researchers and design practitioners alike. We therefore re-conceptualize the very notion of theory to fit the specific needs of our design research community.

Theory is a conceptual construct that enables researchers in many disciplines to collaborate, communicate ideas, and build on the work of others. Theory lends particular structure to the telling of our beliefs that generally involves talking about distinctions and causal relationships. This structure has proven to be a particularly useful one in advancing what is known. Hence, for many research disciplines the activities of building and testing theory have a central role. However we often forget that there exist many different understandings of what theory means (Thomas 1997). Different disciplines have developed different notions of theory. Each notion of theory is valuable and useful for that particular discipline. For example, as empirical data is of less importance to mathematics, a mathematician’s concept of theory is likely to be less concerned with whether constructs relate to empirical phenomena. And the Mathematician's notion of theory is different from that of a physicist or from what an organizational behavior researcher considers theory. Each field has developed what we call its own theory-discourse-culture along with its own embedded values and mindsets. In sum, we make a rough distinction between these two predominant approaches to theory:

1. Natural Science Theories—Descriptive and predictive theories developed from the perspective of observers detached from the situation.
2. Social Science Theories—Descriptive theories developed from the perspective of observers in the situation.

Currently, as design researchers, we talk about theories of design, according to the discourse cultures of other disciplines. Sometimes we think of theory as do physicists (Dixon 1987), other times as do cognitive scientists (Gero 1999), or management scientists (Hatchuel & Weil 2003), and we borrow the particular structures from these disciplines. While these theories are interesting and useful, they have not allowed a sustained discourse among the broader community of design researchers let alone between design researchers and design practitioners.

As design researchers interested in improving the activity of designing, we need to be able to talk about theory in ways that help us accomplish this. Our theories do need to be relevant for both design research and design practice. The current challenges suggest there may be a relevance-gap between the researcher’s scientific approach, focused on generalizability, and the design practitioner’s approach, focused on situatedness. Some instances of theory have been able to bridge that relevance gap and have enabled a discourse between researchers and practitioners. For example Gibson's Theory of Affordances (Gibson 1977), as revisited by Norman (2002), inspired both practitioners and researchers. It allowed a fruitful conversation wherein both communities adopted parts of the theory to inform what they do—even if it was not always as intended (Norman 1999). For example, it allowed practitioners to see objects in ways they had never seen them before, and it directly informed how they would design them (Fukasawa 2007). On the other hand, it has inspired many exciting studies that delivered new understanding (Ju & Leifer 2008).

How could we design a theory-discourse-culture useful for design practitioners and design researchers alike? How could theory be structured to grow a culture of designerly inquiry (Cross 1982), that supports us in what we do, helps us in communicating our understanding and lets us expand and improve our knowing and doing? So far, as design researchers we have often failed to be relevant for design practice. We have not communicated our work in ways that allow other researchers to build upon it. This failure to establish a sustainable discourse between research and practice is faced with a growing need of design practice to have it supported by...
theory. On the other hand, there is a great desire among design researchers to engage in and contribute to design practice. This potential has not been sufficiently realized.

We therefore aim to introduce the notion of a new kind of theory that fills the gap between research and practice. We name this approach Perception-Action Theory. Perception-Action Theories are actionable theories developed from the perspective of practitioners in the situation. The label “Perception-Action Theory” refers to theory that is grounded in the first-person experience of designers engaged in the activity of designing. We refer to implicit or tacit understanding (theory) as well as the ways of seeing (perception) and doing (action) that designers develop through designerly (Cross 1982) interactions with objects and people. We do not intend to propose another theory about designing or about design practice. It is a new kind of theory that we have in mind and a new kind of theorizing around it. In the same way that Grounded Theory (Glaser & Strauss 1977) is not a specific theory but rather a specification for building theory, we intend Perception-Action Theory to stand for a corpus of theories. And as Grounded Theory methodology was proposed as an approach to develop Grounded Theory, we propose a Perception-Action Theory Methodology as an approach to develop Perception-Action Theory.

2. The job of Perception-Action Theory

What job does theory have in design research? Like many other design researchers we entered the field of design research with a background in analytical engineering and science—the “sciences of the natural” as Herbert Simon (1969) put it. But we are also designers at heart, wanting to change existing conditions for the better. When trying to combine these two perspectives we were faced with a dilemma. We had the option of doing scientific research as observers detached from the situation; or doing social science research with a situated understanding but without changing the situation itself for the better; or be designers and actively change the situation without being considered as doing research. The dilemma we faced was between studying a design situation and changing it, while bridging the gap between generalizability and situatedness of our understanding. It is a dilemma unique to the practice of design research. The job of Perception-Action Theory is to address this dilemma.

As design researchers, we can develop social science theories, cognitive psychology theories, or mathematical theories on the activity of designing. We may have the advantage of adding particular insight because of our own individual prior experiences in design practice and the empathy we have for the people we study, but building those types of theories means adopting methods and practices that researchers in other disciplines are also trained and able to do.
Perception-Action Theory is a kind of theory that only design researchers are able to develop. In other words, it builds upon the skills and natural inclinations of the design researcher, who identifies as both a researcher and designer. Such a “blueprint” for theory, relevant to design research and practice, must underscore those activities that only design researchers are able to do and are trained to want.

A typical job of theory is to provide speculations about truth and to give answers. Perception-Action Theory in design research and practice is more. Beyond only obtaining understanding through a traditional “scholarship of merit”, it must also tackle its “scholarship of impact” (Lande, Adams, Chen, Currano & Leifer 2008) and inspire useful possibilities. Research-led inquiry is generally driven by Deep Reasoning Questions (Eris 2004). A Deep Reasoning Question is a question that is convergent in nature and it operates under the assumption that a specific answer, or a specific set of answers, exists for a given question. A hypothesis, for example, is a question of the deep reasoning type. However, practice led inquiry often operates under the diametrically opposite premise: that for any given question, there exists, multiple alternative known answers as well as multiple unknown possible answers, regardless of them being true or false. These questions are divergent in nature, they are Generative Design Questions (Eris 2004). That is, rather than asking “What happens when people are designing?” we can also ask: “How can we improve how people are designing?” Designing happens in the space between divergent and convergent questions. Design research is the only field of inquiry in which both types of questions explicitly motivate what we do. Therefore, the job of Perception-Action Theory through its conceptualization and methodology should never just be providing answers but also always opening a space for possibilities and imagination.

3. Perceptual Field, Action Repertoire, and Theory-In-Action

We introduced the notion of Perception-Action Theory because we value and enjoy designing and theorizing. We see value in engaging in these two activities as a community. With the notion of Perception-Action Theory we aim to ground a theory discourse in embodied experience, in what it is that designers perceive while they are designing, and in the repertoires of actions designers can choose from while they are designing. Currently theory and practice are disjoint. We want to build a theory discourse that is grounded in experience, or in how things “feel inside” (Bernstein, Latash, Turvey & Corporation 1996, p. 184:158) as cited by Ingold (2001). We propose this shift because, in agreeing with Ingold (2001), we “regard technical processes not as products of intelligence but as practices of skill.” Ingold puts the coordination of perception and action at the core of a skill. He argues that if we want to understand a skill we need to “shift our analytic focus from problem-solving, conceived as a purely cognitive operation distinct from the practical implementation of the solutions reached, to the dynamics of practitioner’s engagement, in perception and action, with their environments.”

To engage in a theory discourse that is grounded in experience, current skills and to engage in a theory discourse that opens up the designing of new skills for design practice we want to introduce the notions of (1) Theory-In-Action, (2) Perceptual Field, and (3) Action Repertoire. We introduce these notions through an explicit reflection on an anecdote from a design class: One of our colleagues taught an introductory course in design. In this class he had an assignment to design an object that is gratifying to handle. One student spent an incredible amount of time on exploring what it meant for something to be gratifying. She experimented with different materials, shapes, and surface structures and finally presented an object that whoever held it did not want to let it go. The kidney-shaped object was simple, smooth, and just the right size to hold comfortably in one’s hand. A slight weight imbalance made it particularly compelling. In the end all we usually see is the beauty of the object. However, in the course of her designing, the designer gained insights to identify what characteristics were relevant, how to
change those characteristics, and why certain manipulations led to specific outcomes desirable to her. We might say she developed her own implicit gratifying-to-handle-theory as an implicit theory-in-action. Let us assume that at the beginning of her exploration she probably had some ideas of what it means for something to be gratifying to handle. However she didn’t let her designing be guided by her initial theory, which would have been to design an object based on what she already knew. She rather embarked on a course of wayfaring in the purpose-context of designing something that was gratifying to handle. In that wayfaring she extended what we call a Perceptual Field, a corpus of noticings that are relevant in a particular purpose context. Things like “surface structure”, or “weight imbalance” might have been components of her perceptual field. She also extended what we call her Action Repertoire, her corpus of behavior enabling her to manipulate her environment. A relevant action could be labeled “polishing”, or “adding an imbalance weight”. A related example of an exploration that led to the development of new distinctions, possibilities for action and theory is described in Niedderer’s explorations in designing mindful interactions (Niedderer 2007). We want the notion of Perception-Action Theory to help us in reflecting on and in guiding design explorations by paying particular attention to what it is we are “seeing”, “doing” when engaged in an interaction and then to help us ask why certain doings let to certain changes.

**Perceptual Field**

Goodwin describes how different professions “see” and how their seeing makes particular interpretations and actions relevant (Goodwin 1994). Our notion of a perceptual field is inspired by his paper on professional vision. With perceptual field, Goodwin refers more literally to what is in a person’s field of vision. We, in contrast, refer to perceptual field analogous to a magnetic field. With this analogy we want to emphasize the notion that the boundaries of what we attend to are fluid, and that what we perceive gravitates towards known distinctions such as the ones established through a Munsell color chart (Goodwin 1994).

We define a Perceptual Field as sensing organized around a purposeful activity. With the notion of a perceptual field we want to refer to what one notices when one is engaged in the activity of designing. This noticing can refer to things in the environment or to internal states and feelings. A Perceptual Field can, for example, be set up through disciplinary training, or through certain media that make specific characteristics salient. Re-framing in terms of a Perceptual Field means shifting from one Perceptual Field to another Perceptual Field.

**Action Repertoire**

Analogous to a perception, we define an Action Repertoire as moving organized around a purposeful activity. With an Action Repertoire we want to refer to the choices from a corpus of behaviors a designer has when engaged in the practice of designing. An Action Repertoire can be seen as the corpus of behaviors a designers has at his or her disposal when engaging in a conversation with the situation.

**Theory-In-Action**

With theory-in-action we refer to the heuristics, beliefs, expectations, and explicit understandings that guide what we pay attention to, what actions we choose and how we evaluate the outcome or our actions. Argyris and Schön refer to this as Theory-in-Use (Argyris 1995; Argyris & Schön 1989). Our aim is to engage in reflective conversations about these heuristics, beliefs, and expectations to build explicit and sharable theory.
4. Designing Perception-Action Theory

The purpose of a practice to design Perception-Action Theory is to instrument designers, to enable them with new ways in interacting with their environment. We envision a new set of tools, methods and instruments to facilitate the development of Perception-Action Theory.

What tools, frameworks, and practices let us design new ways of seeing and doing and then reflect about them? We believe that there is not a single process, framework or tool that can accomplish this but rather a conglomerate of things that we can adapt and add to in ever new ways. Many components of a methodological package are already available that we can use in designing Perception-Action Theory and that we can develop further. We borrow most of the components we found useful from approaches developed in engineering design, anthropology and organizational behavior research. We organize these components as to whether they contribute in the development of a Perceptual-Field, an Action-Repertoire, or a Theory-In-Action.

**Approaches in developing Perceptual Fields**

At the Center for Design Research we have a lab, we call it the Design Observatory (Carrizosa, Eris, Milne & Mabogunje 2002), that we have used for the past 20 years to design perceptual fields. Before Eris’ (2004) work, when we looked at designers interacting we never “saw” their questions, before Mabogunje (1997) we did not see the language they were using, and before Ju (Ju & Leifer 2008) we did not see what she called implicit interactions. We could say that we have invented ever-new ways of “seeing” and experiencing design activity and we have developed tools to invent new ones along the way. Many of these tools are at an intersection of anthropology (Goffman 1971; Sacks, Schegloff & Jefferson 1974; Schegloff 2007; Suchman & Trigg 1991) and engineering (Jordan & Henderson 1995; Tang 1989; Tang & Leifer 1991).

**Approaches in developing Action Repertoires**

As researchers however we focused on “seeing”, describing, and predicting design activity. We mostly sat in the audience watching designers designing, never participating in the action and only intervening when setting up a new context for new design activity to observe. This allowed us to build perceptual fields and turn them into explicit coding schemes. However we never developed action repertoires and explicit coding schemes for what we do when we are designing. We need to learn how we can engage not only in the seeing of but also in doing of designing and then theorize on our seeing and doing when engaged in design research. We found traditions of research like Action Research (Lewin 1946), Action Science (Argyris 1983; Argyris & Schön 1989), or Participatory Action Research (Whyte 1989), that emphasize the principle of action, but without a concrete link between the action of changing the situation and the theorizing that leads to generalizable and shareable knowledge.

**Approaches in developing Theory-In-Action**

The body of tools, frameworks and practices for theory-building far exceeds the one available for building perceptual fields or action repertoires. Approaches such as the Grounded Theory methodological package (Glaser & Strauss 1977), case study research (Yin 2008), or the Building Theories from Case Study Research approach (Eisenhardt 1989) are available in building theories based on empirical data. In addition we need approaches that support introspection (Dörner 1994) and building theory inspired by personal experience and insight (Glaser & Strauss 1977).
The literature cited above shows that many approaches exist that are useful in building theory about and relevant to the practice of designing. However those different approaches have never been combined in a way that is useful for designing and in a way that only design researchers can bring them together.

5. Summary and outlook

In this paper we put forth our position of there being a need for a new conceptualization of theory in design. This position is motivated by our frustration that while the notion of theory has been valuable in research, the current notions of theory do not seem to support a research practice that we as design researchers find valuable, that we enjoy engaging in, and most importantly that only we as design researchers are able to do.

We proposed Perception-Action Theory as a kind of theory and methodology for developing theory that fits the particular demands and abilities of design research. We see Perception-Action Theory as a means to explore the ways through which we can design new skills for researchers and practitioners. This idea rests on an anthropological understanding of what constitutes a skill (Ingold 2001). Our aim, however, is not only to study existing skills but also to engage in activities to design new skills that enable designers to engage with their environment in novel ways. We proposed that the job of Perception-Action Theory is not only to provide answers but also to inspire possibilities in its development and use.

We hope that Perception-Action Theory inspires a fruitful discourse among design researchers that inspires the development of new approaches unique to the research aimed at understanding and improving the practice of designing.

Acknowledgements

We kindly thank Hasso Plattner Design Thinking Research Program and the Kempe Foundation for the support that made this work possible. Many of the ideas developed here were tried out in the ME397 seminar on Design Theory and Methodology at Stanford University. We therefore want to thank the students in that seminar for their contributions and suggestions.
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Is There a Need for a Design Thinking Process?

Tilmann Lindberg
Hasso Plattner Institute, Potsdam, Germany

Raja Gumienny
Hasso Plattner Institute, Potsdam, Germany

Birgit Jobst
Hasso Plattner Institute, Potsdam, Germany

Christoph Meinel
Hasso Plattner Institute, Potsdam, Germany

Abstract
Sequential process models play a core role in design thinking education, although design thinking principles ask for more adaptability and flexibility of design workflows than those models suggest. This paper explores how far there is a need for a design thinking process and suggests an alternative conceptualization that is both congruous with design thinking principles and viable for design thinking didactic.

1. Introduction
Design thinking has become a widespread approach to solve socially ambiguous design problems. In design thinking education, sequential process models are applied to help students to apply design thinking principles to design project exercises. This however entails a paradoxical situation, as there is a fundamental conceptual conflict between the same principles that ask for situational flexibility and adaptability of workflows, and the normalization of workflows as suggested by those models. In this paper, we ask whether there is a need for a design thinking process. We propose avoiding this paradox through an alternative conceptualization, using “working modes” instead of process steps that are interlinked variably following heuristic “working rules”. We aim to draw up a design workflow model that is in agreement with design thinking principles as well as concrete enough to be used for design thinking education.

2. Design Thinking Workflow Principles
In the broadest sense, design thinking refers to the “study of cognitive processes that are manifested in design action” (Cross et al. 1992), and thus indicates a general research focus independent of what design paradigms dominate. Research on as well as the application of design thinking has become prevalent over the last three decades. It rooted in 1970/80ties case study research by Lawson (2004; 2006) and Cross (2007b) on how outstanding designers approach problems and develop solution concepts and has evolved to a broad discourse on the exploration and analysis of cognitive strategies that carry the generation, synthesis and creative transformation of divergent knowledge within design processes (Beckmann & Barry 2007; Owen 2007). Moreover, those strategies have been reinterpreted as normative guidelines for design projects and creative problem solving in general [1]. In this connection, design thinking was translated into holistic frameworks moving beyond designer’s professional domains and
gradually applied to various disciplines and fields of innovation in both academia and business (Brown 2008; Drews 2009; Dunne & Martin 2006; Grots & Pratschke 2009; Martin 2009; Plattner et al. 2009). In particular those normative interpretations of design thinking have led to a vast variety of conceptions and intentions of use, which make it sometimes complicated to see the common traits.

However, we find it helpful to understand the basic principles of problem solving in design thinking with two pairs of terms: the problem and solution space on the one hand, and diverging / converging thinking on the other hand. While the first gives fundamental insights on how design problems are perceived and constructed, the second basically shows how to learn and deal creatively with relevant knowledge within design thinking-led problem solving.

A concept of the problem space was first introduced by Newell et al. (1967). They locate the representation of possible solutions in the problem space itself without regarding a separate solution space—according to the logic once a problem is comprehensively stated, the optimal solution can be rationally derived from the inner structure of the problem [2]. In opposition, Cross & Dorst (cited in Cross 2007b) brought up the notion of “co-evolution of problem and solution”. They regard designing as a dualistic approach that regards both problem and solution space as to be explored, whereas it is neither possible to fully understand a problem, nor to deduce rationally an “optimal” solution [3]. Initial problem space exploration aims at constructing subjective representations of diverse stakeholder perspectives setting the problem space’s yardsticks. Those representations however are not—according to scientific standards—‘representative’: they serve as inspiration for an exploration of the solution space, first by working out ideas and then by turning ideas into tangible sketches and prototypes. Making things tangible, yet, allows designers to learn again more about the problem space, for instance when communicating about those ideas with the stakeholders. Consequently, the designer’s awareness of both problem and solution space will be reviewed and renewed with each other until the designer perceives a distinct match between them (Cross 2007b).

**Figure 1. Basic Principles of Design Thinking Workflows [4]**

The distinction between diverging and converging thinking however shows how both spaces are explored. This pair of terms goes back to Guilford (1969), who sees ‘divergent and convergent production’ as elementary cognitive factors of problem solving and in particular the former as an important factor of creative work. Divergent thinking means dealing with a problem by discovering a broad range of its aspects—for instance the divergent perspectives constituting
a design problem or the divergent possibilities that make up the solution space. Convergent thinking, conversely, brings together those divergent aspects to comprehensive frameworks and concepts, for example by synthesizing user observations to clear-cut point of views or by prioritizing ideas and specifying design concepts.

The significance of both principles for tackling design problems has been pointed out e.g., by Dym et al. (2005) and Rhea (2003). It is hypothesized that the general course of design workflows within problem and solution space either shows divergent or convergent directions, though both divergence and convergence show in each space fundamentally different traits. In the solution space, divergent and convergent thinking support the creation and elaboration of ideas and concepts. In the problem space, however, they show how to gain and handle relevant external knowledge within ‘wicked problem’ settings, without being dependent on scientific modes of thinking. Design thinking aspires divergence instead of representativeness in order to develop a broad inspirational understanding about a situation, and it does not expect more (or less) from convergence as to summarize a certain state of knowledge or to capture and elaborate a certain idea or concept.

In consequence, design thinking is the interplay between diverging activities of opening up the problem and solution space and converging activities of synthesizing and selecting. Contrary to scientific thinking, the knowledge processed in design thinking has to be neither representative nor entirely rationalized, rather it serves to obtain an exemplary but multi-perspective understanding in order to creatively transform it to a solution for the ambiguity of wicked problems. Summing up, this interplay can be put down to three basic characteristics, that engenders a system of checks and balances to ensure that the conclusive solution will be both innovative and suitable for the social system that the design problem addresses (see also Fig. I):

• **Exploring the problem space:** When exploring a problem space, design thinking acquires an intuitive, not fully verbalized, understanding, mainly by observing exemplary use cases or scenarios, as opposed to formulating general hypotheses or theories regarding the problem; and synthesize this knowledge to points of view.

• **Exploring the solution space:** When exploring the solution space, design thinking asks for a great number of alternative ideas in parallel and elaborates them with prototyping techniques. In this manner, ideas are being consciously transformed into tangible representatives.

• **Iterative alignment of both spaces:** These representatives of ideas and concepts facilitate communication not only in the design team, but with users, clients and experts as well. Thus, design thinking helps to keep in touch with the problem-relevant environment and can use this information for refining and revising the chosen solution path(s).

### 3. Contradictions in Design Thinking Process Models

As argued above, problem solving in design thinking can be put down to three underlying principles. As we discuss in this paper how far it is reasonable to speak about ‘design thinking processes’, we now would like to distinguish this term from the term ‘design process’ and discuss certain contradictions that this term entails.

‘Design processes’ mean basically all the activities put together being premeditated or employed to solve a certain design problem. There is a long tradition of academic discourses on modelling design processes, whereas one can tell between two intents: on the one hand, design process models as explanatory-theoretical representation of design activities; on the other hand, design process models as prescriptive statements on how to solve design problems. Models of the first category generally are rather abstract and support theory building; models of the second category however illustrate already fixed design approaches or paradigms, often with the intention to facilitate the organisation of real-life design activities [5]. The term ‘design
thinking process’ yet has somewhat different connotations. First, ‘design thinking’ points at only those design activities that address design problems which are rather ambiguous, blurred in character and not definitely definable—so-called wicked problems (Rittel 1972; Buchanan 1992). As a consequence, the way in which design processes are perceived is rather indefinite as well. Thus, the idea of a normalized process that tells in which step sequence designers come to the right solution is ultimately rationalist idea, following rather a scientific way of problem solving [6]. Even if there is also from a design thinking perspective no doubt that each design problem solving constitutes itself in a certain sequence of process steps, the question would be how predictable and thus how determinable those sequences are.

This however is no trivial question. On the one hand, there are—as described—design thinking principles that influence the processes in reality, for instance the principle to explore the problem space before going into the solution space. On the other hand, those principles cannot be taken to derive a normalized sequence of phases as ‘optimal’ process model—owing to the fact, that design thinking emphasises too strongly problem-related learning and adaptive concept creating to be constricted in a uniform process. Thus workflow standardizations would be contra-productive as the progress of design thinking-led problem solving does not lie as much in sticking to the phases of the process as in understanding and adapting to the ambiguity of a design problem. Design thinking process models therefore have to struggle twofold: firstly, they must depict context-sensitivity and situational adaptability of workflows without loosing conceptual clarity; and secondly, when they propose instructions for real-life projects, they have to make clear that they offer ‘only’ guidance and no definite means for design problem solving. In sum, design thinking process models have to deal with the fact that design thinking is originally no process, but that it shapes processes.

As a result, there is in design thinking discourse apparently more ease in developing explanatory and theoretical models (as in Fig. 1) than prescriptive and concrete ones. Owen (2006), for instance, models knowledge processes in design thinking workflows from a theoretical standpoint very insightfully, and Beckmann & Barry (2007) do the same with learning terminology. Design thinking processes models with more prescriptive and concrete character however (that is models giving instructions for practical use) tend to struggle finding the balance between flexibility and sequentiality. Brown (2008), for instance, distinguishes the general phases ‘inspiration’, ‘ideation’, and ‘implementation’, and groups and orders for each phase the questions to ask or the actions to do. To weaken sequentiality, he arranges the model in a circular manner and connects the phases with both forward and backward linkages. Another model has been formalized at the Hasso Plattner Institute of Design at Stanford and is used as a didactic process model for design thinking education (Plattner et al. 2009; for a similar model see Grots & Pratschke 2009). It distinguishes the phases ‘understand’, ‘observe’, ‘synthesis/point of view’, ‘ideate’, ‘prototyping’, and ‘test’. As Fig. 2 shows, though these phases are put in a sequential order, linearity is avoided through iterative links connecting all phases with each other.

The purpose of such prescriptive design thinking models is to give a comprehensible and rather intuitive picture of an idealized design thinking workflow with the aim of helping people to
adapt and apply it. Those models show hybrid traits, as they tend to ‘flirt’ with sequential process depictions in order to achieve better lucidity while trying to avoid at the same time the impression of linearity through circular logic or all-connecting feedback loops. This ‘balancing act’ may make sense for didactic reasons in order to help design thinking students to apply design thinking principles in project-based learning courses without having them already internalized. Thus, the sequence of phases can be seen as a case of a design process designed for learners, while the iterations elucidate adaptability and context sensitivity. Yet, we think that those models entail the risk of misconceptions as their sequential framework may obscure that design thinking is no process, but shapes processes.

4. An Adaptive Design Thinking Workflow Model Proposal

As a result of the previous discussion, there is a need for a comprehensive model that guides design thinking learners through project-based learning lessons. On the other hand, there is also a danger of misconception when falling back upon sequential process models, as those models make the underlying design thinking principles somewhat indistinct. To overcome this contradictory situation, we suggest avoiding the traditional process terminology consisting of phases, sequences and feedback loops. We think, that this terminology has been rather chosen on account of its commonness and comprehensibility than its conceptual fit. Considering that design thinking workflows are shaped by underlying principles giving rise to processes without prescribing them, we suggest to model those principles on a concrete level by using as basic distinction both terms ‘working modes’ and ‘working rules’. While the former are recurring steps of the problem solving process, the latter are heuristics that help to decide how to interlink the modes to a helpful process.

4.1 Eight Working Modes

By using the term ‘working modes’, we assume that there are certain sets of activities that recur in any design thinking-led problem solving workflow. As detailed below, we distinguish eight different modes with distinct goals and means:

a. (Re)Framing the Design Problem

Goal: This is the focal mode of problem space evolution. Its goal is to frame and reframe the scope of the problem space and thus the question to ask for further learning efforts (Brown 2010, Schön 1984). This mode opens every design workflow—mostly based on information given by the client as well as the own expertise—and is applied when an altered state of knowledge does not match the way that a problem is framed.

Means: Means how to frame: e.g., Fractionation (e.g., de Bono 1970). Means how to reframe: e.g., Synectics (Gordon 1961).

b. Grasping External Knowledge

Goal: This is the focal mode of problem space exploration. The goal is to collect problem-related knowledge that is not already part of the designers’ expertise. Studying who the particular stakeholders of a design problem are and how they think and act is compulsory for this mode—in particular with regard to the users. In this mode, designers deal with two different types of knowledge. While it is rather easy to grasp ‘explicit knowledge’ as it exists already in forms of documents, reports or clear-cut statements, it is considerably more intricate to gain so-called ‘tacit knowledge’, containing unspoken thoughts, feelings, habits or needs (Nonaka 2007; Wagner 1987). Tacit knowledge however is a vital part of problem space exploration. Developing
empathy for the users’ needs, for instance, and exploring what bothers them means to deal with situations in which the most revealing aspects may be not expressed directly.

**Means:** The basic means of this mode is communicating, observing, recording, and empathizing, supported by manifold methods (e.g., interviews, survey questionnaires, focus groups, cultural probes etc. (e.g., Laurel 2003; Visocky O’Grady 2006)). Typical user research can be performed by field studies, interviews, or self-experiments (e.g., Beyer & Holtzblatt 1998; Jones 1992). Additionally information can be obtained by literature and desk research. At a more developed state in the design process, the focus will be put on user feedbacks on visualizations and prototypes.

c. **Knowledge Pooling**

**Goal:** This mode presupposes a team carrying out the design project. Its goal is to combine the versatile amount of knowledge so as to create a mutual knowledge base among all team members. It is important not only to transmit explicit information but also impressions and empathic understanding. This mode is important due to two reasons. First, when grasping external knowledge team members often divide their focus because not everyone can attend all appointments due to time and budget restrictions, or there may be dedicated, experienced user researchers for those activities. Second, knowledge pooling is important for developing a multi-perspective understanding of the problem space. As every team member introduces an own personal or disciplinary perspective, the team as a whole enhances sensitivity for a wicked design problem setting.

**Means:** The most important means is to inform team members about insights from user research and share also the empathic knowledge which was collected. A very common method is Storytelling (e.g., Quesenberry & Brooks 2010; Brandes et al. 2009).

d. **Synthesizing**

**Goal:** Recurrently, designers are confronted with a large quantity of information—they may be problem-related or solution-focused —, being too widespread to be completely included in the subsequent design workflow (Kolko 2010). Thus the goal of this mode is to synthesize information by grouping, structuring or condensing them to a (preliminary) conclusion as basis for further work (Howard 1988). Synthesizing is a critical part of a design workflow as it decides about how to converge highly divergent states of information and thus how to process them.

**Means:** 1. Creating abstract frameworks, e.g., with the help of ‘Concept Mapping’ (e.g., Kolko 2010). 2. Converging into concrete representations, e.g., in form of a ‘Point of View’ or ‘Persona’ (fictional character profile) (e.g., Long 2009; Laurel 2003).

e. **Path Selecting**

**Goal:** At certain points in a design workflow, designers learn about several options of proceeding, and—under the condition of limited time and resources—they must decide in which direction they further want to go. This can relate to both what questions guide exploring further the problem space and or ideas will be worked out to solution concepts. The goal of this mode is making those decisions consciously and deliberately with the whole team (and maybe with the client also), as it is otherwise likely to loose tracks of the project as well as to harm the mutual understanding of the design workflow.

**Means:** ‘Group discussions’ are a starting point for this mode, followed by methods like ‘Elevator Pitches’ (e.g., Skambraks 2004; Pincus 2007). For the conclusion of this mode, voting techniques like e.g., ‘Dot Sticking’ or ‘Dotmocracy’ (e.g., Baxter 1995; Tague 2005) are useful.
f. Ideating

**Goal:** Creating a vast variety of ideas is crucial for finding the ones that prove themselves as viable (Brown 2010). The goal of this mode is to create manifold and various ideas on possible solution paths without judging or criticizing them (thus wild or seemingly strange ideas are welcome) in order to achieve a large quantity of ideas. Selecting ideas is not part of this mode (à path selecting). Expressing and applying the personal creative potential of all team members is important. Preferably a diverse team is involved when it comes to ideating, as inputs from people with different backgrounds increases the variance of ideas.

**Means:** There are many creativity methods supporting this mode, primarily ‘Brainstorming’ (e.g., Brandes et al. 2009), ‘Brainwriting’ (aka Method 635) (e.g., Rohrbach 1969; Baxter 1995), Mind Mapping (Buzan & Buzan 1996) and ‘Synectics’ (Gordon 1961; Jones 1992).

<table>
<thead>
<tr>
<th>Mode</th>
<th>Problem or Solution Space</th>
<th>Diverging or Converging Thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (r)eframing the Design Problem</td>
<td>Problem Space</td>
<td>Starting or Coupling Point (C→D)</td>
</tr>
<tr>
<td>b. Grasping External Knowledge</td>
<td>Problem Space</td>
<td>Diverging</td>
</tr>
<tr>
<td>c. Knowledge Pooling</td>
<td>Problem Space</td>
<td>Coupling Point (D→C)</td>
</tr>
<tr>
<td>d. Synthesizing</td>
<td>Both Spaces</td>
<td>Converging</td>
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<tr>
<td>e. Path Selecting</td>
<td>Both Spaces</td>
<td>Coupling Point (D→C &amp; C→D)</td>
</tr>
<tr>
<td>f. Ideating</td>
<td>Solution Space</td>
<td>Diverging</td>
</tr>
<tr>
<td>g. Concept Specifying</td>
<td>Solution Space</td>
<td>Converging</td>
</tr>
<tr>
<td>h. Making It Tangible</td>
<td>Solution Space</td>
<td>Converging</td>
</tr>
</tbody>
</table>

g. Concept Specifying

**Goal:** The goal of this mode is to bring certain ideas on a more detailed level. It asks to think with scrupulousness about an idea and to concentrate on the facets that should be incorporated in the next sketch or prototype. The concept should be further revised and specified with ongoing iterations, eventually leading to a profound strategic planning document. This mode is the preceding step for making ideas tangible (see mode f).

**Means:** There are different means to support concept generation (Pugh 1990), e.g., ‘Concept Mapping’ (e.g., Novak & Cañas 2008), ‘Frameworks’ or ‘Process Diagrams’.

h. Making it tangible

**Goal:** This mode’s goal is to visualize and objectify ideas and concepts to enable feedback from potential users and stakeholders. The level of refinement of visualizations and prototypes depends on the stage or amount of iterations in the design. In the beginning, there should only be a rough representation of the concept, such as a sketch on paper or roughly built mock-up (Buxton 2007). Such ‘low resolution’ depictions or prototypes help to get quick and cheap feedback on the general idea of a design concept and are thus indispensable for rapid learning cycles. As more the designers have filtered out a particular concept, as higher should be the resolution of prototype because they help learning about the details of a concept (Edelman et al. 2009).

**Means:** In early stages of the design, typical means are simple visualizations in form of sketches (e.g., Visocky O’Grady 2006). Later all different kinds of prototyping methods are used (known
by different sometimes inconsistently used labels: e.g., low- and high-fidelity prototyping, paper prototyping, mock-ups or wireframes (e.g., Beyer & Holzblatt 1998; Warfel 2009).

We distinguish these modes both with regards to the pairs of terms ‘problem and solution space’ and ‘diverging and converging thinking’. As Tab. 1 shows, the modes a, b, and c support problem space exploration, the modes f, g, and h solution space exploration, and the modes d and e are supportive in both spaces. Likewise, the modes b and f show fundamental divergent traits and the modes d, g, and h convergent traits. We regard the modes a, c, and e as coupling points linking up divergent and convergent movements.

4.2 Six Working Rules

As described above, we see these working modes as basic activities recurring in every design thinking workflow. We furthermore suggest six working rules that give heuristic assistance on how to apply and combine them in a design thinking workflow. We see these rules in particular valid and viable for design thinking novices. The more advanced a designer is, the less normative should those rules be regarded.

1. **Every Mode Is Important**: All modes should be incorporated in a design thinking workflow.

2. **Initial Problem Space Exploration (Phase I)**: At the beginning, the problem space has to be extensively understood before one can pass over to the solution space. The team iteratively executes the problem space modes (see Phase I in Fig. 3). For novice design thinkers, we suggest to start with the following order: Framing the Design Problem, Path Selecting, Grasping External Knowledge, Knowledge Pooling, and Synthesizing.

3. **Finding a Viable Scope Before Entering the Solution Space (Phase I)**: Two criteria help to answer the question when to enter solution space for the first time: a) there should be a certain scope of the problem to which the gathered knowledge has been converged and that does not alternate substantially with further iterations; b) the design team should regard this scope as a viable background for ideating and concept development.

4. **Problem Space Exploration as Combination of Unfolding, Selecting and Re-Representing Solution Paths (Phase II)**: Solution Space exploration relies on three aspect: a) finding manifold potential solution paths by ideation techniques, b) learning how to select a group of them to put more attention on, and c) learning about their facets by means of diverse representation techniques (e.g., concept drafts, sketches, prototypes). We suggest an order of working modes for design thinking novices: First, ideating for new idea generation, followed by synthesis and / or path evaluation, concept specifying, and making it tangible.

5. **Balancing Solution Paths with the Problem Space when Tangible Representations are Available (Phase II)**: The problem space should be re-entered when a tangible object is on hand that allows collecting feedback from stakeholders with the purpose of supporting revising, refining or rejecting a certain concept. For design thinking novices, we suggest the same sequence of working modes as in phase 1: Exploring the Problem Space, Information Pooling, Synthesis, Reframing the Design Problem and Path Evaluation, before entering the solution space again.

6. **Ending the Workflow when a Concept is Saturated**: The design workflow should ideally come to an end when balancing problem and solution does not suggest significant modifications of the design concept. Then the concept is saturated.

With Figure 3, we propose a model that shows how modes and rules interact against the background of the design thinking principles illustrated in Fig. 1. In this model, we draw several distinctions that show the different layers of design thinking workflows. First, we look at problem and solution space in parallel and use this distinction to discriminate two phases: the initial problem space exploration (Phase I) as well as the following co-exploration of solution and problem (Phase II). Second, we depict the alternation of divergent and convergent thinking throughout the workflow by using the quadrants of the circles as metaphors for both kinds of
thinking. Third, we tell apart a prescriptive workflow for novice design thinkers (whereas the position of working modes should be seen as suggestion and not as law) and the rather volatile workflows of advanced design thinkers. Fourth, we try to balance both the adaptive toolbox that design thinking offers and the recurring patterns that design thinking demands by showing up where the freedom to decide what to do next is stronger or weaker. We are aware that this model gives in the depicted form very complex information so that it would be viable only for conceptual and not for didactic reasons. The different layers however can be easily scaled down so as to transform it into a more comprehensive form.

Figure 3. Adaptive Design Thinking Workflow Model

5. Concluding Remarks

Concluding, we answer the question whether there is a need for a design thinking process from two perspectives. First, we described design thinking as a broad problem solving methodology that is as such no process, but shapes processes. There is unavoidably a process in every design thinking project, namely what is constituted by the sequence of the chosen design activities within the broader frame of design thinking. Those processes still are no need or precondition for a design thinking-led project, but a necessary consequence. However, when a design thinking process is understood as a prescriptive series of design actions, the answer is more ambivalent. From a conceptual point of view, such ‘design thinking models’ create contradictions in themselves, as they would turn the process from a consequence to a precondition. From a didactic point of view, however, they could make sense as guidelines for design thinking novices, but entail a certain danger of misinterpretation when they are interpreted too orthodoxly. In order to circumvent this danger, we think that also didactic design thinking models should not draw on customary process terminology—in order to maintain a clear distinction between prescriptive design thinking methodology and resultant processes. We proposed a model that tries to show ways to combine both claims—the conceptual and the didactic. In a next step, we would reduce the complexity of the model (in particular the illustration in Figure 3) in order to work it up for practical use.
Notes

1. See Lindberg et al. (2010) for a closer discussion of this normative reinterpretation of design thinking.

2. With this approach Newell et al. are representatives of a positivist perspective on design (cf. Alexander 1964) in contrast to a constructivist perspective followed by e.g., Rittel (1972). See Dorst and Dijkhuis (1995) for more details.

3. See also Cross (2007b) and Dorst (2006) for further corroboration of this argument.

4. Own depiction, partly inspired by an unpublished IDEO draft and Buxton (2007).

5. Lawson (2006) gives several examples as well as a profound critique for descriptive-analytical design models. For a comprehensive collection of design models, see Dubberly (2004). For a detailed discussion and further classifications of design process models, see Wynn & Clarkson (2005).


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Design Thinking in the IT Industry: Exploring Language Games on Understanding, Implementation and Adoption

Tilmann Lindberg
Hasso Plattner Institute, Potsdam, Germany

Ingo Rauth
Hasso Plattner Institute, Potsdam, Germany

Eva Köppen
Hasso Plattner Institute, Potsdam, Germany

Christoph Meinel
Hasso Plattner Institute, Potsdam, Germany

Abstract
In the course of the evolving discourses on design thinking, efforts have been made to apply design thinking to the IT industry with the intention of helping IT development out of too technically oriented design processes. Drawing on an explorative field study, we examined experiences made with those efforts to understand what it means to put design thinking into operation in an IT context. In this paper, we ask how people create meaning about the given problem setting in order to come up with empirically substantiated hypotheses on the issues involved in understanding, implementing, and adopting design thinking in the IT industry.

1. Introduction
1.1 Technical Bias in IT Design
IT development processes ask for highly trained professionals who are qualified to deal with complex technical issues, as programming languages or software and hardware architecture. Competencies in software engineering are not only important for taking part in programming, but also in designing the software. As every decision about the design of an IT-system unavoidably manifests at the level of architecture or code, expert knowledge and thinking play an important role already for early design decisions. Consequently, the educational background of hardware and software engineers has strong influence on mind-set building and problem solving. As a result, IT development has the tendency to take place within an “exclusive” expert’s world.

In past and present times, these circumstances lead to the fact that technically and analytically trained IT engineers take on the designer’s role as well, although they have not been professionally trained in that field. The word “software design” is, in fact, almost exclusively associated with technical issues. This “technical bias” in IT design entails that a design problem’s technical complexity receives more attention than its social complexity. As a result, IT development has been struggling with the situation that functionalities and interfaces shape up as incomprehensible, inappropriate or simply unoriginal for the user, while other features considered as essential or meaningful from a user’s point of view are not addressed.
Overcoming this situation, however, has become a key issue for the IT industry. As times in which the IT market grew mainly driven by technology push dynamics went by, the challenges that IT development faces exceed the established focus of an engineering expert’s world and ask for the integration of further perspectives on problem framing and solution finding. Within the IT world, this problem has been tackled so far in two different ways. On the one hand, new design disciplines such as interaction or user experience design came up taking on specifically the role of the “user’s advocate” within development teams (Buxton 2007; Mandel 1997; Vredenburg et al. 2002). On the other hand, new software engineering approaches, in particular those summarized under the umbrella term “agile development”, put strong emphasis on an incremental and iterative development process that is adaptive to user feedback throughout (Beck 2003; Pichler 2008).

1.2 Design Thinking in the IT Industry?

The present debate on applying design thinking to IT industry also addresses this problem, however with a primary focus on broadening thinking patterns in IT development. Design thinking is associated with a problem solving style that supports dealing with the socially ambiguous aspects of a design problem. In contrast to orthodox engineering design paradigms, the corresponding problem solving patterns build rather upon heuristics and situational reasoning than on analytical and rationalist thinking. Approaching design problems is not regarded as a process of definition or final specification as an analytical problem solving process would suggest, but of a continuing approximation to viewpoints of exogenous stakeholders (i.e., the users, clients, manufacturers, law-makers) that finally decide about a solution’s viability and quality (Dorst 2006; Krippendorf 2007). To do so, design thinking relies on concept developing by using preliminary and even intuitive knowledge about a design problem, while proofs of concepts are adduced by negotiation between different and probably conflicting stakeholder perspectives (Beckmann & Barry 2007; Owen 2007). In design thinking, problems are perceived as ‘wicked’ (Rittel 1972), saying that there is no possibility to frame design problems into well-structured units before the actual problem solving process starts. The relation between problem and solution is not like deriving the latter from the former, as purely analytical approaches would suggest, but like framing problems and solutions interdependently in frequent iterations (Cross 2007; Lawson 2006). Also, the key knowledge in design thinking is not the expertise of specialists but the knowledge of stakeholders that is supposed to be learned for every design process once again. The process behind design thinking thus builds rather on learning about problem and solution than on applying already learned knowledge, and therefore supports all activities of grasping multiple knowledge and multiple perspectives for inspiration and learning concepts as well as the creative transformation into new concepts (Brown 2008; Lindberg et al. 2010). All together, design thinking embodies tackling those ‘fuzzy’ aspects of a design problem, which are in purely engineering-led approaches left aside, and is thus suggested as a useful supplement to problem perception and solving in ‘traditional’ IT development approaches.

However, beyond purely conceptual thought on applying design thinking to IT development, many questions remain open. How can design thinking be conceptualized and distinguished within software engineering on a practical level? How can it be imparted and organizationally implemented? How is it understood and adopted to daily work routines? Finding answers to those questions still is a challenging endeavor, as there is a lack of both strategic models and hands-on experience.
1.3 Exploring Language Games on Design Thinking

To set initial research on those questions, we conducted expert interviews mainly with IT developers that have been trained in design thinking workshops as well as with trainers and observers of those workshops. The basic insights gained from these interviews showed the topic’s complexity quite clearly. Albeit the majority of interviewees regarded design thinking by some means as enriching, we discern partly different views on what design thinking is and how it can be adopted and implemented. We hypothesize that this variety of perspectives affects not only implementation and adoption, but shows also a paradoxical trait of design thinking itself, namely that it is neither perceived as an insubstantial ‘buzz word’, nor as a delimited concept. Between both extremes, its meaning seems to be strongly subjected to vivid ‘language games’.

‘Language games’ is a concept developed by the philosopher Ludwig Wittgenstein (1984) that explains how one word can carry an infinite series of meanings—depending on the context or situation in which a word is used. Wittgenstein puts language in analogy to games, because each game represents a certain set of backgrounds, goals and rules. Some are constitutive; others are rather implicit and can be modified. Wittgenstein applies this as metaphor to language, stating that rather the language games than the words decide whether communications work: when people play with the same words but according to different rules, there would be a great juxtaposition of language games hindering each other to succeed. Thus we regard it as important to identify and distinguish ‘language games’ on design thinking in order to create a basic understanding about how to apply design thinking to the IT industry. To do so, we employ a systematic approach to qualitative text analysis based on ‘grounded theory’. In what follows, we will give a short overview about our research setting and our method of investigation.

2. Research Setting and Methodology

We conducted 30 expert interviews (Bogner et al. 2005) with three groups of people working in the IT industry in Germany and the US: first, design thinking experts that educate IT engineers in design thinking; second, IT engineers that have been trained in design thinking; and third, experts from specialized design disciplines like user experience design that observe these efforts.

All interviewees were involved with design thinking in the form of a particular didactic workshop model either as trainer, participant or observer. Those workshops followed an approach being popularized by the design agency IDEO as well as the Stanford d.School model (Plattner et al. 2009), in which small, multidisciplinary teams (generally without a professional design background) tackle a seemingly simple design challenge (for instance: how to improve ticket machines for public transport) and are supposed to understand how far the own imagination of a viable solution changes after learning about the stakeholder perspectives (in particular the users’). To do so, those workshops suggest a prescriptive process model guiding the team through a design workflow in which first the team learns about the problem, then synthesizes the gained information to a framework of knowledge, using this frameworks as inspiration for ideation, and develops, prototypes and refines those ideas iteratively by means of frequent user feedbacks.

We developed interview guidelines with slight variation between the first and the other groups. Those guidelines contain three groups of questions: first, questions about the interviewee’s and his department’s role in the company; second, questions about his view on design thinking; and third, questions about his opinion how to implement and adopt design thinking to IT companies. Each interview lasted approximately one hour, was recorded and later on literally transcribed.

We used grounded theory as methodological framework for data analysis (Strauss 1998). Grounded theory is an approach developed in social science for empirically substantiated
theory generation and is particularly useful when it is required to frame a fuzzy empirical setting. Condensing empirical data in frequent iterations and comparisons in order to develop coding schemes is the main driver of theory generation. We pursued an ‘axial coding’ approach, as we presupposed ‘language games’ as core category for the data analysis process. We used the software MAXQDA to support the data analysis process (Kuckartz 2007). We synthesized our coding schemes to three hypotheses, which are depicted below.

3. Language Games on Design Thinking in the IT Industry

We looked at three issues in our analysis: first, how is design thinking understood as such; second, how is it understood in respect of IT development; and third, how is it discussed within the scope of the implementation to organizational structures and the adoption to personal working routines. Dealing with these questions, we developed three hypotheses, which will be expounded below.

Hypothesis 1: The understanding of design thinking is more aligned when it comes to describing its general goals and principles; differences however increase when it comes to describing design thinking on a more applied level.

This hypothesis is related to the question of how design thinking is understood as such. We found out that there are no contradictory differences of opinion on what design thinking generally is, albeit the ways how to express this vary. One interviewee stating that design thinking is “willingness to ask (…) ‘do I really solve the right problem; and then to try out what the right ways are to solving this problem’” [1], stresses another aspect than an interviewee stating design thinking is “that the usability of the product and acceptance of the end user determines the design of a product”. Another quote combines both messages: “design thinking is a way to get out of your narrow view of what your problem is and (…) look broader and take everything from your environment in a view that kind of helps; (…) solve the problem that you need to solve, so most of the time it’s going out and talking to users and talking to customers and anybody who is (…) associated with that problem.” Generally spoken, the interviewees emphasize either one or both of the following aspects, namely (a) finding the viable solution to the fairly understood problem, and (b) both the viable solution and the fairly understood problem are delimited by the user’s point of view. Both aspects are deeply complementary, so that we do not see any confusion of language games when it comes to a general explanation of design thinking.

However, when it comes to applied explanations of design thinking, we discerned two divergent views. On the one hand, design thinking is explained as a methodology with a strong focus on a prescriptive process model, supportive tools and an underlying team structure. This can be exemplified with one interviewee distinguishing three levels of information about design thinking: first, “specific tools and techniques, which are things like how to run a brainstorming workshop or how to do user interviews or the very specific tangible activities and tools that you do”; second, “the group dynamic piece” of (…) teams working on problems (…) and how do you get them to (…) come up with new ideas”; and third, “the overarching categories” (he uses ‘categories’ instead of ‘phases’ as he wants to avoid the image of sequential process). On the other hand, design thinking is seen rather as a mind-set from which people draw their actions without relying on instructions from a formalized method. One quote shows this transition quite clearly: "On the one hand, (...) design thinking is a method that I associate mostly with the whole process and its phases; and on the other side it is a sort of mindset. (…) And I think you don’t have to go through the whole process when you have this attitude (...). You just should have the intention in mind and try to live it.” We see in both views fundamentally different qualities. The first view regards design thinking as a bundle of methods that can be realized by means of organizational arrangement; the second regards it as a way of thinking that has to be internalized by means of education. Thus we assume that this causes a juxtaposi-
tion of language games that can make it difficult to agree on the concrete purpose of design thinking in a company: Is it a meta-disciplinary attitude that people should learn, or is it an organizational technique that people should stick to?

**Hypothesis 2: Design thinking is rather understood as a learning approach contributing to IT development than a development approach in itself.**

Our second hypothesis is connected with the question of how far the understanding of design thinking is related to IT development. This is a central aspect as it entails, whether design thinking competes conceptually with existing IT development techniques, or if it is regarded as contribution to those techniques. We found quite a clear picture. None of our interviewees sees design thinking as a clear-cut alternative to existing software development approaches, independent of the approval of agile approaches as SCRUM or sequential approaches such as the waterfall model [2]. Instead, the general focus is on the learning aspect of design thinking regardless of what development approach is in favor. The following quotes exemplify this: “(Design Thinking) is imagining, understanding a problem space, and eventually the search for solutions, whereas one let things drift at times, without any restrictions imposed upon oneself, but open for all possible kinds of ideas, then however making very quick steps to find out what is viable and what is not.” This interviewee, a software developer, emphasizes the value of design thinking in fast-track (and thus inexpensive) learning about problem space and potential solution paths outside the prearranged restrictions (that IT development altogether would entail). Another interviewee points out the difference between design thinking as a learning approach and developing itself: “Design Thinking does not guarantee an outcome. That is completely in conflict with the idea of working with uncertainty. So, understand that forming fast, lean, simple, even with prototypes that are reflective of the end state, you are not moving forward to but make you smarter about how the end state should be. That in itself is a tool. It is not an alpha release (...). It’s just a thinking tool to understand the problem.”

We see that design thinking is regarded as a contribution to a certain notion on software development in general, namely ‘how to build up a novel and viable design’—whereas the notion ‘how to build up a functioning IT system in time and budget’, which every IT development process has to tackle as well, does not play any role. This however suggests that the first notion has not been effectively addressed in IT engineering as otherwise design thinking would have been perceived rather redundant than contributing. As one IT developer stated about design and development in general: “There is no specific statement on design in the build process, so that the build process doesn’t say anything about design. But it is up to the individuals who dig the build process and then apply their design thinking based on their understanding.” This statement exemplifies the inherent ‘technical bias’ in IT development (see 1.1). It shows that the process of building software is more constituted than the process of designing software, so that the question how to build a viable design is likely to be subordinated to how to build a functioning system. The knowledge gap that this imbalance creates seems to be the reason why design thinking attracts developers.

**Hypothesis 3: There are two groups of language games when it comes to implementing or adopting design thinking to IT development: the firsts treats design thinking and IT development as two separate worlds, and the second as an integrated one.**

Our third hypothesis relates to both questions: how people speak about the organizational implementation and how they speak about the personal adoption of design thinking to IT development. We found equally two underlying language game patterns, namely that design thinking is treated (a) as an external, self-contained matter linked but not integrated to IT development, and (b) as an influence to change IT development itself. We call these patterns the ‘two-worlds games’ and the ‘one-world games’ respectively.
When it comes to implementing, the ‘two-worlds games’ manifests in the idea that design thinking is realized in a project prior to the actual development process. Our interviewees describe this either as a service by an external ‘task force’, and/or as a form of workshop in which also some developers contribute substantially so that they can act as “design advocates” in the development process later on. However, the crucial transition between both worlds is generally a prototype as the outcome of the design thinking process that ought to serve as a starting point for the development process—and thus gets “thrown over the fence”, as two interviewees say. Against that background, discussions on adopting design thinking lead to controversies on how design thinking prototypes can be picked up by the developers later on. One interviewee sees different conceptions of prototypes as a hurdle between both worlds. He stresses that design thinking prototypes eventually embody completed concepts “to which you can get down afterwards asking: how can we translate this to a real product?”, whereas prototypes in IT development rather initiate a process of conceptualizing: “You build software prototypes because you have otherwise nothing to look at when you discuss what you actually need—which would be extremely difficult. (…) It is easier to define requirements in the software world as a delta to something existing.” This discussion shows that there is a danger of misconception at the transition between both worlds. Developers are more used to treat prototypes as a form of tangible assistance for the development process and not as a non-technical blueprint for the final product. Connecting both worlds is regarded as critical as the following statement exemplifies: “(…) design thinking people should learn that what they deliver is not enough for that what developers need. On the other hand, also developers should learn that sticking post-its casually and creatively, filling them with writings and permanently rearranging them is also serious and valuable work that provides results that afterwards the developers need.”

We found many perspectives on how to merge both worlds to a ‘one-world game’. The most general of these views treats design thinking as an imperative, or rather as a kind of ‘wake-up call’ for developers to alter the way they work. Implementation happens in this sense through people who take this up and change their mindsets and problem solving routines. As one of our interviewees states: “It is cultural change. The people just have to learn to change their views.” This is rather a symbolic approach of implementing, as it is about demonstrating the benefits of design thinking-led problem solving and asking people to internalize and to apply it. Yet, as one interviewee stated about the workshop experience: “Many were enthusiastic about it. Many said: ‘I want to adopt it somehow, I just do not know how,’ or: ‘how can I tell my boss?’

We were able to identify a strong tendency that, when design thinking is communicated as an appeal to developers, they appreciate the general idea but doubt being able to apply it within the tight frames of a development organization. Moreover, we found out that there is severe risk perception involved. Many had problems aligning the openness and the ‘explorative detours’ in design thinking with common performance measurement systems for IT development projects that rely on project plans, milestones and punctual shipment: “When you are under time pressure and have to finish your tasks, then you refer to what you are assessed by and what you have to fulfil—and those things where everybody would say: ‘yes, that would make sense’, they’re skipped anyway.” Against the background of those organizational practices, design thinking is perceived as an uncertain method, which may be helpful to come up with innovations, but also entails a high planning (and justification) risk. The willingness to apply design thinking in daily work therefore ends when superiors ask for results without backing explicitly the use of a design thinking approach.

We found two views that try to overcome this dilemma. Some suggest to implement design thinking in form of an obligatory phase of development processes, others intend to translate design thinking to an adaptive toolbox that can be applied by developers depended on what kind of problem they are faced with (instead of in which phases they are). The first would treat the learning effect of design thinking itself as an objective that has to be achieved; the second would make the use of design thinking so flexible that requests of using design thinking
methodology could be formulated very specifically. However, within the frame of our study, both ways of implementing design thinking were not realized so that we could not gain further insights about them.

Table 1. Language games on implementing and adopting

<table>
<thead>
<tr>
<th>Two-Worlds Games</th>
<th>Implementing</th>
<th>Adopting</th>
</tr>
</thead>
<tbody>
<tr>
<td>DT as a foregoing project;</td>
<td>‘Picking up what is thrown over the fence’</td>
<td></td>
</tr>
<tr>
<td>DT as a service</td>
<td></td>
<td></td>
</tr>
<tr>
<td>One-World Games</td>
<td>DT as a ‘wake-up call’;</td>
<td>‘DT is appealing, but needs backing by the organization’;</td>
</tr>
<tr>
<td>DT as a process phase;</td>
<td></td>
<td>‘Choosing DT tools when it helps’</td>
</tr>
<tr>
<td>DT as an adaptive toolbox</td>
<td></td>
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</tbody>
</table>

In sum, also this discussion confirms the observation that language games diverge as more applied people think and speak about design thinking. Table 1 summarizes the variety of views on how to implement and adopt design thinking in the IT industry.

4. Conclusion

Drawing on the image of ‘languages games’, we showed that there is no single way how meaning is created about design thinking in IT development, but rather an evolving variety of ways. This was substantiated in hypotheses 1 & 2 pertaining to the range of understandings of design thinking in general and in IT development in particular, as well as in hypothesis 3 as for matters of implementing and adopting. We regard an initial incongruity between design thinking and IT development as a basic cause for this juxtaposition of language games. Design thinking is not a concept that seamlessly infixes as a further development approach to the IT world. Instead, it is a self-contained methodological field that can serve as an example to tackle shortcomings of established IT development approaches, i.e., the technical bias, by suggesting further attitudes towards knowledge and categories of knowledge for IT development. As a result, it remains fuzzy what exactly the overlaps between design thinking and IT development are like. Applying design thinking to IT development thus presupposes strong translation efforts that set off—as shown in our study—the emergence of divergent and partly incongruent language games. We regard the resulting juxtaposition of language games both helpful and destructive. It is helpful when it stimulates reflection and awareness of the constraints and limitations of established IT design approaches. It can be destructive when it comes to implementing and adopting design thinking, as there is a danger that parallel meanings weaken the communicability of the concept, and dissolve it in the end within a ‘semantic nirvana’. As implementation and adoption request clear-cut concepts, it is not surprising that our interviewees tried to wipe out the fuzzy overlaps between both worlds either by separating them into two distinct worlds, or by merging them into one integrated world. With both ways, our interviewees seek to bring clarity to the rules determining the language games on design thinking in IT development. This shows quite plainly that promising attempts to implement or adopt design thinking presuppose clear images of how design thinking can be thought to IT development. Though the fuzzy overall picture of language games, our study allows distinguishing different models on connecting design thinking and IT development processes:

- In the split project model, design thinking is handled as a separate process before the IT-process phase. Its main purpose is to map out potential directions in terms of user needs and to inform the IT development process with an initial “package” that is handed over to the subsequent development process.
- In the champion model, an initial design process is likewise used to inform the subsequent development process. But instead of “throwing the package over the fence”, one or more project members of the development team participate in the design thinking process.
to be able to act as an communication agent to explain and maintain the gained design knowledge throughout the development process.

• In the **design to development model**, design thinking is a central technique for the front-end of the development process itself. The overall process is changing from a design thinking to an IT development process when the conceptions of problem und solution are specified enough to translate them to development tasks. This implies that there is a strong overlap between the personnel in the design thinking and in the development phases.

• In the **toolbox model**, design thinking is not regarded as a distinct project or process phase, but as a bundle of methods developers can draw on to solve certain design problems they could not solve by means of common IT development methods. In this case, design thinking is narrowed down to a well-defined box of tools for adaptive support.

However, also this range of models carries some inherent contradictions due to the fact that the respective implementation strategies imply different conceptualizations of design thinking itself. A design thinking toolbox, for instance, focuses rather on handy and selective techniques, while a split project focuses also deliberately on a coherent design thinking process carried out by skilled personnel. This observation is supported by our hypothesis 1, stating that design thinking is more apparent as a general concept than as an applied one. Implementing design thinking seems to be thus strongly connected to a conceptualizing process—and a wide range of possible applied design thinking models seems to be an inevitable consequence. To further explore and to develop the range of models in greater detail will be an important task for both future research and management practice.

**Notes**

1. German quotes are translated to English by the authors.

2. Albeit the majority of our interviewees showed preferences for agile development approaches, sequential approaches are favored when it comes to large-scale IT development projects due to its better planning reliability.
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Design thinking implemented in software engineering tools: Proposing and applying the design thinking transformation framework

Alexander Luebbe, Mathias Weske
Hasso-Plattner-Institute, University Potsdam, Germany

Jonathan Edelman, Martin Steinert, Larry Leifer
Center for Design Research, Stanford University, CA, USA

Abstract

Design thinking has collected theories and best-practices to foster creativity and innovation in group processes. This is in particular valuable for sketchy and complex problems. Other disciplines can learn from this body-of-behaviors and values to tackle their complex problems. In this paper, using four design thinking qualities, we propose a framework to identify the level of design thinkingness in existing analytical software engineering tools: Q1) iterative creation cycles, Q2) human integration in design, Q3) suitability for heterogeneity, and Q4) media accessibility.

We believe that our framework can also be used to transform tools in various engineering areas to support abductive and divergent thinking processes. We argue, based on insights gained from the successful transformation of classical business process modeling into tangible business process modeling. This was achieved by incorporating rapid prototyping, human integration, knowledge base heterogeneity and the media-models theory. The latter is given special attention as it allows us to break free from the limiting factors of the existing analytic tools.

1. Introduction

In this paper we propose a framework to align software engineering tools with design thinking. We strive to apply paradigms experimentally derived from design thinking research with the aim to transform convergent engineering tools, designed and used for analysis, into abductive, divergent tools. In this paper we experimentally focus on the discipline of software engineering, as it is a fitting representative for many engineering disciplines. Its tools used are designed to analyze real problems and situations, build mathematical models based upon the same, and allow handling those models algorithmically.

It is an early observation in computer science (Brooks 1975) that effort, that is, time spent on development, is hard to predict. Software design is notoriously hard to discuss, especially with end users. This is rooted in the intangible nature of software and the very discipline specific language. The most users can see is the user interface, which literally is only the tip of the iceberg. To exchange deeper level knowledge about systems, different tools for data, process and architectural modeling have been developed. They have mathematically defined semantics and are the sharp knife for communication amongst engineers. These analytical tools however can hardly be used to discuss software attributes with end users. Consequently, software often does not meet customer expectations (Krallmann et al. 2007).
In the last decade, the introduction of agile development as a methodology (Martin 2003) stepped up to ease this pain. Agile development demands that the evolving software product is constantly presented and discussed with end users. This helps to identify divergent expectations early on and avoids expensive misunderstandings. Agile development is a huge advancement over original software engineering methods, such as the waterfall or the V-model (Zhu 2005, pp. 55-57). However, agile development treats the symptom and not the underlying problem of suboptimal early communication. Agile development has no means of communicating conceptual decisions and its impact with common end users, as end users are not “language and knowledge compatible” with the specific concepts that engineers use to capture their knowledge.

Generally tools and development behaviors employed in software engineering aim to reduce risk and to (re-)produce a product of high quality at predictable costs. The underlying logic roots in production line manufacturing (Clements & Northrop 2001). It is worth noting that management approaches for traditional product and software development are slowly converging; both rely on classical engineering philosophies. This includes well-defined procedures and analytical tools to ensure validity of results by reducing uncertainty and complexity of the problem.

Unfortunately, this formal approach to product and software development fails to support exploration and discovery of unexpected issues. Based on the research of what designers and engineers really are thinking and doing when they successfully create products, services, and enterprises, a powerful process for innovation has emerged: design thinking. It integrates human, business, and technological factors in problem-forming, -solving, and -design. It creates a vibrant interactive environment that promotes learning through rapid conceptual prototyping. Figure 1 depicts design thinking as a journey through five stages as suggested by Leifer & Meinel (2010).

![Figure 1. Design thinking is commonly visualized as an iterative series of five major stages. To the left we see the standard form. To the right we see something closer to reality (Leifer & Meinel 2010).](image)

So far, the deployment of design thinking specific insights and procedures for software engineering has been rather constrained (Lindberg & Meinel 2010). Mainly the intangible nature of software, its inherent complexity and specific language hampers user integration. Our aim is to attempt to bridge this gap by proposing a design thinking transformation framework. With it, we aim to firstly identify and secondly alter design thinking compatible software engineering tools.

Our framework is grounded in insights gained from having extensively studied the impact of media choice on the design process. Section two introduces the media-models framework as a heuristic for understanding the convergent or divergent nature of tools. In section three,
we show how we have applied the knowledge about behavioral change induced by media to a specific software engineering tool: business process modeling. In section four, we propose a general framework based on the results from a series of studies, experiments, and observations. This framework is comprised of four qualities to identify transformable engineering tools and to highlight possible leverage points. In the final section of the paper we conclude with a discussion.

2. Steering discussions in team-based design

The past few years have yielded powerful insights into how to gear analytical tools towards design thinking: Through the substitution of analytical media tools with generative media tools, designers can trigger increased abductive activities and potential in development scenarios.

Media filters and characterizes information. Every class of instantiation of media is different in respect to the information which is embodied in it. Hence, media with different characteristics enables us to do different kinds of thinking; different media afford different kinds of thought. A prototype made of plasticine will provoke different feedback than an computer rendered image. The choice of media characterizes the information transmission in a similar way. Media provides affordances for thinking and acting because it conditions how information can be communicated and what can be done with it. Thus, we see media as an “actant”, and not just a passive container.

When people externalize knowledge they use media, whether in the form of sound waves in the air (spoken words), e-mails or paper. Contemporary studies in cognitive psychology have emphasized the effect of media on what people can think about and how they think about it (Tversky 1999; Maglio et al. 1999; Clark 2008). If media directly influences the direction, breadth, and depth of communication, the question is how to maximize the effectiveness of media in a given phase of product (or software) development. The media-models framework (Edelman 2009) considers the dimensions of media and their effect on the conversations that designers have during the development process.

Media-models can be seen as intermediary objects used during the development and negotiation of designs, processes, products, and services in team based design. The framework is based on field studies and experimental evidence examining three dimensions of intermediary objects in use by design teams: abstraction, resolution, and ease of change (Edelman 2009).

**Abstraction** is defined as the highlighting and isolation of specific qualities and properties of an object, such as color, size or function. Fewer represented properties indicate a greater abstraction from the actual object. Because representations with higher levels of abstraction have fewer properties with which to contend, they are easier for designers to work with than models with many properties. This ease comes at a price: abstract models are not complete, but offer only a slice of or a perspective on a product or service.

**Resolution** refers to the fidelity with which an object is defined with respect to its final form. For example if a final product is a car—a Lego model of a car would be considered low resolution. However, if the deliverable is made of Lego and the Lego model shares the same dimensions, then the Lego model must be considered fully resolved. Resolution and abstraction are orthogonal properties inherent in media-models used for communication. In Figure 2 we show some sample media in a coordinate system by abstraction and resolution.

**Ease of change** is the third dimension that media-models share. It refers to the amount of effort required to change an idea embedded in a specific media-model. The resistance to
change is also referred to as “viscosity” by Blackwell (2001), though his focus is on dimensions of notations, whereas the ease of change that we refer to here is a dimension of media-models.

All three media dimensions are at play when people express their ideas in a model. Less abstract models require designers to consider more properties. Higher resolution models afford high precision when making parametric changes to a model. On the other hand, abstract, low resolution models afford global or paradigm changes.

As an example of media-model choice, a car manufacturer might build an actual roadworthy prototype of the next generation car product. This type of media model is highly resolved, absolutely not abstract and hard to change. That prototype is well suited for detailed examination just before mass production. It is not suited to question the fundamental design. In contrast, a miniature car made of plasticine is highly abstract, less resolved and easy to change. This type of representation might be suited for general design discussions but does not reveal details. These two extreme model choices showcase the contrast between “analytic” media-models and “generative” media-models.

We call media which affords parametric change analytic media, and media, which affords a multiplicity of potential global solutions generative media. In lab experiments with designers, we have observed that analytic media leads people to discuss adjustments of parameters within the design, while generative media affords discussions of the general concept of the design. It is simply meaningless to discuss parametric adjustments with a low resolution model. In other words, media choice conditions communication in product design.

This effect is also implicitly known in software engineering. Best practices for user interface (UI) designers suggest to use sketched paper prototypes to discuss UIs with end users rather than polished screenshots or even the actual UI (Buxton 2007). The sketched representation abstracts, e.g., from color and does not resolve the design, e.g., the actual size of buttons. Thus it allows the user and UI designer to concentrate on the underlying concepts of the human-computer-interaction. However, in software engineering, UI design practices are an exception. Classical software engineering is mathematically driven and committed to analytical techniques and media. We applied our insights from the media-models theory to one particular software engineering tool, business process modeling.
3. A software engineering tool transformed

Business process modeling is the act of mapping knowledge about working procedures in organizations to a graphical representation, the business process model. This is popular in the context of business process management, an approach to structure work in organizations (Burlton 2001). That includes modeling, analyzing and improving the working procedures. Automating processes in software systems offer great potential to save time, enhance reliability and deliver standardized output (Davenport 1993; Hammer & Champy 2003). In the last decade, business process management, and therefore also business process modeling, has become an IT-driven topic (van der Aalst et al. 2003). IT support for business processes requires significant software engineering effort. As is typical for software projects, misunderstandings in the early stages lead to expensive change requests at later stages of the project (Boehm 1981).

In current practice, requirements are gathered in interviews and workshops. Post-its and software tools dominate the employed media. In explorative studies we observed that Post-its allow end users to easily map their knowledge. However, Post-its do not embody concepts. Thus, the resulting Post-it stream does not express the knowledge in the frame of a business process. It typically requires a process analyst to collect the information and create process models from end user input. The model is then discussed with end users and is refined until fully accepted. Process analysts can choose from a wide variety of modeling software that supports language specific iconographies, syntax verification and process automation qualities. For novices, these are expert tools. Thus, for efficient use, modeling software typically remains in the hands of the experts. Changes to the model have to be channeled through them.

The limited access to the model for non-experts motivated us to change the media for business process modeling. We aimed to empower end users to express their knowledge as processes and directly apply changes to the model. The early development of generative media for business process modeling included Lego, crafting accessories, and Post-its. After some iteration we found that, acrylic tiles with process modeling iconography sharpened the discussions of process modeling experts and domain experts (Edelman et al. 2009; Grosskopf et al. 2009). The specific iconography embodies process modeling concepts and thereby enforces basic framing. At the same time, the rough media is more flexible than a digital model and lifts resolution constraints. In other words, software and logic does not restrict the use of elements. Thus, logical constructs can be less accurate or can be ignored entirely during modeling. It is even possible to (ad hoc) break the process modeling frame and incorporate different concepts into the model for discussion.

During process modeling workshops, a process analyst is enlisted to explain process modeling and to guide the group through the workshop. Instead of filtering and translating input from different stakeholders, the analyst becomes a facilitator of the group’s internal consensus finding. This enables an integration of human and social interaction into process design. Now multiple people work together at the same model which is laid out on a table top. They can immediately point at, touch and change the model to demonstrate ideas. The shared common knowledge is represented at the table in tangible media. We therefore call this approach t.BPM, tangible business process modeling.

Figure 3 depicts t.BPM in the framework of media models. Traditional business process modeling software allows for different levels of granularity. A range of simple to technically sophisticated representations can be contained in one model. The resolution of each piece of information however is typically high. By contrast, t.BPM can only embody a limited set of information at a time, but through more or less accurate use of the process modeling concepts, the resolution might vary. In comparison to Figure 1, please note that these are relative measures.
We conducted first user studies with t.BPM in 2009 (see Figure 4, middle). As predicted by the media-models theory, we observed people to question the overall design of the process more often. Global changes were acceptable with easily changeable media. We also found that the absence of computers for process modeling narrowed the gap between modeling experts and novices. Only a few concepts have to be explained before the modeling can start. Application specific knowledge is not needed as the tool is intuitive to use.

In a case study conducted in a hospital environment (see Figure 4, right) we also observed a flexible abstraction level for t.BPM as a tool. A five day workshop with hospital doctors on clinical pathway modeling (processes in hospitals) started with rough mapping and became a detailed and sophisticated model for discussion over time. The workshop was facilitated by an experienced BPM consultant, who used t.BPM with only a few concepts as a minimal ground for information sharing.
Over time the BPM facilitator introduced more concepts when needed, and when discussions focused on details of the models. On day three, t.BPM was complemented with other media such as software modeling tools and print-outs. Our analysis of the workshop showed that software-based process modeling media is more suited for navigating through large sets of process models than t.BPM. However, when creating new models, discussions genuinely turned back to the table with t.BPM.

4. Design thinking transformation framework

The insights and experience we gained during iterating and testing t.BPM led us to identify some core qualities that we believe are key for transforming analytical convergence tools into abductive divergence tools. Therefore, based on our roughly twenty prototypes we would like to suggest a design thinking transformation framework consisting of the following four qualities:

Q1 Iterative creation cycles

As depicted in Figure 1, we identify five major development stages: problem definition, need finding & specifications, ideation, development and deployment/testing. The classical analytical process goes through those five stages once. Iterative approaches in analytical disciplines, e.g., in software engineering, propagate iterations by slicing the problem into small pieces and solving one piece within one iteration. This is what we call “iterative refinement cycles”. Parts or details are determined iteratively. Fundamental, underlying ideas are not questioned.

In contrast, design thinking suggests to iteratively create new solution ideas. Inexpensive prototypes are key enablers to explore the solution space by trying out many different ideas. This is what we call “iterative creation cycles”. In t.BPM, easily movable elements enable fast prototyping of ideas as creation cycles.

Q2 Human integration in design

In both product and software development ambiguous, informal human needs are transformed into formal requirements to be used in analytical reasoning. Therefore, analytical disciplines tend to limit the user interaction in order to reduce ambiguity and uncertainty in the analytical process. Users present needs to developers, who in turn present well crafted solutions to users.

Design thinking calls for repeated, physical integration of stakeholders in the design and ideation phase. This is not only helpful to get instant feedback on ideas. Integrating users into the design process makes them engaged and advocates for the solution they helped design. Often, members of the user community can help promote new solutions, get them accepted and avoid resistance to adoption.

Q3 Suitability for heterogeneity

A high degree of specialization leads to a strong fragmentation of knowledge. The more sophisticated the discipline, the stronger the fragmentation, even within disciplines. Sophisticated models that are used in those disciplines for detailed discussions and deep reasoning are not well suited for the incorporation of heterogeneous knowledge bases.

Design thinking works with interdisciplinary teams by using simple visualization and prototyping techniques to transport ideas and integrate knowledge from stakeholders with heterogeneous background.

As a rule of thumb, the further apart the disciplines, the simpler the models that they can use to share and integrate information. By ‘simple’ we mean the amount of concepts required to understand the model. As an example, in t.BPM we condense the BPMN standard (OMG 2009)
to four basic shapes and the minimal concepts of control flow, data and resource allocation. This is embodied in the shapes and markings drawn on the table.

Q4 Media accessibility

Typically, in analytical disciplines, solution designs are digital throughout. Advantages such as versioning, computer-assisted analysis and easy distribution have outweighed advantages of physical representations. Really?

Design thinking research suggests that each instantiation of media affords particular types of interactions and changes to a designed solution (Edelman 2009). This happens because the media-model dimensions (abstraction, resolution, ease-of-change) define the interaction space in which people can define their solution. We learned with t.BPM, that tangible media remove barriers for participation. No expert knowledge is required to handle the media. This enables people to change the models, and therefore, the solution themselves.

Framework applied

We now propose an early stage framework based on the four qualities that can be used to identify the level of design thinking factored into existing tools. We test it by using common conceptual modeling approaches from software engineering.

We assume as a working hypothesis that, for any software development tool, this design thinking transformation framework allows us to judge its closeness to divergent design thinking vs. its closeness to convergent analytical thinking. To test this hypothesis we have selected four standard analytical modeling techniques from software development. We choose:

- Data modeling, often done with entity-relationship diagrams (Chen 1976), is used to represent information objects (e.g., dog), their attributes (e.g., age) and relation to other information artifacts (e.g., is owned by). It is used to specify database schemas.
- Use case modeling, part of UML (Fowler & Scott 2000), is used to depict roles (dog owner), their applications (e.g., go for walk) and dependencies between applications (e.g., go for walk requires find leash). It is used to visualize complex application scenarios.
- Object-oriented modeling, also part of UML (Fowler & Scott 2000), describes classes of objects (e.g., dogs) with attributes (e.g., age), behavior (e.g., bite, sit) and interrelation to other classes of objects (e.g., has owner of type human). It is used to model the structure of object oriented programs.
- Classical process modeling (Scheer et al. 2005; OMG 2009) depicts steps (go for walk), their interdependencies (e.g., find leash before going for a walk), responsibilities (owner has to find leash) and data used in the process (e.g., newspaper to read in the park). Process modeling is used for analysis, simulation and automation of working procedures, business processes.

All these modeling approaches were developed within the IT community and are software supported. In t.BPM we use the idea of classical process modeling. We transform a tool’s media, from software to tangible, we involve the stakeholders in an iterative creation process and we simplify the notational system. Thus, we can integrate more people with heterogeneous knowledge bases into the creation of the solution.

In the following section, we rate the software development tools for their design thinkingness, and therefore the effort required for transformation. We rate according to industry’s best practices which implies that individual applications of the tools might differ from our assumptions. We rate with a (-) if current practice is contrary to proposed design thinking practice. We rate
(o) if it is not in line but aspects point into the right direction. And we use (+) if it is in line with the design-thinking-way that this aspect is practiced.

Table 1. Design thinking transformation framework applied to software modeling techniques

<table>
<thead>
<tr>
<th>Q1 Iterative Creation Cycles</th>
<th>Data Modeling</th>
<th>Use Case Modeling</th>
<th>Object Oriented Modeling</th>
<th>Classical process modeling</th>
<th>t.BPM process modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
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<tr>
<td>Q2 Human Integration in Design</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Q3 Suitability for Heterogeneity</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Q4 Media Accessibility</td>
<td>0</td>
<td>0</td>
<td>0</td>
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We rate classical modeling tools with (-) for Q1 as they rely on software support to visualize their concepts. Software tools in this area afford iteration for refinement but not iteration for creation. For Q2 we rate (o) if users in practice typically provide feedback to intermediate solutions, otherwise (-). A (+) is given only if customers are actively participating in the design process.

For Q3 we rate (+) if concepts can easily be understood and adopted with little introduction time. We rate (o) if the representation is simple enough to be read and mainly understood without expert knowledge. We rate (-) if it requires expertise and experience to read the model and understand the implications. For Q4, we rate (o) if only experts can create models and others can only make comments, e.g., on printouts. t.BPM here scores (+) as it allows non-experts to apply changes.

We note that no classical tool is purely analytical. Nonetheless, no classic tool or method is truly an abductive, divergent tool in the sense of design thinking tools.

At the present time, we have not developed proper scales for the qualities proposed. However, the framework has enabled us to identify and to separate the very classical convergent analytical software tools from other tools that have incorporated some design thinking rules.

Indeed, as we have shown with the creation of t.BPM from classical process modeling, it is possible to transform an analytical tool into an abduction divergence tool. The framework at hand provides us with four fundamental questions as a starting point for the transformation:

1. How to incorporate rapid prototyping and iterate for the creation of new ideas rather than refinements?
2. How to ensure the continuous integration of the user and his participation in the design process?
3. Which concepts are required for communication in order to establish a model for shared understanding amongst participants with heterogeneous background?
4. How to choose media to support questions 1, 2, 3, and realize media accessibility?

Although we currently only have one, though very successful example, we believe that the same approach may be used for other software engineering tools, to judge their level of design thinking and to identify the starting point for a possible transformation. We would like to call our framework design thinking transformation framework (DTTF) and, with this paper, put it forward for discussion.
5. Discussion and future research

We have proposed the design thinking transformation framework. DTTF consists of four qualities: iterative creation cycles, human integration in design, suitability for heterogeneity, and media accessibility.

The DTTF is grounded in years of design thinking research on media and the insights gained from transforming classical business process modeling into t.BPM. We have used the DTTF to assess different software modeling tools. However, we believe that this DTTF is not limited to contrasting design thinking with computer science.

We invite other researchers to use this design thinking transformation framework for other disciplines and show applicability and shortcomings. For our future research, we aim to develop mature scales to measure the design-thinkingness of tools with respect to the qualities described in this paper.
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Leading ideas: Design Thinking as aesthetic process innovation

Maria Lundberg
School of Management
University of Technology Sydney, NSW, Australia
SINTEF, Norway

Tyrone S. Pitsis
Centre for Management & Organization Studies
University of Technology Sydney, NSW, Australia

Abstract
Core elements in Design Thinking can be applied to process thinking to strengthen the dimension of managerial and organisational process innovation as one that is fundamentally aesthetic. We identify Design Thinking as a phenomenological, aesthetic, iterative process open to ambiguous interpretation and sense making, and argue that the creative forces and the ability to practice Design Thinking as a method can be viewed as crucial to many processes,—as a co-creation of collaborative processes with a shared future orientedness that lead to generative experiences. We argue that the success of creative processes in organisations may not be as much about the final product as about the ‘inter-subjective interactional’ processes leading to the final product or service.

In any process where the generation of new ideas is a main component, unleashing creativity can be understood as a leadership challenge. Claiming that the quest of management and leading ideas is an important issue in the exploration of Design Thinking as aesthetic process innovation, we also explore which are the skills and assets that characterize leadership practicing the difference that makes a difference in aesthetic process innovation.

Leading ideas: Design thinking as aesthetic process innovation

...in our life today there are almost no limits set on the way we furnish our intimate surroundings, nor on the materials we use in reading, listening, watching, and talking, nor in the way we dress and appear in public. We live in an era of unprecedented freedom of choice within the private sphere. There are many imagining—mediation—and actualization possibilities open and waiting to be realized. However, this takes active training for sensitive and subtle aesthetic perception and for the development of the ability to design from within the available skills of the participants (‘lebenswelt-skills’). Rolf von Eckartsberg (2008, pp.10-15)
Design Thinking within the core design domains has traditionally aimed at producing a physical product as its result. In other domains, the result may not be a physical object but an abstract concept, an idea, or a service. Design Thinking is gaining increasing attention as an important area of research, theory and practice, and can be paralleled to the growing field of managerial and organizational innovation. In viewing Design Thinking as aesthetic process innovation, we approach the process itself as a creative phenomenon; a creative process, requiring creative practices for creative outcomes. Increasingly the rhetoric is that businesses, as well as government and non-government organizations, are devoting attention and resources to being innovative and creative. For many, Design Thinking holds great promise and that it no longer is restricted to the domains of ‘creative businesses’ alone, such as industrial and graphic design, or architecture (Golsby-Smith 2008; Brown 2008; Davis 2010; Raney & Jacoby 2010; Martin 2009; Brown 2009), but to all manner of organisations. Yet, in spite of the attention being paid to the concept there seems to be little if any research on how Design Thinking is applied in practice as a form of process innovation.

Process innovation refers to methodological, managerial, organizational and technological improvements in how organizations operate, function and exist (e.g., business process re-engineering); and product innovation includes improved ideas, goods and services (see Poggenpohl & Sato 2009). Design innovation implies innovation in thinking about design, which is an important element of Design Thinking. In this paper our focus is on Design Thinking because only Design Thinking seeks to actively imagine and create solutions to complex problems in an improvised and also co-created way (Lawson & Dorst 2009). Where Design Thinking is traditionally often described as a ‘method for doing’, we suggest an approach based on phenomenology, investigating Design Thinking as a ‘way of being’ rather than simply a way of thinking. As part of this, we advocate a promising future for applying Design Thinking as method for process innovation in organizations namely as a facilitator for collaborative ‘ways of being’.

Design Thinking is a methodology that permeates the full spectrum of innovation activities (Brown 2008, p.1). Transcending from being a best practice model well known within traditional design businesses, the concept is now widely embraced as the ‘hot new thing’ in many different businesses where innovation is crucial. Brown argues that for leadership, innovation is regarded as a crucial source to differentiation and competitive advantage, as such ‘they would do well to incorporate Design Thinking into all phases of the (innovation) process’(Brown 2008, p.2). As much as Brown’s statement aligns well with our aspiration for investigating Design Thinking as an enhancement for innovation, we observe there is yet unexplored territory concerning how the incorporation advocated by Brown can be feasible in everyday worklife practice. We believe it would be difficult to find a manager in todays business world claiming she does not want her organisation to be innovative. Innovation management theory is being taught as part of the MBA curricula all around the world (Martin 2009). Design Thinking has been introduced as a concept that can work innovative wonders in organisations.

Concomitant with the increased interest in Design Thinking as a new solution for dealing with old obstacles, there are questions being addressed concerning the actual value of Design Thinking as a concept itself. Is it really just old wine in new bottles? Does it really work? Is there any value in incorporating Design Thinking as a method in organisational processes, and eventually;—what difference does Design Thinking actually make to businesses? How does Design Thinking as a method correspond to contemporary research on collaborative creativity? Last but not least;—what practical managerial value and implications will Design Thinking as aesthetic process innovation elicit if applied to organisational practice?

From visual wrap up to wrapping out the process

Design in business has long been understood as the visual wrap up of an idea (Brown 2008, p.2). Indeed, branding design has for many organizations become a crucial success factor that
transcends the product into the everyday (Kornberger 2010; Norman 2002): for example, the Nike swish has become more important than the shoe, the term Google becomes a verb in everyday language ‘to be googled/to google it’. The story of how the Coca Cola bottle and brand was developed might illustrate how the visual forming of the idea becomes crucial in order to make the idea sustainable. The Coca Cola design was made in order to make the product stand out and has become one of the world’s strongest brands. Originally, from etymology, the term design also refers to this action, meaning to mark out or devise, and so it is obvious that Design Thinking can have critical strategic implications around communication of intent, brand, and identity.

Today it can be argued that Design Thinking applied as a methodology in innovation processes is perhaps not so much about the wrap up of the idea as it is about the wrapping out the processes and practices that will lead to the idea. We suggest that perhaps the most important feature of Design Thinking is that it is not about the final product as much as it is about the process leading to the product: that is, it is a quality of experience relating to an entire process. As Bjorkeng, Clegg and Pitsis (2009) illustrated in their piece on practice innovation in a mega-project, the innovative design of an alliance leadership team led to innovations in management and organizational practices and processes, which also had several spin off innovations that are being recognised internationally as cutting edge (see also Carlsen & Pitsis 2008). As processes need to be managed and led, approaching Design Thinking as aesthetic process innovation will explicitly involve managerial implications for leadership. We therefore advocate that it is essential to view leadership and leading ideas as an important issue in the exploration of Design Thinking as an aesthetic process of innovation.

Process innovation is quite an abstract and all encompassing concept and can mean almost anything to do with the innovation of processes. In this paper we view process innovation as that which pertains to managerial and organizational innovation. Here we use Birkinshaw, Hamel and Mol’s (2009, pp.826-829) definition:

as a difference in the form, quality, or state over time of the management activities in an organization, where the change is a novel or unprecedented departure from the past...the generation and implementation of a management practice, process, structure, or technique that is new to the state of the art and is intended to further organizational goals.

Applied to organizational contexts, Design Thinking is a form of managerial and organizational innovation because it implies an innovation in the process of managing and organizing, and more specifically leading. We therefore add to managerial and organizational innovation the idea of ‘leadership innovation’, which is ignored by Birkinshaw et al., but is explicit in our model of Design Thinking as an ‘aesthetic process of innovation’—to paraphrase von Eckarstberg (2008). The aesthetic process of innovation is the inter-subjective, sense based, participatory and experimental process of innovation, where ‘the creation of a way of life together’ takes form and becomes the source of innovation that is meaningful and valuable in both a shared and private sense (von Eckarstberg 2008). Here, we propose von Eckarstberg’s notion that the aesthetic, relational experience can be translated to organisational encounters, where the collaborative creation in specific is what fuels aesthetic innovative processes:

Rampant and precipitous growth of modern consciousness in the domains of technical reason has lead to the withering and suppression of the realms of imagination and inspiration, of creativity...The quest for a ‘convivial society’, through cooperative syner-gizing of differences: This quest is entrusted to each person and to each generation. We are to create our way of life together anew each time. The political and socioethical form that this bequest takes has to be full commitment to the free, cocreative, democratic, and difference-respecting life of dialogue among equals. Everybody has a voice
that he must be encouraged to express and he must be listened to seriously and with openness (2008, pp.16-17).

Similarly, Miles et al. argue that because the collaborative relationship is built on caring, trust and intrinsic motivation, ‘collaboration has a higher potential for knowledge sharing than either competition or cooperation’ (Miles et al. 2005).

The collaborative ‘creating together’ should be seen as crucial both to innovative processes, and to process innovation, the latter being our concern here (Bjorkeng et al. 2009; Pitsis et al. 2003; Clegg et al. 2002). Building on the idea of collaborative creation as a process of aesthetic innovation, we proffer that the idea of prototyping in Design Thinking can function as a facilitator for the aesthetics in process innovation. This is mainly because of prototyping’s implies aesthetics as its main feature, and that it embodies the collaborative quality that makes process innovation possible—or what we identify as aesthetic process innovation.

The idea of ‘aesthetic innovation’ solves a problem for both managerial innovation and Design Thinking as methods of innovation and creativity, because the aesthetic process of innovation is a constant process of leadership and collaboration. That is, once an innovation happens it is no longer an innovation, once an idea is created and acted upon it is no longer creative, although it can be innovated. In terms of how Design Thinking is being applied in the business contexts, there seems to be an implied assumption that it is something that is turned on and off like a tap, to produce an outcome in a highly functional, rational, and mechanistic way (being anything but an aesthetic process), but if we were to see Design Thinking as a fundamental aesthetic process occurring intra- and inter-organizationally; the co-generation of ideas becomes a continuous process of becoming—in terms of organizational and individual identity authoring (see Carlsen 2006). That is, with von Eckarsberg (2008), going from actualizing possibilities to actualizing realities. Where Design Thinking both opens up possibilities for what could be in an aesthetic way, and realizes the actual experience of such things as aesthetic due to its inter-subjectively generated nature. As long as the user experiences the outcome as aesthetic, the difference in how they use it is less relevant, because its use and value is in its aesthetics. Leadership in this context means leading the process whereby people in organisations co-create their way of life, managing the processes just as much as managing for innovation (see Amabile & Khaire 2008). As such we see leadership playing a crucial role in Design Thinking as process innovation. If Design Thinking as aesthetic process innovation is in its essence about creating together—as we propose it is, the multiple facets of aesthetic leadership practice should be included in the researchers map.

**Design Thinking—the co-construction of a shared vision**

What is generally being described as Design Thinking fundamentals corresponds well with research on creativity and what we know about creative dynamics in organisations. Based on their research on creativity and the role of the leader, Amabile and Khaire argue that to enhance organisational creativity, a company must be open to people with diverse perspectives from different disciplines to share their ideas, and willing to tap thoughts from all ranks, not relying on formal hierarchy in the organisation (Amabile & Khaire 2008).

Amabile and Khaire’s (2008) research aligns well with Brown’s characterization of design thinkers as possessing empathy, integrative thinking, optimism, experimentalism and collaboration. Brown claims that these stand out as fundamental features of people who succeed as design thinkers (Brown 2008). There is no requirement that they must be trained as professional designers to be in possession of these qualities. On the contrary, Brown argues that he experiences many people outside the design business to have a natural aptitude for Design Thinking. This natural talent, he states, can be unlocked with the right development and contextualized experiences. Unlike Brown, we do not want to imply that we believe that there is some innate
or biological basis to Design Thinking; rather what should be highlighted is that Design Thinking is made up of a set of processes, and that these processes are also open to innovation and transformation. Design Thinking is always evolving and becoming as a concept. It therefore requires a high degree of reflectivity and transformative leadership approaches. With the right organizational design, leadership and management, many individuals in organisations could experience a creative blossoming as design thinkers, if only given the opportunity and resources to do so. The capability of leadership to co-construct a shared vision can thus be seen as an underlining dynamic in Design Thinking as an aesthetic process innovation.

**Design Thinking as a shared future orientedness**

Martin (2009) has argued that Design Thinking is a collaborative methodology that builds on complementary, multidisciplinary experiences. The future perfect idea allows the experience to be iterative and improvisatory. We argue that this future perfect idea is also illustrated in prototyping as a core principle and crucial tool within Design Thinking (Brown 2009). In Design Thinking, the prototyping and the prototype is a fundamental form of and result of collaborative and iterative activity in search of the best solution—a future perfect state as opposed to a perfect future state [1]. It is the explicit result of ‘making a way together’, in von Eckarstberg language. Design Thinking is contextual and personal, it is integrative, and it is interpretive (Brown 2009; Martin 2009). The prototyping and the prototype is manifest in Design Thinking as the ‘human-centered design ethos’ (Brown 2008, p.1). The human-centred design ethos is traditionally most recognisable in the industrial and technological world, where designing products for the end-users must take into account the end-users’ perception of the product’s usability and utility, recognised as an activity involving the experience of emotions as well as the aesthetic senses (Dorst 2010; Lim & Stolterman 2008). Over the last 20 years the experience of user interfaces is noted as a crucial factor in the success of a product, and so the design process makes user experience central to any design (Norman 2002). Design Thinking is an emergent theme that attempts to provide a pragmatic framework for dealing with complex thinking in designing solutions to problems: be they architectural, technological, and increasingly social and organisational (Martin 2009; Pitsis 2011).

Building on Tylor and Ladkins typology of development processes, the prototyping as an engaging activity can also be understood as a projective technique, where participants can express notions and feelings that are otherwise not very accessible or possible to articulate in a more conventional setting (Taylor & Ladkin 2009). The prototype function as an invitation to convey the here-and-now experience, in a context of shared future orientedness. It allows for contradicting opinions and paradoxes, where different qualities embodied by the prototype encounter can be explored (Lim & Stolterman 2008; Dorst 2010; Brown 2009; Martin 2009). How does it feel touching it? What if we look at this solution from the other way around? Could we replace that element with another? Does it feel good, looking at it? Through the interacting with the prototype, the agents are pro-actively invited to engage with the potential becoming: Do I feel good, imagining myself into this future environment? What could make me feel better? Do I see this becoming something I would like to be a part of?

We understand prototyping and prototypes, being a core element in Design Thinking, as an aesthetic embodiment of the complex, contradicting, paradoxical and new. Furthermore, we suggest that both prototyping as a core activity in Design Thinking and the physical manifestation of an idea represented by the prototype, serves to demonstrate its relationship to phenomenology generally, and its future orientation particularly. As a dynamic concept Design Thinking combines intuition with expert knowledge and experience. It is both experimental, speculative and also highly iterative. It is making a way together;—it is in its very essence collaborative creation. Design Thinking, as with phenomenology, is thus an aesthetic based form for sense making, and so has important implications for organisational and managerial theory, research and practice. Its phenomenological power dwells specifically in the combining of
various qualities of experience and competencies, where creativity is unleashed namely by the ability to contain diversity, not control it or restrict it.

**Design Thinking—the phenomenological exploration of co-created meaning**

Phenomenologists dedicate their everyday lives to exploring the ways in which humans co-create meaning, and how people act and interact symbolically through language, signs, symbols and artefacts of human interactions (see Herbert-Mead 1947). Phenomenology has always been a method for making sense of phenomena and their experiential quality. Phenomenology is intentionally about methodology for making sense of and explaining and acting upon the world (Schutz 1971). Pragmatic phenomenologists such as Alfred Schutz, Martin Heidegger, and psychologists such as Rolf von Eckarstberg and others were not as concerned with ‘subjective’ experience as they were with ‘inter-subjectivity’. That is, how people construct and create meaning with, because of and for others through taken for granted knowledge from the past, experiences in the present and projections into the future.

Phenomenological ideas, such as that proffered by von Eckarstberg (2008), allow us to take the idea of design beyond simply the design of things such as buildings, products and services, and even beyond a way to design solutions and thinking about problems, to a state of design as being qua non. That is, phenomenology is the original Design Thinking method that actually takes Design Thinking beyond product design, to the ‘aesthetics of perception’ and the ability to ‘design from within’ in the ‘service of higher integration’ of human actions. As such, current ideas of Design Thinking do not differ substantially from ideas inherent in managerial and organizational process innovation, it is just that those in the management and organization theory domain, and those in the design field have constructed alternative realities around the same methods of enquiry. By integrating the phenomenological ideas above, particularly the inter-subjective ‘aesthetics of perception’ we are able to provide a form of Design Thinking that goes beyond just product or service, to one that is inherently a human relational activity (practice) and an ongoing, aesthetic process of becoming.

Therefore, as already stated, the essence in Design Thinking can be paralleled to that of phenomenology, particularly what we refer to as Schutzian phenomenology. The father of American pragmatic phenomenology, Austrian philosopher, Alfred Schutz (1944) argued phenomenology is a method of social science and not a philosophy, as is often incorrectly stated. As a method it is all about making sense of experience in the past, present and future. As such, it is a quality of inter-subjectively generated experience about objects and events in an agent’s life-world [2]. All experience is social, made sense of subjectively from concepts which have evolved inter-subjectively through symbolic interactions—included but not limited to language, jargon, architecture, art, and office space [3], which requires people to create and share meanings in order to make-sense (Schutz 1944; 1967; 1973), moreover we make sense and experience the world through those in our past (predecessors), those in our physical present (associates) and temporal presence (consociates), and those in our future (successors), and in situ.

With Schutzian phenomenology’s strong emphasis on temporally based social constructionism (that is a shared future orientedness) and implicit assumption of improvisation as a response to contextualised and ambiguous problems, Design Thinking has strong affiliations with phenomenology’s projective qualities. In the phenomenological idea of ‘future-perfect thinking’ actors inter-subjectively experience a future state and treat it as a realised potentiality. As such this enables actors to co-design and act upon their projects as complete thus by-passing the inherent ambiguity and uncertainty inherent in all projected human action (Pitsis et al. 2003).
Design Thinking as managing for a shared future perfect state

As we have argued, the prototyping of an idea, making it visual to test out its features and get a kinaesthetic experience of it is a key element in traditional Design Thinking as a methodology (Brown 2008). The prototyping implies interaction with the user, where ideas are shared, discussed and developed in a collective setting. The aim is to get a ‘feel’ of the product. In this context, we find that product can be translated to process, as the process itself and its innovative qualities are seen as the product. In the end, the ambition is to achieve a positive feeling with the end-user interacting with the product (the process). Desmet and Hekkert show how it has been stressed in design theory that the emotional experience evoked from user experience with objects is a key to successful product development (Desmet & Hekkert 2009) Building on this, a holistic approach is required when designing for people, taking seriously the experienced quality of the relationship between the product and the stakeholders. This relational dimension to the experienced quality of a new concept is what Jacoby and Raney (2010) argue is the reason why Design Thinking and prototyping is such a powerful tool in strategic business processes, because people are able to get a feel of what is created or being created,—because prototyping addresses the aesthetic experience (the future-perfect).

We suggest that applying Design Thinking as aesthetic process innovation means by its very definition a new emphasis on participant involvement. Ownership and involvement has long been advocated as critical success factors for any process implying innovation in managerial and organizational processes. In change management literature the appraisal of the involvement of stakeholders in a change process is self-evident. What Design Thinking as methodology implies, particularly through prototyping, is involvement of the user. In an organisational context, if the manager is viewed as the lead designer, the Design Thinking is about designing the managerial process. The user to whom the design of the process will be addressed, will be the actors relevant to the organizational contexts: the employees, internal-external customers, peers, colleagues, suppliers and so on. It follows that if the manager as a ‘lead designer’ wishes to succeed with the implementation of something new, the key (and if feasible all) stakeholders—that is ‘users’—must be involved. The relationship between the employee and the new concept must be verified as generative. If not, the risk is that the emotional experience with something new will be tainted with negative connotations and most likely be rejected by the users. Employees will seldom embrace a change in which they do not see meaning, or which represents more pain than pleasure. Not being involved in a process where change is decided creates no bonding. There is no relationship building between the employee and the new change. Building on Jensen and his theory about function versus feeling (Jensen 1999), it does not matter if the change in itself might have logical reasons for being a good decision for the corporation. If it does not feel good, it is not perceived as good, and chances are that the implementation will not succeed. As such, ideas are about aesthetics. Leadership in Design Thinking as aesthetic process innovation is thus about caring for the aesthetic element in the innovative process,—the collective process of ‘making a way together’. This means Design Thinking as managing for a shared future perfect state.

Design Thinking as a strategic tool: Bringing the significance of aesthetic imagination forward

As implied earlier, applying Design Thinking as process innovation in organisations means bringing in participant involvement and interaction within the processes involved in the creation and realisation of ideas. If we conceive of Design Thinking as a strategic tool, in its core the tool represents a future-perfect interaction between the designer, the product and the users which is inherently an aesthetic process of innovation. In an organisational context, that means interaction and dynamic involvement with the manager, the new and the employee.
With prototyping, the kinaesthetic dimension is present, signifying an aesthetic experience within the process.

In this context, Design Thinking and prototyping as an inter-subjective and future oriented activity means bringing the aesthetic element forward within the innovative process. We argue that such sense based experiences embodied in prototyping grounded interactions facilitate creativity,—and thus, they enhance the generative process. Taylor and Ladkin have advocated the importance of accessing embodied, sense based knowledge, that is, aesthetic grounded knowledge, through what they define as presentational knowing (Taylor & Ladkin 2009);—knowing through sense based activities that engages the aesthetic perception. We understand prototyping and prototypes as a form of presentational knowing, because the very making of a prototype implies imagery, movement and creation in an interactive setting. Namely the physical, tangible quality in the making of, and interacting with, a prototype, allows for a presence based, collaborative sense making and at the same time;—the experience of future becoming.

The prototype is supposed to be a model, a raw sketch, of the unfinished idea (Brown 2009). Its pure incompleteness is what makes it such a powerful tool in process innovation. Prototyping is in its essence a sample of von Eckartsberg’s theory on the Dasein-Synthesis applied to organisational practice. In the collective process of prototyping and reflecting upon the prototype, von Eckartsberg’s notion about imagination, idea, word and deed become manifest in full incarnate activity.

A body of research literature suggests that the significance of positive emotions for creativity and innovation in any organisational context cannot be ignored (Amabile & Kahire 2008; DeGraff & Lawrence 2002; Florida & Goodnight 2005; Razulzada & Dackert 2009). Schroeder and Fillis have described organizations as comprised of people, and since people undeniably are comprised of aesthetic qualities, then aesthetics comprise part of the fabric of organizational experience and reality (Schroeder & Fillis 2009, forthcoming 2010). The combination of the aesthetic dimension brought forward by prototyping as a sense based, strategically future oriented and collaborative activity, and the emotional experience evoked by prototype based interaction, is targeting the essence of organisational life. It is also closely related to Schutzian phenomenology’s strong emphasis on temporally based social construction and von Eckarstberg’s (2008) aesthetic ‘way of life together’. Hence, Design Thinking as a methodology in process innovation is also an approach built on emotional experiences. This implicates management and leadership as a key challenge in the Design Thinking process. Applying Design Thinking calls for directing a process where emotional experiences are facilitated as a main source for innovation. As a consequence, exploring Design Thinking as aesthetic process innovation means to investigate which skills and assets are required in leadership practices in such aesthetic processes.

**Design Thinking—imagining the emotional experience**

Empirical studies in action based research show that prototyping can function as an extremely efficient and powerful tool in collaborative creativity, namely because it evokes emotions, which in turn call upon the imaginative [4]. In collaborative workshops with a Norwegian oil-and gas company, several elements of Design Thinking have been applied in order to enhance collective creativity and innovation. Bringing together professional experts from different divisions and with different background and experiences to sketch out and make prototypes from new ideas has proved to be a very potent methodology. The results are convincingly positive regarding the quality and relevance of the outcome of the process. Yet it represents some obvious challenges for leadership. The professional diversity that makes for an outstanding cross-fertilization of ideas and inspires innovation also embodies conflicts and contradictions, tensions and interpersonal issues. While it is our experience that emotions are often not being recognised as pertinent to business innovation by the management fashionistas, the setting of an affective context that Design Thinking represents, clearly introduces an enticing but challenging palate.
to the management table. This is not the least due to prototyping as an engaging and potentially highly emotional activity.

In their review of what they call a decade of design and emotion, Desmet and Hekkert write about the sense perception and emotional experience of products (Desmet & Hekkert 2009). They refer to Jensen’s claims that what matters, is the emotional experience that is conveyed by interaction with the product, and not the product as a serviceable tool (Jensen 1999). In Design Thinking as methodology, the importance of the emotional experience is perhaps especially manifested in user testing where prototypes of new concepts are exposed to users for feedback. Prototyping is all about visualising the idea and thus create the diverse space where the combining of qualities blend and add to the creative imagination as to develop and improve the idea. Jacoby and Raney point out that prototyping as a basic element in Design Thinking applies not only to the creation of specific products,—bringing the iterative building process into a business context can yield a great difference to a strategic planning process (Jacoby & Raney 2010). They argue that by ‘building rough and rapid prototypes we can ask the questions that ultimately inform our larger decisions’ (Jacoby & Raney 2010, p.37).

There are no research based statistics showing that for example an experienced CEO is more likely to contribute with more fresh or better ideas than would a junior employee. On the contrary, the opposite is more likely, and so the ability for leadership to enable and support creativity is crucial (Hunt 2009). We suggest that prototyping as a tool in Design Thinking as an applied methodology can contribute to a different way of experiencing the co-creation in processes, where it is not a matter of experience that defines the level of Design Thinking capability but a matter of collaborative trust and exploration of the incomplete—in the becoming.

We strongly believe that in applying Design Thinking as aesthetic process innovation in organisations, the quest for innovation is about ‘a way of being’ more than a ‘way of thinking’. We thus suggest that the awareness of managerial and organisational being and the experience of becoming in a collaborative context can be strengthened by the implementation of Design Thinking in processes. As we have seen, Design Thinking is an aesthetic based, collaborative process and builds on complementary experiences; closely related to Schutzian phenomenology. Design Thinking applied to managerial and organisational processes is about the facilitation of a shared aesthetic future orientedness. We have advocated here that the essence in Design Thinking—the making a way together- can be paralleled to that of phenomenology, where we see the prototyping element in Design Thinking playing a crucial role as a facilitating, kinaesthetic and aesthetic tool for innovative experiences and practices. In the process of encouraging the novel, aesthetic leadership is all about encouraging the novel process. Applying Design Thinking to the process can contribute to this novelty and open up the ‘possibility of possibilities’ (Schutz 1967); in the making of a new way of organisational life together and the experience of innovation and creativity as an aesthetic process.

Notes

1. Future perfect does not mean ‘a perfect future’, as such future perfect is a shared idea of a prototype and aesthetic quality of experience. Perfect future, on the other hand, is an ideal or utopian end state: it cannot be a prototype as it is the ideal, and hence the only possible, perfect end state. Future perfect is an ongoing, iterative and impovastory process.

2. Agent referring to not only individuals but also a group or an organizational entity.

3. See the work of George Herbert-Mead for greater insights into symbolic interactions.

4. Ongoing research project by the research team at Sintef Technology and Society, Knowledge Creation, SINTEF, Oslo, Norway.
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Impositions of order: Strategies for establishing coherence—a comparison between design and fine art practices

Janet McDonnell
Central Saint Martins, London, UK

in conversation with

Graham Ellard
Central Saint Martins, London, UK

Stephen Johnstone
Goldsmiths College, London, UK

Abstract
Ellard and Johnstone have collaborated in their fine art practice for over 15 years[1]. Their works include large-scale video installations, architectural light-works, films and drawings, all of which have been exhibited widely in galleries and museums. Currently they are engaged in creating a series of 16mm film works. The first, ‘Proposal, for an unmade film’ was completed in 2007. The second, ‘Machine on Black Ground’ was first shown in 2009. Work on the third film, ‘New Museum’ is currently underway.

This paper is based on conversations with Ellard and Johnstone in which McDonnell prompts them to articulate how they impose order on their work. McDonnell’s aim is to explore the similarities and differences in the strategies used by designers and fine art practitioners to impose enabling constraints on a project. Enabling constraints are defined as devices, arbitrary, pragmatic, aesthetic and other which artists or designers impose to create coherence in a work or to create a discipline for the working process. Enabling constraints are those which result in the setting in place of potential for creative freedom within imposed boundaries and/or frameworks.

The paper concludes that further understanding of the (design) creativity that arises from prepared minds (in Pasteur’s sense) might come from investigating the prepared minds of fine art practitioners; and that a study of long term collaborative practice is a more appropriate unit of analysis for understanding how order is imposed on creative projects than a focus on individual projects themselves.

1. Background
1.1 Designers’ impositions of order
In the design research literature over the last forty years we find a wealth of material concerned with how order is imposed on complex design situations; these are one class of coping strategies for dealing with ill-structured ‘problems’. Amongst this literature are descriptions of experienced designers’ skill in imposing order, epitomised by Donald Schön’s story (1985) of the pedagogic exchanges between Quist and Petra and his more abstract conceptions of designers’ reflective practice in terms of naming and framing operations within the naming-
framing-moving-reflecting descriptive model of design practice (Schön 1983). The character of expert design performance was given more specificity in the work of Akin in the 1980’s (starting with Akin 1986). From this we have learned about the characteristic problem structuring capabilities of expert designers, in particular their approach to generating design outcomes via movement between consideration of the whole (breadth) and the parts/detail (depth) of an emerging design. Writing at about the same time as Akin, Rowe (1987) characterised architectural design as getting started by establishing organisating principles; it is through these that Schön’s imposition of order is effected.

Darke (1989) complements and parallels Rowe’s more abstract characterisation, again in the context of architectural design, with her more concrete notion of the use of primary generators. Looking at much more recent writing we see that, although the terminology has expanded over the decades, what is being characterised has remained consistent. For example, Dong’s recent work (2009) in using computation linguistic techniques, specifically latent semantic analysis, gives us access, by new means, to what he describes as the ‘collection of materiality so as to form a coherent whole’. This collection, the aggregation, is the prerequisite to the accumulation and thence appraisal that comprises the components of designing (characterised by Dong in linguistic terms). Lawson (2004) summarises his own prior studies and those of others drawing attention to a number of facets of design expertise to emphasise the types of knowledge structures that, developed through experience of designing, allow designers to perform efficiently individually and in concert with others in ways which leave room for adding ‘something new’ (p.448).

1.2 Purpose of the study

Our aim is to investigate the extent to which the phenomena mentioned above which collectively describe mechanisms for imposing coherence and order on a design situation and the necessity, value and outcomes of doing this in a design context can inform understanding of collaborative fine art practice. We are also keen to look beyond these accounts, drawn from design research literature, to identify strategies particular to fine art practice which fulfil similar roles; thus, to return something (back) to further inform our understanding of creative design practice.

In the brief enquiry described here we focus attention particularly on the recent and current film works that Ellard and Johnstone are engaged upon. Our observations are particular to the ways in which these two long-term collaborators have worked on three recent 16mm film projects and our ‘data’ comprise reflective conversations about the creative process through which these works have come to be made. We focus on the relationships between the decisions that are made that can be construed as imposing enabling constraints—and the creative potential which is thus set in place once a regime is decided upon—for example what Johnstone has described as the rhythms that determine the way film shots are thought about.

We might expect to find that a salient feature of how the imposition of a discipline or rules operates in a fine art context is the freedom to create fictions both in the setting and the breaking of rules in the service of the work once the initially imposed order has served its purposes. If we are able to shed some light on the strategies that are at work in the fine art context where creative practice is preeminent and clients, customers, users, audience are not a consideration, we might be able to increase the repertoire of creative design practices or see designers’ practices for imposing order to facilitate creativity in a new light.

We need to bear in mind that (these) artists set their own challenges (and in this they are akin to the ‘creative experts’ who Cross (2007) reports as ‘solving similar tasks from first principles each time, rather than recalling previous solutions’ (p.113)). Of course along the way they may solve problems to realise their intentions and to meet the standards they set for themselves. We
might, then, expect to see some parallels with the ‘solution’ orientation of designers (Lawson 1990) even if the notion of a ‘problem’ at the macro-level is not a useful concept in the fine art context. This study also begins to pose questions about areas where design research needs to go if we are to improve our understanding of design practice as it takes place over time in long term creative collaborations.

1.3 Approach to the study

The description of practice presented below is a preliminary, partial ‘sketch’ prompted by the invitation to respond to the theme of DTRS8. It is a description based on two studio visits by McDonnell to hold conversations with Ellard and Johnstone focused on efforts to elicit accounts of the aspects of Ellard and Johnstone’s fine art collaborative practice around the topic of enabling constraints (though the term itself was not used directly). In the first meeting a broad ranging discussion was prompted by a series of topics introduced by McDonnell. These touch on the principle themes from our current understanding of designerly ways of operating, comprehensively and succinctly brought together by Cross in Designerly Ways of Knowing (2007). The topics broached were as follows:

- Notions of ‘client’ in the broadest sense. Who the work is ‘for’.
- Planned vs, opportunistic—in both process and content; ‘talk-back’ and surprise (cf. Schön 1983; 1985); consequences.
- Uses of representations: to support ‘organizing things’; handling different levels of abstraction; movement between these (cf. Cross 2007, p.57); ‘tools’ for thinking with.
- Dealing with uncertainty; getting ‘stuck’ and strategies for ‘unsticking’.
- Evaluation and judgement.
- Guiding themes; setting and solving challenges.
- Practical activity and transitions between modes of working; getting started and knowing when a work is ‘finished’.

The second conversation focused more particularly on enabling constraints prompted by the conversation in the first session. The conversation unpacked a number of terms that were introduced or arose during the first conversation including story, scenario, alibis, conceits, armatures, atmosphere. The account below is based on these two conversations, supplemented by material from a recently published interview with Lucy Reynolds (2010) that was available prior to the two interviews. The Reynolds interview provides material about physical constraints (medium, technology) which are deliberately employed to impose discipline on the work and on the process of making it, as well as being instrumental in contributing to the realization of cinematic objectives, for instance the creation of the atmosphere of a work.

For the purposes of this textual account, enabling constraints are sketched below in two orthogonal projections, one focusing on thematic coherence in Section 2, the other on aesthetic coherence in Section 3. Section 4 suggests that materiality—here the materials and process of film and film making—are another source of productive constraints, although they are given only brief treatment in this account. Describing these as projections is an attempt to convey their inseparability for analytical purposes, their non-viability as distinct entities and to acknowledge the polyvalency (openness to a number of different interpretations) of a completed work and its component images. All quotation marked text below is taken from the two conversations unless other attribution is indicated.

2. Thematic: alibis and conceits

For Ellard and Johnstone, the coherence ‘behind’ a film is most accurately captured by the term alibi. Story, and even scenario are terms with too much association with narrative to accurately capture the function and nature of a conceit (a term they also are comfortable in using). An alibi does a number of things. It serves the film makers by giving ‘an excuse to make a film’
about a building, a set of buildings, a location or other kind of material object such as advertising images or photographs of interiors in books and magazines. It lets them take a position, a point of view, in relation to the objects of interest. Alibis serve as made-up stories that provide the ‘pretext’ to ‘give into the temptation that they (material objects) might be something else’; alibis ‘structure the way we look at things or sort through our found material’ (Reynolds 2010, p.5). A conceit provides a concise point of view which ‘does not have to be reasonable’, for example ‘we are in a church and we think it is the inside of a projector’. Conceits are deliberately ‘naive (mis)construals’ that allow the film makers to explain (to themselves for the purposes of creating the work) what ‘we are doing’. Alibis can be seen as synonymous with scenarios only in so far as they can be seen as a speculative answer to a what-if question, e.g., ‘what if we’ve just arrived here from Mars’.

Alibis also serve performatively any (human) characters that appear in the works—giving (via imputation of the viewer) an alibi for acting in certain ways, for speaking, for engaging with their surroundings and with objects in certain ways. An alibi accounts for and permits certain activity (and implicitly denies other). Alibis have a functional role in delivering coherence during the creative process, they are scaffolding which can be dispensed with at any point when they have served their purposes and no importance is attached to how a viewer interprets the final work, ‘there is always a pleasant surprise when other people are interested by it (the work), intrigued by it, but in a way it’s us that are fascinated first, we enjoy the fact that we don’t feel an obligation to anyone else’.

There can be more than one alibi or conceit, and each may operate at different levels of granularity, setting the point of view for the work as a whole or some detailed nuance within it. They can be contradictory, they play an organizing role, ‘becoming the point from which it is possible to shoot film’, they can be cast aside when they cease to serve; the ‘rules’ they imply can be violated. Alibis and conceits are prompted from images initially, from some ‘visual affinity’. For example, Johnstone describes the background to a painting by Graham Sutherland, ‘the black ground could easily be deep space’. Both artists describe looking through the betongglas (glass blocks set in concrete) from inside the Kaiser Willhelm Memorial Church in Berlin thus, ‘it seemed that we were somehow submerged or underwater…. looking out through the windows of a capsule or a submersible’ (Reynolds 2010, p.5). The structure of the betongglas, stained glass partitioned in concrete ‘cells’, invited an association with film frames, ‘we thought this is what it would be like to be trapped in an optical printer’ (op.cit. p.7).

Alibis and conceits support the need to create and maintain a coherent atmosphere in a work. For example, in the making of one work, there is a background conceit that images from three buildings are parts of a single artifact which is somehow underground and being controlled as part of a mission or project. This furnishes part of an orientation for the work, Machine on Black Ground, an orientation which Johnstone characterizes as an atmosphere rather than a story—story having too much of an overtone of explanation, too much monosemy, to be an acceptable label for how the device functions. In some senses then, alibis work functionally like Darke’s primary generators, they do form a starting point, they fulfil a role as initial generators for a project. Darke describes primary generators as being capable of justification on rational grounds, a difference with Ellard and Johnstone’s alibis, however what she actually writes is ‘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 an act of faith.’ (emphasis added). She also talks of designers’ fixing on objectives selectively—and that this selection is based on things which they, as individuals or as a professional group, value highly and which are self-imposed. They do this for reasons that rest on their subjective judgement rather than being reduced to a process of logic.
Ellard and Johnstone’s alibis and conceits certainly work as generators and at the same time draw attention to particular properties of their subject matter so that they can develop an atmosphere, working with visual material to ‘confront it as both alien and familiar’.

3. Aesthetic: visual concerns and armatures

Ellard and Johnstone have a set of formal concerns; aesthetic pre-occupations which remain with them from one project to another. Some of their concerns are with plays with depth of focus, light reflected on surfaces, ambiguities of scale, and confronting the visual sensation that familiar objects can appear alien as mentioned above. As is the case for many other artists, those familiar with their work recognize this consistency. Ellard and Johnstone are able to speak of this hinterland of connections, people—architects, former students, book-sellers, friends and professional colleagues—who draw their attention to associations that they think might be of interest. For example, there is an unmade project related to the Melnikov House in Moscow. A friend who is an architect drew their attention to some of the work of the Italian architect Carlo Scarpa (one of his chapels has similar windows to those in the Melnikov building) and thence a link to the work of Franco Albini in museum design which they had come upon via another (independent) route. They describe this as having a collection of ‘informants’ who point things out to them, talking about them and how they ‘join up’ informally as coincidences (whilst probably recognizing that they are not accidentally coincidental).

Certain visual preoccupations thread through all the work to the extent that the collaborators find talking about how a particular project starts a nonsensical notion. In past conversations, talking about the start of any project has always led to a regression back through the 17 years of their collaboration together. ‘These things (works) are built out of a set of interests that have developed over a really extended period of time, there isn’t a starting point.’ The ‘start’ of a future project lies in a previous one; it might be a shot of 10 seconds or ‘where a pan ends up’ in, or for, a previous work. If pushed they can trace the ‘germ’ of the project they are currently actively working on (2010) but as they predict it ‘weaves right the way back’ to their first collaborative work in 1993. We might call these long-standing pre-occupations, ‘fascinations’ or prejudices the signature formal concerns of Ellard and Johnstone.

Competent designers do not approach a new design brief from an arbitrary perspective or an uninformed viewpoint. The prejudices a creative designer brings to a design situation are an essential component of what enables him (predisposes him) to see it the way he does (Gadamer 1975) as a certain kind of task or challenge and to see it as a situation in which he is able to exercise skilled judgment. It sets the framework within which he can create something and evaluate it on the basis of some appreciative systems (Vickers 1965; 1968). In the world of design, as well as in some contexts of fine art practice, the signature concerns are what guides clients to commission work from one practitioner or practice rather than another.

For Ellard and Johnstone research, in whatever form, oriented and supported by the alibis and conceits, takes the work so far but research ‘is a point to start and then we think cinematically’. The sequences in the film works themselves are not ‘driven by narrative in any sense’. Any notion of development within a work comes from ‘creating logical movement from one image to another without being constrained to tell a story’. Once the point of view furnished by the alibi has played its part, ‘images take over, priorities shift to the images’. The sequences are ordered by local and global references between the images, via ‘the subtleties of particular images and the complex webbing of (visual) interconnections between them’ (to borrow Macdonald’s phrase from his description of the work of independent film maker Nathaniel Dorsky (Macdonald 2006, p.79)). Composition of sequences is ‘dictated’ by some visual rhyme; visual and temporal rhythms, repetition, pacing of movement, diagonal and other compositional patterns and echoes, texture and colour contrasts, depths of fields and focus, sounds and their relationships to the imagery and movement. ‘In fact we deliberately shot much of the material
in Coventry and Berlin to confuse the scale of things and create illusion, stained glass walls and organ pipes filmed to look like cities, light falling through stained glass windows to look like a constellation in space.’ (Reynolds 2010, p.7) Coherence comes from both addressing the visual preoccupations and attending to visual rhythms at the full range of temporal scales the work will allow.

4. Materiality: thinking through materials and processes

Space limitations here preclude a comprehensive account of all of the types of constraint that serve to impose discipline on the works and working that came up in our conversations. So far we have completely ignored how the materality of film, filming and the other processes associated with getting to a final print are made to serve creatively. Again, any consideration of this is inseparable from the thematic and aesthetic perspectives sketched above. We start with the most obvious omission, so far, namely the framing of images through the view-finder. Looking through the camera is how the footage to be shot is viewed. Framing of images—by eye, by hands, using mounts (see Figure 1) is a constant imposition on a scene, an image in a book, a location.

![Framing of images](image1.png)

**Figure 1.** Framing of images

Locations, installations, objects, are looked at through the lens. ‘We write a kind of shooting script but we do it when we arrive looking through the lens and we plan the day’. The shooting script is a list of shots not a sequence, sequencing comes at the editing stage and is determined in accordance with the atmosphere being created, the criteria for ‘logical movement’ and the pre-occupations indicated above in section 2 (see Figure 2). ‘We do not shoot footage unless it seems to insist on itself when we look through the camera’.
Representations at different levels of abstraction, other than sketches to indicate what the shots should be, are not used. When editing commences a sequence board (a story board without a story) is used as ‘a kind of pragmatic thing to help us think about it (the film) ... it’s a memory board of images we like and might use ... not a blueprint ... not prescriptive they are armatures to help us think and talk rather than being absolute’ (see Figure 3). At work here are the skills associated with an understanding of how to work with the materials and materiality of filmmaking. The technology Ellard and Johnstone choose to work with restricts what can be done; the constraints imposed are viewed as productive opportunities. Film is shot using a Bolex clockwork camera which, on full wind, allows a maximum of about 28 seconds shooting at a time. There’s something about the restrictions of using 16mm and a clockwork camera we have found really productive—we used just three types of shot—and we were then working to a regime where you were either shooting for a full wind, or a half wind, and so on.

‘Out of that comes a sort of rhythm that determines the way you think about the shot, and then how you start to put the final film together. That has a strong relationship to the process of
shooting’ (Reynolds 2010, p.4). These, self-imposed, technical constraints impose a formality, a rigour, and demand a discipline in shooting footage that is ‘a really valuable and productive structuring principle’, one which fits with the collaborators’ practice of working to low shooting ratios (about 1 to 3). Here, in relation to the (choice of) technology question, it is worth noting again the artificiality of deconstructing what is, essentially a holistic creative endeavor. The choice of technology itself serves the aesthetic concerns of the collaborators, particularly in terms of the atmosphere they wish to create namely ambiguity in the viewer’s reception of work in which archive (found) footage is juxtaposed with recently shot material ‘that could have been made at some point anywhere in the last fifty years’ (Reynolds 2010, p.3) and the visual and sonic qualities of 16mm film, viewed in the same place as its projection. The technology also supports a long standing interest (dating also from the start of the collaborative practice in 1993), ‘an interest in technologies that are either redundant, or obsolete … and the possibility they afford … to think about the past via the promise of technology to deliver a future that was never delivered … this anachronistic technology becomes the means to rethink the present in relation to the past’ (Reynolds 2010, p.3).

When researchers study designers they often stop at the point where a design is ‘completed’ prior to construction, development, manufacture, or implementation (the choice of term depending on the design discipline). We know design continues after this (for example, there is the notion of silent design (Gorb & Dumas 1987) and in software engineering, design drift into implementation is viewed as a significant long-standing problem). For Ellard and Johnstone creative activity pervades the entire process from seeking funding, through the phase of alibis and conceits, to shooting, editing, grading, proofing right up to the point where an exhibition print is struck. This is another of their reasons for finding the question about where a project starts problematic. A project has ‘multiple beginnings’ better characterized as a process of ‘discovery rather than delivery’ in and at each of these stages. This fine art practice is better characterised as having an on-going openness rather than being opportunistic. Opportunism has a functional overtone whereas openness relates more closely to surprise and insight. ‘One of the things that really hit us after we had filmed in Lanzarote, and we were looking at the footage was the sense that these people were maintaining a space that no longer had a function’.

In the study of creative design practice, and in design innovation we can learn much about the essential need of the creative practitioner to be motivated, surprised, excited and challenged throughout the, inevitably, multi-stage association (i.e., from inception to realisation as artefact) in any genuinely creative activity, by studying creative fine art practice.

5. So what for design thinking?

The description presented here is based on only two reflective conversations with two fine artists who have engaged in collaborative practice together for 17 years. Ellard and Johnstone responded to prompts to talk about where their long-term interests lie, and how they have worked together recently to pursue them through creating 16mm film works. The account above draws out features of their practice which relate to the notion of enabling constraints, describing other aspects of their practice to provide additional context. A number of things stand out which point to under researched aspects of design thinking at the creative end of the design spectrum. These centre around long term collaborative practice.

One issue is the need for more studies which look beyond the start and end of particular projects (however long they may be) to understand how value systems, preoccupations, prior histories of those taking part—of working with each other/in institutional settings—influent and influence both individual projects and the relationships between collaborators. A second issue concerns the whole notion of prepared minds in the sense used by Pasteur (1854) when he said, ‘where observation is concerned, chance favours only the prepared mind’ (Vallery-Radot 1900).
While Ellard and Johnstone talk about ‘peculiar kinds of coincidences’ and chance they also show clearly that what they attend to makes these happenstances anything but. They appreciate this themselves, ‘our research half finds us as well as us finding it’. They talk about others finding ‘something recognizable in our work’ such that they can say ‘it reminds me of’ and thus act as agents drawing material to the collaborators’ attention (sometimes closing a circle as exemplified above with the routes to Franco Albini). They can talk about the choice of a building where they made a film as being ‘because it was a place in which certain images could be produced’ (Reynolds 2010, p.6).

Atman, writing recently what she refers to as a ‘thought piece’ (Atman 2009), has revisited Herbert Simon’s ideas on creativity in the context of scientific discovery, which, in turn drew on Pasteur’s notion of the role of prepared minds. Her context is lessons for engineering education, a concern for the initial nurturing of minds that will, in due course, be capable of recognizing the surprises that chance offers up. She writes, ‘an individual cannot be creative in a vacuum. She or he must have a sufficiently deep understanding of an area to enable surprise to happen: a leap to a new discovery or a creative solution to a problem.’ Surprise implies a backdrop of expectation, the unsurprising. So that when Ellard says, ‘one of the things that really hit us after we had filmed in Lanzarote, and we were looking at the footage was the sense that these people were maintaining a space that no longer had a function’ he is displaying his (mind’s) readiness, his predisposition (as set out in Section 2 above) to respond to the opportunity to confront visual material ‘as both alien and familiar’.

Much of the design research which looks at ‘inspiration’ utterly ignores the unremitting nature of the attuned eye (mind) of the creative practitioner—an eye which is never off-duty so to speak but always receptive to particular stimuli, being capable of perceiving (seeing something as something) in a very particular way, we might say with a heightened sensibility. Johnstone begins to capture this pervasive orientation to certain phenomena, which in the study of design ‘expertise’ is under-researched when he says, ‘we have a set of formal concerns we spot them in other things, we are always looking for things that link to our aesthetic preoccupations. It (noticing something) starts to suggest a space in which the characters and things might operate.’

Notes

1. For more detail on this collaborative practice see www.ellardandjohnstone.com.
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Curriculum Design Thinking:  
A New Name for Old Ways of Thinking and Practice?

Gavin Melles  
Faculty of Design, Swinburne University, Australia

Abstract  
The term design thinking has two current meanings—the study of the practices of working designers—the other meaning refers to the human-centred ‘open’ problem solving process decision makers use to solve real world ‘wicked’ problems. Design thinking in this latter sense has increasing purchase outside the design fields per se. Claims have been made that design thinking in this sense can radically improve not only product innovation but also decision making in other fields, such as management, public health, and organizations in general. Although many remain skeptical of the concept and its broad application, many design and management schools in North America and elsewhere, now include course offerings in design thinking. The lack of such courses in Australia presents an opportunity to design a curriculum for design thinking, employing design thinking’s own practices. Curriculum development is something of a wicked problem in itself, aiming to develop a future course of action based on current precedents and other sources of information, which are then trialed in practice. This paper describes the development of a design thinking unit at Swinburne University through design thinking practice.

1. Introduction  
The term design thinking is used to refer to the study of the practices of working designers (e.g., Cross 2006; Dym et al. 2006; Lawson 2006), and, to the application of this human-centred ‘open’ problem solving process to real world ‘wicked’ problems in other areas (Rittel & Weber 1973). This transfer from design to non-design domains is possible, it is argued, as design possesses a distinct logic of practice (see Bourdieu 1990) capable of application to a range of real world problems. Thus, Buchanan (1992) suggests that design thinking, as consistent with Dewey’s pragmatism, has logic (technologia) with potential applications to different fields. Common denominators for definitions of design thinking are the pragmatist notion of experiential knowledge, abduction, and wicked problem solving. What these concepts mean is the first topic of discussion here.

2. Abductive, wicked and synthetic?  
That design thinking as the logic for ill-structured problem solving is fundamentally pragmatic has also been noted by several scholars (see Melles 2008; Ockham 2000). Romme (2003), for example, specifically claims that:

Design is based on pragmatism as the underlying epistemological notion. That is, design research develops knowledge in the service of action; the nature of design thinking is thus normative and synthetic in nature—directed toward desired situations and systems and toward synthesis in the form of actual actions. The pragmatism of design research can be expressed in more detail by exploring the normative ideas and values characterizing good practice in professions such as architecture, organization development, and community development (p.562).
Design thinking often refers to the pragmatist notion of experiential knowledge making (see Chiasson 2001). Following James and Dewey (see Goodman 2002), this implies that knowledge making emerges out of embodied practice and experience; this is also true for aesthetics (see Spector 2004).

Abductive logic focuses on what Josephson (see Josephson & Josephson 1995) calls ‘inference to the best explanation’; a decision making process common in legal, medical and other reasoning (see Walton 2004).

For design specifically, Bodker and Christiansen (1997) relate abduction and scenarios to design thinking in the following manner, ‘We view design as a process of cooperative abductive thinking in which scenarios crystallize a shared understanding of the product (to be), thus populating the space between theory-driven and situated design’ (p.230). This translation of abductive reasoning into the design domain suggests that (future) concept proposals provide answers to circumstances of design problems as potential futures (see Figure 1 below). In human-centered and participatory design the experiential knowledge making is brought about through collaborative prototyping.

Following Rittel and Weber (1973), Buchanan (1992) suggests the significance of the familiar concept to design is that ‘Design problems are ‘indeterminate’ and ‘wicked’ because design has no special subject matter of its own apart from what a designer conceives it to be’ (p.16). While this interpretation has some value, it is misleading in that Rittel and Weber (1973) developed the notion of wicked (indeterminate) problem solving in relation to relatively large scale (urban) planning decisions. The nature of the wickedness had to do with the complexity of the sources and processes involved in making decisions in such a space. It is not the case that all design problems can or should be so characterized, in that in many industrial applications the degree of uncertainty and fuzziness in the designing of a toaster or chair for mass production is not complex in the relevant sense.

The final characteristic often alluded to in relation to design thinking is designerly logic. The idea that design constitutes a different mode of thinking to that of science and the humanities is not new (e.g., Simon 1996; Cross 2006). In relation to this, Charles Owen (2007) suggests that different fields are concerned more or less with both symbolic and real questions and methods and locate themselves along a continuum of analytic—synthetic and symbolic—real concerns (see Figure 2 below). Owen suggests that the combined effect of design thinking and science thinking for problem solving with designerly aims is better than either alone (Owen 2007, p.22).
If design thinking embodies the concepts outlined above, it may provide an answer to the search for a theory and science of design distinct from both empirical science and humanities and arts traditions. In addition to describing an approach to product innovation, design thinking may, it is claimed, improve decision making practices in other fields, such as health care delivery (Duncan & Breslin 2009), library system design (Bell 2008), strategy and management (Lester, Priore & Malek 1998; Dunne & Martin 2006), operations and organizational studies (Romme 2003), and more broadly social innovation (Brown & Wyatt 2010). In these other fields the employment of designerly strategies, e.g., visualization, co-design, through the decision making process creates a better environment, it is argued, for quality outcomes. This transfer to other applied domains effectively means moving design thinking from product innovation to other fields and applications. In relation to curriculum design, students must be exposed to these concepts through readings so that they are able to see the intellectual heritage of the notion design thinking and can begin to see the potential and limitations of such a concept for practical applications.

3. Design thinking as product innovation

Tim Brown (2008) suggests that a shift to designerly thinking in product innovation has come about through designers taking on innovation as upstream innovators with a focus on physical products and systems and services, ‘rather than asking designers to make an already developed idea more attractive to consumers, companies are asking them to create ideas that better meet consumers’ needs and desires’ (p.2). Citing a range of past and present examples, Brown illustrates design thinking as a three stage process with the following diagram (see Figure 3). Effectively then the shift to design thinking in other fields can be seen as a by-product of the expansion of the innovation process to include the ecology or system of the product(s) being imagined.
The essential insight from such work and that of IDEO in general is that product innovation and development should remain a central aim of design thinking. The translation of design thinking into the management domain has also generated descriptions which contrast design thinking with conventional decision making.

4. Management, business applications

Stressing the relevance of wicked problem solving for business and management, Dunne and Martin (2006) contrast typical design thinking in organizations with design thinking as follows, ‘Whereas managers avoid working on wicked problems because their source of status comes from elsewhere, designers embrace these problems as a challenge (p.522). This characterization of management and design is, of course, idealistic but offers an avenue for design thinking to spread its wings, so to speak. A concrete example of design thinking in practice, however, illustrates the method in action outside of design.

Holloway (2009) describes and exemplifies the design thinking practices of SAP Design Services Team (DST) created by the Hasso Plattner Institute, as follows:

Beginning with a holistic, “3608” understanding of the problem, including customer’s needs (explicit and tactic), the end-user’s environment, social factors, market adjacencies, and emerging trends, etc., design thinking looks beyond the immediate boundaries of the problem to ensure the right question is being addressed. Using interdisciplinary teams, design thinking incorporates diversity and leverages different paradigms and tool sets from each profession to analyze, synthesize, and generate insights and new ideas. The interdisciplinary nature of design thinking also ensures
that innovations are naturally balanced between the technical, business, and human dimensions (p.52).

One of the key environments for this is the project ‘war room’, which are described as follows:

The design thinking approach also encourages teams to create “project war rooms” and to work visually using pictures, diagrams, sketches, video clips, photographs, and artifacts collected from their research to create immersive work environments that allow the team to gain deeper, more intuitive empathy and understanding of their users' needs. Using rapid iterative development cycles, teams build rough, “throw-away” prototypes for validation with end-users and project stakeholders (p.51).

Similar strategies have now become common practice for design thinking consultancies, such as Second Road (http://www.secondroad.com.au/) in Australia, and Humantific (http://www.humantific.com/) in the US, specializing in Design Thinking and related practices for organizational (re)design. Such strategies have also developed in other institutions teaching design thinking, such as the tools developed for K-12 education (see idesignthinking http://www.idesignthinking.com/). Thus, together with design thinking for social innovation, the scope for the practical application of design thinking is enormous. For curriculum design, some measure of this breadth should be included in the curriculum design so that students are exposed to these cases and able to trial such approaches also.

5. Design thinking: course precedents

Clearly if the practice of bringing design thinking to new fields is more than the latest fad it could represent something of a gold mine for curriculum renewal in design schools. And indeed the recent history of design thinking in North America now includes course offerings, at the Rotman School of Management, Toronto (Canada) and Stanford University’s D-School. As things currently stand there have been three broad approaches—design thinking as program units, design thinking as course logic, e.g., Masters in design thinking, and design thinking as individual seminar or lectures, and design thinking (in combination with any of the above) as a general philosophy for schools. Five examples follow.

Open University UK: U101
http://www3.open.ac.uk/study/undergraduate/course/u101.htm

From the School of Design, U101 is an online undergraduate (first year) course available to students in a range of disciplines and on completion can count towards degrees outside design, for which it is a foundation course. According to website 'The course is presented in four blocks corresponding to the different levels at which design thinking can have an impact on our lives: at the individual, group, social and global level... Central to the course is an online virtual design studio, where you will upload your practical work—using images you have created—to discuss with other students and your tutor’. There are five tutor marked assignments and a design portfolio and a 1500-word essay make up the end-of-course assessment.

University of Minnesota College of Design: DHA 1101W
http://graphic.design.umn.edu/documents/DHA1101W_000.pdf

Introduction to design thinking is a semester long first year course for design majors and other students. According to the syllabus, ‘This course is an introduction to the theories and processes that underpin design thinking and practice. Students investigate the interactions between humans and their natural, social, and designed environments, where purposeful de-
sign helps determine the quality of those interactions, the practice of the design professions,
and the power of design in culture. Assessment consists of three written papers, three exams;
two creativity projects and two creativity assignments. A mixture of weekly book chapter and
journal article readings create a reading thread through the semester. One hour lectures refer
to the readings and the tutorials later in the week are taken up largely with assignment and
project work development and critique.

North Carolina State University: D100/D101
http://itunes.apple.com/us/podcast/d100-design-thinking/id289217952

One hour lectures focus particularly though not exclusively on design thinking in architecture
and other design disciplines. The course has an art; architecture and design focus as opposed
to a business. According to website, 'Design topics including: processes, methods, philoso-
phies, theories and special topics such as making choices in a consensus driven organization
or in a collaborative venture. A companion course to the second semester discipline specific
Fundamental Studios'. D101 meanwhile 'evolves from the direct application of design thinking
principles in the various design disciplines. It is intended to give a variety of perspectives from
which to proceed into the design process. Students are expected to write reflections on the
material presented in class, to develop a personal philosophy of design statement and to con-
clude with the construction of a design thought model that represents each student’s thinking
process. A review of relevant films and invited lecturers from the design disciplines'.

Simon Fraser University: TECH 124 Design Thinking
http://www.techone.sfu.ca/documents/doc/22

Within the Faculty of Communication, Art and Technology (FCAT), TECH 124 is a first year
semester long course with readings and project work (40%), and individual design journal
(15%), and mid term exams on readings and lectures and workshop style tutorials. The course
is aimed at design students and has a design focus, as evidenced by set texts—Lawson, B.
to the website, 'Investigates the role that design and the designer play in the world around us,
and explores how design facilitates our understanding of our environment and facilitates com-
munication with others. It examines the importance of precedent in design and how examples,
models, patterns or standards reflect learning and critical thinking. Throughout the course
students will, individually and in teams, use design questioning processes as tools to develop
their critical thinking skills and to explore the role that design plays in their lives and the daily
functioning of their communities'.

HPI: Universitat Potsdam: Design Thinking School
http://www.hpi.uni-potsdam.de/d_school/curriculum.html

Two twelve week modules are offered at basic and advanced levels. The six week project work in
the basic course is developed together with industry partners, as is the advanced track. Atten-
dance is two full days per week. A presentation documenting students projects from 2010 gives
a picture of the level of work (http://www.hpi.uni-potsdam.de/fileadmin/hpi/d-school/mate-
rial/Programm_2010.pdf. This is a course for postgraduates with strong design backgrounds
aiming to develop particular skills, with each team of four to five from a range of faculties
working with industry partners.
Review Summary

Courses to date enrol primarily design students and may form part of a broader base of foundation studies for such students. Enrolment is allowed by non-designers and encouraged at the postgraduate level. The significance of readings varies between courses with a majority still employing design-oriented texts. Lectures also tend to focus on design and innovation issues. The degree of project work and industry involvement varies with the level of the course—undergraduate or postgraduate. A common feature in practice and in courses is also the use of visualisation tools and other strategies, including prototyping, familiar to design students. This review of leading edge schools and their programs suggests the need for a mixture of project work and readings in curriculum design. Where possible project work in teams should address real world problems; it was particularly the opportunity to use on-campus locations that seems useful in course design.

6. Designing a course for delivery in 2011

In attempting to develop a distinct approach for Swinburne University, a review of five course offerings and their characteristics was conducted to identify common and differentiating features with a view to Swinburne course development. Together with an understanding of design, cases of its application and non-designer understandings of design thinking provided information for an approach to this curriculum design as itself a wicked problem which could be addressed in a way reminiscent of research through design (see Wayne 2003; Wiggins & McTighe 2005; Zimmerman, Forlizzi & Evenson 2007).

As a result of reviewing these precedents and considering the characteristics and needs for design thinking as reflected in the literature, a semester long program to be delivered in semester 1, 2011 was developed. A project-oriented semester long course (12 weeks) with relevant readings and mid-point assessment of projects, outcomes and aims to expand the designerly basis of undergraduate designers (http://courses.swinburne.edu.au/subjects/Design-Thinking-HDC011/local). The course has the following aims and objectives:

The unit aims to introduce students to concepts and methods associated with design thinking in a range of design and non-design contacts. This unit will explore key concepts associated with the practices of design thinking, such as ideation and prototyping, ill-structured problem solving, collaboration/participation and human-centredness. This introductory unit will complement the other issues addressed in the design management minor and concepts and practices in business and management. Students will have the opportunity to develop their design thinking competence through application to real-world projects.

The following outcomes would be developed: applying design thinking strategies and concepts to real-world problems via reports, mini-tests and presentations; developing expertise in the framing and solution of real world problems using design thinking and show in reports, and presentations; developing expertise in the range of tools and methods used to solve such problems and demonstrate this in reports and presentations; communicating design thinking applied to a specific context in the public setting of a presentation. Assessment processes aim to group students to work on projects on campus initially, which will require combined human-oriented, service-scoped designerly outcomes. Milestones through the semester stage the process and feedback possibilities. Projects need to be undertaken by groups of students in on-campus locations, e.g., library, health service, bookshop, where human, space and product innovations are required. Propositions should embrace all issues and follow a process.
7. Discussion

Here it is claimed generally that a focus on applied, albeit wicked problems, requires a general informed eclecticism that is less concerned with abstract theoretical outcomes than practical user-oriented solutions (Rittel & Weber 1973). The development of program offerings includes an intellectual and practical review of ideas and resources in a way reminiscent of research through design. This has been the case with the development of design thinking at Swinburne.

Owen (2007) suggests that a number of questions remain to be answered about teaching design thinking. How long should the program be? Who are the best candidates for the program? What levels of experience and schooling should be required for entrance to the program? What is the ideal mix of design tools and thinking and tools and thinking from other fields to best prepare students for their working environment? What mix of academic and internship experience should be planned?

These questions continue to be relevant for the development and teaching for all programs. They are particularly relevant to designers and design schools embarking on an expansion of their programs in this direction. Answers to these questions will develop as further programs are developed and evaluation of such programs is provided. The pragmatic value of a theory is measured by its results and applications. As further evidence comes in about the scope, application and success of design thinking in other areas, so may we better judge the value of this ‘new deal’.
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Collective Intelligence and Design Thinking

Paul Murty
University of Sydney, Sydney, Australia

Mercedes Paulini
University of Sydney, Sydney, Australia

Mary Lou Maher
University of Sydney, Sydney, Australia

Abstract

Collective intelligence (or CI) has recently emerged as a potential magnifier of design thinking. A surge of internet-based social computing applications are achieving surprising results from people thinking collectively, without the aid or restrictions of formal organisation, supervision, or even payment in the conventional sense. Some well known applications, such as Threadless and Top Coder, involve design activity in different ways, suggesting that more ambitious applications are possible. We propose that applying CI to more varied and complex forms of designing will require greater understanding of both collective intelligence and design thinking and how these may be combined to best effect. This paper considers three questions whose resolution may lead to a more general understanding of design thinking through the lens of collective intelligence: 1) how existing CI applications contribute to design thinking; 2) requirements for Collective intelligence for designing (or CID); and 3) how to support design processes in a CID environment. We conclude that existing CI applications are already developing innovative ways of applying collective intelligence to designing, and that design activity in CID applications can be facilitated by structures and incentives that support self-organisation.

1. Introduction

Collective intelligence (or CI) is an emergent phenomenon that has long existed and evolved in human cultures. It can emerge spontaneously, or be induced, and develop in many forms and settings. Facilitated by Internet technology, CI has emerged as a powerful, economical, human resource. In drawing upon and representing the cognitive contributions of many people, CI offers a potential to magnify design cognition in ways analogous to a functioning brain, drawing upon many neurons.

In this paper, we use the term CI to refer to the phenomena associated with internet-based applications that allow anyone to contribute, in the spirit of the ideas described in “Here Comes Everybody” (Shirky 2009). Some of the best known internet based CI applications, (often referred to as crowdsourcing), including Wikipedia, Threadless and Top Coder, involve hundreds of thousands of participants interacting, collaborating, or competing with one another. The large numbers are indicators of popularity, success and processing scale, however numbers alone do not explain why or how these applications grew and now function so successfully. Many grew rapidly from modest beginnings. Significant bandwagon effects, evident now, came later. Success stems from the quality of, and personal gain from, the interaction, collaboration...
and competition, that people experience with one another and with the environment of the application.

New CI applications with fundamentally different approaches, literally new paradigms, are emerging continually. Therefore, the potential contribution of CI to designing and how to achieve it most effectively is a challenging, evolving topic.

In an earlier paper (Maher, Paulini & Murty 2010), we examined three dimensions of a conceptual space for computer-supported collective design: 1) representation: technologies that provide shared digital representations of the design artifact; 2) communication: technologies to support communication and collaboration; and 3) motivation: principles, incentives and structures that motivate designers and others to participate in collective design. Following an analysis of six CI applications the study found that successful CI attracts and facilitates participation from individuals who are intrinsically motivated to participate, for deeper personal reasons than financial reward, career or social advantage. An associated finding was that the wider the spectrum of motivational factors supported by the system, the more likely the application is to succeed and produce useful outputs.

This paper takes a step forward to consider issues and questions related to design thinking including: how existing CI applications contribute to design thinking; requirements for CID; and principles for organising a CI environment to support design processes.

2. How existing CI applications contribute to design thinking

Few systems based on CI occupy the design domain. However, CI has been successfully utilised for activities associated with designing, notably at the ideation and evaluation stages. We describe four: Threadless, Kasparov v Team World, Top Coder and Webcanvas.

Threadless is a web application that utilises crowdsourcing. Participants are encouraged to contribute T-shirt designs, which are voted for by the user community. The most popular designs are selected for manufacture. Voting results are made available to motivate and guide designers towards a winning design. Although no explicit collaboration occurs on the designs, Threadless supports a thriving community, with an engaged public discourse on the designs, which enables collaboration to occur among participants without prompting or guidance from the top down.

Threadless relies on its community at three key places in the design cycle. At the conceptualisation phase designs are generated by the community, for free. At the evaluation phase, the community votes for their favourite designs, providing the company with free market analysis. As a result of this kind of crowdsourcing, the community acts as designers, clients, and the potential market, ultimately purchasing the products.

Two activities commonly associated with designing are lateral thinking and problem-solving. A chess game requiring both was played over the Internet in 1999, between Gary Kasparov the reigning world chess champion at the time and Team World, a diverse assembly of five consulting chess champions, chess clubs distributed internationally, many thousands of amateur players and strong chess analysis software. Chess, with its clearly defined rules provides a highly structured environment, where participants need to assess various complex scenarios to choose the strongest move. Design strategies were invoked during game play to conceptualise solutions and problem-solve. The collaboration and internal competition of the community, coupled with the computed aggregation of their ideas, ensured that each move was formidable. One unprecedented strong move was made against Kasparov. Later, a breakdown in commu-
communication resulted in one uninformed move, ultimately leading to Kasparov’s victory. Kasparov later affirmed the significance of the game, stating: “The sheer number of ideas, the complexity, and the contribution it has made to chess make it the most important game ever played.”

Top Coder is an intriguing example of how a commercially successful website, combining crowdsourcing and competition can be applied across many aspects of a complex design process. Top Coder provides coding solutions to software design problems, which it presents to its community as individual design challenges. The ultimate product is typically a synthesis of individual solution modules. The site offers a choice of coding tasks and encourages coders to compete for prize money, status and the privileges of being a top coder. Incentives are designed to ensure individuals are motivated to participate, whatever their level of knowledge or experience. Detailed coder statistics and rankings are displayed. Support is provided in the forum pages, which also serve as a platform for socialising and distributing the group’s intelligence. Coders can also post a project for others to complete. The group is hierarchical and appears to embody graduated levels of collaboration. Coding is an ideal design task for CI, as it has clear inputs and outputs, a well-defined process in the middle, and results are quantifiable. A more recent venture by the group, Top Coder Studio, extends the Top Coder business model to logo design, web design, print design, and idea generation.

Webcanvas is a shared sketching application, comprising an online wall, on which people doodle. The wall has tremendous zooming capabilities, allowing small spaces to be enlarged and filled. Webcanvas has no business model. It aspires to be an ongoing collaborative artwork and a verification of the extent to which an open community can produce a work that is sympathetic and responsive to the individual efforts of its members. In a design scenario, open-ended shared representational tools like Webcanvas could host group sketching, supporting design analyses and conceptualisation. Webcanvas is an example of self-organising design activity with no direct attribution to individual designers. Technologies such as Webcanvas can lead to changes in the way a design task is approached and the kinds of discoveries that may be made.

Existing software applications can be appropriated as tools to support CI. Virtual worlds, online forums, and community sketching sites, originally created for different purposes, can be used in a more focused way for collaborative designing. Not all CI applications provide platforms for their communities. Some, like the I Love Bees project (McGonigal 2008), simply publish data in social networking sites and allow the community to find their own resources to support collaboration. Success for these systems relies heavily upon a deep understanding of the unique requirements of the target community, as well as flexibility and adaptive responsiveness to changing needs.

These systems generally, embody ways of utilising the attributes of collective intelligence to achieve key objectives in the design process (such as ideation and evaluation), within a variety of business models. Of equal importance is their ability to support individual interests and to maintain active communities, through effective incentives, thereby achieving stability and sustainability.

3. Requirements for CID

We propose that CID developers should draw upon knowledge of both: 1) requirements of computer support for designing, by individuals and groups; and 2) existing CI models. These areas contribute complementary models and support environments for collective design. In an earlier paper (Maher, Paulini & Murty 2010), we developed a conceptual space for understanding CI that includes three sets of requirements: communication, representation, and motivation. They characterize successful CI applications in terms of how internet technologies satisfy
these requirements as a guide for developing successful CID applications. In this paper, two additional requirements, guidance and self organisation are also introduced.

3.1 Communication

Effective communications, including shared representations across multiple platforms, play a key role in developing concepts and providing design commentary. CID applications need to be communication-rich and diverse, supporting both synchronous and asynchronous modes, direct, and indirect communications, multiple content types and high speed connections.

3.2 Representation

CID applications are more likely than individual or collaborative scenarios, to require multiple shared representations, to achieve a shared understanding and to support visualization, analysis and synthesis, among a large diverse population. Representation media includes voice, text, sketches, 2D or 3D models and immersive virtual environments.

3.3 Motivation

The success of collective intelligence applications relies on motivated people. It is important to invoke, build and reinforce motivation and also to not demotivate. Key motivating objectives are, to attract, welcome, intrigue, challenge, encourage and reward participation. Extrinsic motivators such as recognition, social opportunities, career and material rewards are also associated with many CI applications. However it is also likely and advantageous that many CI participants be influenced by intrinsic motivations such as ideology, challenge, or fun. Intrinsic motivation is valuable for its durability and its association with creativity (Csíkszentmihályi 1998). A likely general rule is that, for most advanced or most designerly applications, the more motivators the better.

3.4 Guidance

Guidance is both a motivator and a practical necessity. A variety of guidance modes are required, e.g., inform, orient, respond, elicit. User interfaces require flexibility, to match different levels of familiarity and use patterns, and to grow with the community.

3.5 Self-organisation

In any organisation, economies in performance and of scale can be achieved by controlled devolvement of micro-management to lower level participants. This is particularly true of CI applications. While they are typically controlled from the top, self-organisation is the predominant mode of management at the crowd scale. Achieving self organization appears to include two considerations: 1) individual and collective agency for low level tasks; and 2) negotiated collective agency for high level wholistic decisions. Opportunities to incorporate self organisation may be increased if higher levels of intrinsic motivation can be achieved.

4. Supporting design processes in a CID Environment

Studies of designers have identified that conceptual design settings, or situations which require design intervention, have common properties. They are characterised by ill-defined or wicked problems that are not soluble simply by collecting and synthesing information. Instead designing requires interpretation, or pre-structuring of situations. Design proceeds by a parallel or iterative counter-play, of conjecture and a variety of other acts, or processes, that precede and follow, in which solutions and problems tend to emerge and develop together. Often what is vital only becomes evident when designing takes place (Cross 1999). This dynamic has been variously interpreted by different theorists as argumentation (Rittel 1972), a negotiation (Lawson 1997), and a reflective conversation (Schön 1983). Darke (1979) observed that the conjectures
of expert designers were derived from particular ideas, interpretations, or pre-structures, she referred to as primary generators. For this discussion, designing is portrayed as a conjectural process in which conjectures emerge from generators, exploration or discoveries, and also actuate, generators, exploration and discovery, as shown in Figure 1.

![Design Conjecture model (Murty 2009)](image)

The quality of design from a CI application, like more conventional designing, may depend on successful facilitation of conjectural (generate and test) processes undertaken by individuals acting alone, or with others, subject to the properties or rules of the CI application structure.

4.1 Conjecture

Design conjecturing typically means putting forward a possible solution or approach which can be checked or tested against the design requirements. Conjectures may range from bold generalisations to tentative first thoughts. Testing methods and criteria may be the outcome of a similar conjectural process, conducted earlier or in parallel, with or without the capacity to “learn” from experience. In Threadless, designs are submitted as propositions by each designer. In Top Coder, a software task is decomposed into modules and coding propositions for each module are also put forward by individual coders. A CID system needs to provide an interactive environment which assists and motivates its user population to conceive, propose and evaluate conjectures.

4.2 Generator

A generator can be viewed as a particular class of conjecture which conceptualises a stage or aspect of a design or its situation, providing a basis for further conjectures. Darke (1979) proposes a key effect of a powerful “primary generator” is to reduce the range of possible solutions, thereby simplifying the problem. The designer of a housing project, for example, may propose a tower, row house or walk-up apartment configuration as the primary generator. Further understanding of the design can be gained from testing the generator, by deriving and testing further conjectures from it. The row house solution may be tested by generating two alternative site arrangements, such as building along the site contours or stepping across them.

4.3 Exploration

Exploring, in the context of designing, means investigating or searching requirements, potential design generators and conjectural solutions, in a developing design space. Design exploration typically involves a combination of physical and cognitive activities, such as modeling, analysing, experiencing, reflecting and discussing. Individual and group exploratory sessions in many design domains may involve sketching and verbal descriptions of alternatives. Given the situated nature of designing, one act may lead to and inform another in almost any order.

An individual engaged in designing, either solo or as a collaborator, perceiving the transactions of designing directly, may experience the succession of events with little difficulty; no less normal than driving in traffic perhaps. Frequently, collaborations involve people in mutually supportive roles, such as leader, note taker, assistant, etc. When managed well, this structuring
reduces the cognitive load and the workload per individual and improves coherence and predictability, enabling individuals to concentrate on what they do best and thereby achieve more.

As CID cannot replicate the directness and convenience of an organised group of colleagues, working together in the same room, a CID system needs to excel in other ways, by supporting multiple levels of parallel explorations. There may be thousands of participants exploring simultaneously, individually, in collaboration, or as part of a crowd-source. In addition the parallelism is multi-dimensional. There is duplication and there will be different start and end times and conditions, different subjects and different findings.

To produce coherent information which guides and motivates participants, from many separate processes, we propose that the CID system must be capable of supporting: 1) a broad range of shared representation types and alternatives; 2) interaction among participants, proposing and testing generators and conjectures; 3) reporting and dissemination of knowledge; and 4) self organisation and reorganisation. CID applications aiming to tackle more complex design tasks, than (say) Threadless and Top Coder, may require greater communication-richness and diversity than these limited applications.

4.4 Discovery

A discovery is typically an unexpected and novel experience. It may, for example, occur in the form of a new awareness, understanding, recognition or an idea. Individuals make discoveries in many unexpected places and ways, whether working alone or with others; and they make different kinds of discoveries. The significance of different kinds of discoveries, here, is not so much their features, but rather their effects in a design setting. In contrast to many CI applications, distributing many separate tasks among participants, design thinking can require a wholistic sensibility in addition to attention to detail. The effects of some discoveries may be relatively trivial, but a more revelatory experience, may go right to the core of a design. In complex CID applications, having many parallel processes, some form of status reporting may be useful to prompt and inform self-organisation.

5. Conclusions

Three aspects of CID have been considered in this paper:
- How existing CI applications contribute to design thinking;
- Requirements for CID; and
- Support for design processes in a CID environment.

The existing CI applications are revealing in different ways. Threadless began as a simple graphic design application. From it has emerged a thriving community engaged in public discourse, without explicit application support. Kasparov v Team World was not explicitly a design application but it involved many thousands of people in complex strategic thinking, aggregation of ideas and voluntary collaborations leading to at least one new powerful chess move. Top Coder provides solutions to software design problems, but commercial success has led to its recent entry into new design areas, unrelated to computer software. These few examples are sufficient to demonstrate a further important point, that an emerging collective intelligence is not limited by the scope envisaged when the application was created.

CID applications need to be communication-rich in order to facilitate interchange of information and development of concepts. Multiple, shared representations are required to achieve shared understanding and facilitate designing. Successful operation of CID requires an active motivated participant population. Both intrinsic and extrinsic motivators are advocated. We
propose that for advanced, designerly applications, the more forms of motivation supported, the greater the likelihood of success.

A CID environment needs to support iterative design processes, including conjecture, use of generators, exploration and discovery. It must also provide an interactive connective environment, which motivates its user population and facilitates simultaneous collective design processes. Successful undertakings, such as Wikipedia and Top Coder achieve remarkable successes in supporting numerous parallel participant processes. These two systems, while entirely different in many respects, have common features including: a strong central executive group (giving structure to new initiatives); explicitly expressed rule based organisation; welcoming culture; readily available guidance and training information; directions on how to do things (focusing on operational matters, rather than content); coherent sub-dividable tasks; permission to initiate tasks; few or no directions towards or away from particular tasks; and structured peer review or voting procedures. By these measures, the need for top down management is minimised and the concept of self-organisation is promoted.

Whether collective groups are more or less prone to problems associated with informal hierarchies and critical situations associated with collaborative groups (Badke-Schaub & Frankenberger 1999), is a topic of research in progress. One strength of crowdsourcing is that effects of unwanted inputs can be moderated by filtering controls, such as peer reviews and voting, and by large numbers of participants contributing. Problems at the top level, among off-line executives who may overrule the collective, are potentially more damaging for CI applications, than for more conventional collaborations, due to the greater importance of intrinsic motivation among the on-line participants. Transparency of communication across levels can minimise misapplied authority and help sustain necessary participant motivation. But ultimately, applications that fail to master the basics of CI, or lose that mastery, will not survive and many others, with better business models, will replace them.

Can CID really lead to new design thinking activities and strategies? We are confident of both prospects. There is supporting evidence already, in Top Coder and Threadless. Moreover, the presence of CI on the Internet is an instructive example of itself, in being a carrier of collective intelligence, about collective intelligence. The continuing emergence of new and diverse CI applications demonstrates an abundance of previously undiscovered ways of appreciating and applying the considerable intelligence, and willingness to think, of many people worldwide. Are new design thinking strategies possible in CID? Could cell phones do more than make calls? Be prepared for surprises as the technology of CID unfolds and evolves.
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Briefing and Reframing

Bec Paton
University of Technology Sydney, Sydney, Australia

Kees Dorst
University of Technology Sydney, Sydney, Australia
Eindhoven University of Technology, Eindhoven, The Netherlands

Abstract
The ability to reframe a problematic situation in new and interesting ways is widely seen as one of the key characteristics of design thinking, and as one that would lends itself to application beyond the traditional design professions. In this paper we study how experienced designers have professionalised the crucial art of frame communication and new frame adoption with their clients. During briefing, professional designers elicit a client’s frame, reframe it to be more workable and desirable, and reflect it back. The iterative exchange at the start of a project is loaded with framing and re-framing episodes.

In this study fifteen highly experienced visual communications designers were interviewed and asked about briefing activities for what they deemed to be ‘typical’ and ‘innovative’ projects. This yielded rich descriptions of strategies that these professional designers used to enable re-framing of the situation with non-designers, insights into possible difficulties and patterns of briefing practices.

The paper concludes with an overview of activities and strategies that help with framing and re-framing, as well as modes of communication that assist with sharing frames.

1. Introduction
The ability to reframe a problematic situation in new and interesting ways is widely seen as one of the key characteristics of design thinking (e.g., Cross 2006; Lawson 2006; Schön 1987; Schön 1995). It is surprising that apart from a few groundbreaking theoretical papers, there is very little design research literature on how this ‘framing’ actually works. And it is all the more surprising that the scant empirical evidence to be found in design research is often based on the study of design students, while framing is generally associated with higher levels of expertise (Akin 1990; Cross 2004; Lawson & Dorst 2009; Lloyd & Scott 1994).

Within a design context, framing is often seen as the key creative step that allows an original solution to be produced. Designers report on the need to get to ‘the problem behind the problem’ (as initially presented by the client), and about creating a ‘fresh perspective’.

The eighth Design Thinking Research Symposium (DTRS8) has concerned itself with interpreting design thinking for other disciplines, given that aspects of the way designers work and think have been popularised. The main reasons given for this clamour of interest, have been observations about the ability of designers to deal with complexity in innovative, appropriate and illuminating ways (e.g., Brown 2009; Martin 2009; Verganti 2009). If we consider ‘framing’ to be one of the characteristics of design that could lend itself to application beyond the traditional design professions, we need to study how experienced designers have professionalised the crucial art of framing and re-framing.
Within this paper, we have chosen to study the briefing processes that define design projects as a locus for framing and reframing activities, for two reasons: (1) this is where the framing and reframing strategies have to be employed quite explicitly, and where the results of the framing need to be made clear with the client; and, (2) this allows us to study the strategies designers have developed for reframing the problem as it is initially presented by the client. This second reason is particularly important against the background of our overall goal for DTRS8 to introduce framing and reframing activities into non-design domains, as it will provide us with insight on how professional designers deal with framing and reframing while working closely with non-designers.

1.1 Framing

Framing is not a concept that is unique to design theory. The idea of a frame was initially articulated in the field of artificial intelligence (McCarthy & Hayes 1969; Minsky 1975; Sandewall 1972), where, when the view of the present problem was changed or a new situation encountered, a cognitive structure called a 'frame' was selected from memory and adapted to fit reality by changing details as necessary. The idea was based on the idea of 'schema' by Bartlett (1967) and 'paradigms' by Kuhn (1970). This idea was taken up in philosophy (e.g., Denett 1978; Fodor 1983). The idea of framing can also be found in fields diverse as economics (e.g., Tversky & Kahneman 1986), cognitive psychology (e.g., Bateson 1972; Kahneman & Tversky 1984), linguistics and discourse analysis (e.g., Minsky 1983; Tannen 1985, 1986; Tannen 1993; van Dijk 1977), communication and media studies (e.g., Entman 1993; Pan & Kosicki 1993; Scheufele 1999), science and policy studies (e.g., Schön 1994; Triandafyllidou & Fotiou 1998), and most extensively in sociology (e.g., Benford & Snow 2000; Fisher 1998; Goffman 1974; Kaufman, Elliott & Shmueli 2003; Oliver & Johnston 2000; Sherkat 1998; Steinberg 1998; Williams 2000).

It is interesting to observe that there appears to be two distinct ways of defining a frame in this literature—as a product of mental knowledge and meaning structures, (particularly the cognitivist approaches to defining frames, with mind at the centre of things), or as a product of social symbolic structures, (consistent with textualist approaches to defining frames, where discourse is the basic unit) (Reckwitz 2002).

Deborah Tannen has argued that the terms ‘knowledge structure schema’ and ‘interactive frames’ are more helpful as a way to combat this duality in understanding frames. For Tannen, ‘knowledge structure schemas’ are “expectations based on prior experience about objects, events and settings”, whereas ‘interactive frames’ are “a superordinate definition of what is being done by talk, what activity is being engaged in, how a speaker means what s/he says”. Although both are in the mind, interaction frames are more palpably in the interaction (1986).

To be clear, in this paper, we will take the term ‘frame’ to be equivalent to this definition of ‘knowledge structure schema’ and ‘framing’ to be equivalent to this definition of ‘interactive frames’. Given the context for this study, ‘reframing’ will refer to building a new frame for oneself, based on changing one’s view due to briefing interactions, (although it is acknowledged that reframing can also occur as a result of reflection).

Each party in a design situation holds their own ‘frame’. In order to interact with others, each party must have a mental model of the area of interest so that they can begin their exchange. Nelson and Stolterman talk about the initial frame for clients in terms of ‘desiderata’, the initial conception hoping to gain expression (2003, pp. 48–51). In Darke’s extrapolation of Hiller, Musgrove and O’Sullivan’s ‘conjecture–analysis’ model of the design process (1972), the ‘primary generator’ informs the designer’s initial ‘frame’ and gives deeper insight into how designers pre-structure a situation (Darke 1979). From a more recent study, “both designers’ and their customers’ perceptions of what is appropriate and admirable, as well as what is possible, are shaped by their own experiences of similar artifacts” (Eckert, Stacey & Clarkson 2004, p. 1).

These expectations contribute to each party’s ‘frame’, which not only consists of a way of seeing or representing a situation, but is also suggestive of ways to move or interpret relative to this. Frames not only simplify and create alternative views of a problematic situation, they also evoke particular outcome spaces that afford a range of responses. The key aspect for a successful frame is that an outcome is possible.

At the fuzzy front end of a project during briefing, ‘framing’ takes place between the designer and client, where a designer’s professional knowledge, including schemata, guiding principles, recognition and gambits (Lawson 2004) will inform the way they attempt to reframe the situation. Additionally, the client will be intent on framing the situation, based on their often more expert knowledge about the nature of the problem space, as well as their experience with encountered design solution types. They may well have framed the situation but be unaware that frames can change.

1.2 Briefing

Whilst the idea of a brief as a starting point for projects is widely accepted, the activities associated with the creation of a brief and the negotiations for its redefinition are not often examined. From the initial expression of the project by the client, (which can be in written or verbal form, and can be detailed or fuzzy), there is a set of interactions that take place in order to come to a mutual understanding of how the project will unfold. The aim of briefing, then, is to reframe both the client’s and designer’s preliminary appreciations of the situation in order to create an actionable view of the project for both parties. This includes: a desired end state or goal; prioritisation and selection of relevant features; problem scope, solution scope and resource constraints; and projected value (Hey, Joyce & Beckman 2007).

Given our definitions based on Tannen’s work (1986), ‘framing’ can be seen to be the sharing and clarification of each party’s ‘frame’ and ‘reframing’ can be seen to be how frames are changed as a result of social interaction. An accepted brief can be seen to be a frame that is understood and agreed upon such that the designer’s and client’s frames overlap or align to a certain extent.

The iterative exchange at the start of the project is loaded with framing and reframing episodes. By studying this locus of activity, we are able to learn about designerly framing and reframing, without the generative aspects of design being the focus.

1.3 Field of Study: Visual communication

Visual communication as a discipline includes graphic design, web design, illustration and emergent activities such as experiential environmental installations (Box 2007, p. 4). According to Frascara, “The visual communication designer works on the interpretation, organisation and visual presentation of messages” (2004, p. 3). Rather than image-making alone, visual communications designers graft word and image to create hybrid texts (Jobling & Crowley 1996, p. 3). Poyner encapsulates the content and knowledge aspect of visual communication,
accentuating that these designers, “... develop a sphere of knowledge and expertise, select a subject, conduct research, gather material, then create an appropriate final form, using all the resources of design, both worlds and images, to communicate the story or argument” (2001, p. 187).

Given that the majority of visual communications projects occur with non-designers as clients, in either private or public sector organisations of varying magnitudes, we are able to look at framing in these contexts and discover barriers that the designers encounter interacting with these non-designers on projects.

1.4 Research Questions

In this study we focus not on the question where design frames come from, but on how designers reframe beyond the initial frame as presented by the client—that is: ensure that new frames can be adopted in a problematic situation. The two research questions we are exploring in this paper are therefore:
1. How do expert designers experience framing as a socially situated practice?
2. What are the patterns of variation for different experiences of framing?

2. Research Method

2.1 Phenomenographic Approach

In order to understand how designers have professionalised new frame communication and adoption during briefing, we need to ascertain the range of experiences designers have had with their clients and what the critical components of variation are. Phenomenography [1] is well suited to studying the conceptions that expert designers have of briefing and reframing in professional practice, since phenomenography reveals the different ways people experience the same phenomenon and characterises that particular conception in terms of the variation in critical aspects discerned. Key to understanding phenomenography is that “its epistemological stance is grounded in the principle of intentionality”. Cognition is not seen as dualistic, since experience is viewed as an internal relationship between people and the world (Ming Fai 2003, p. p. 145). Given the backdrop of our interest in looking at briefing as a situated practice, and that frames (as we have articulated them presently) are similarly non-dualistic, phenomenography was chosen for this research.

Phenomenography looks at a particular phenomenon from a second-order perspective, where a first-order perspective looks at the world and makes statements about it, and a second-order perspective looks at people’s ideas or experiences of the world and makes statements about them. First- and second-order perspectives are considered complementary views (Marton 1981). There is an assumption that there are limited number of ways of experiencing reality, so for phenomenography, describing the pattern of these variations is the main aim. Varying experiences of a phenomenon do need to be accounted for in language, so the outcome of the inquiry is logically and hierarchically interrelated categories of description, where a conception is characterised by the intertwined “referential aspect—i.e., a particular meaning of an individual object (anything delimited and attended to by subjects)—and a structural aspect—i.e., the combination of features discerned and focused upon by the subject)” (Marton & Wing Yan 2005, p. p. 336).

One critique of phenomenography is its claim to identify ‘ways of experiencing’, and that it is more likely that the data can be understood as “indicative of accounting practices—ways of talking and reasoning ... and that the experiential accounts given by individuals are grounded in discursive patterns” (Säljö 1997). Even if this is so, (and there are good arguments against this, especially from the grandfather of phenomenography, Ference Marton (1995)), this
would mean that phenomenography looks at the formative and social nature of language that surrounds particular human practices and how people learn to mean in those practices (Giorgi 1966, 1975a, 1975b; Schultz 1967; Schultz & Luckmann 1973). This is a good start for understanding how experts frame with clients during briefing!

Another critique has been levelled at the hierarchical structure of the categories of description—that there is the presumption of a definite structure; and, that the meaning of such a structure, since hierarchical, assigns the highest category more value than the lowest, based on some ‘authorised conception’ (Ashworth & Lucas 1998). For this paper, the hierarchy has been established based on the level of framing activity between client and designer. We acknowledge that the categories could be interrelated in another way if the same data was used with a different focus, however, looking at designers’ levels of framing experienced during briefing will give us critical components of variation for understandings of framing.

2.2 Data Collection

Phenomenographic data is most frequently collected through in-depth, semi-structured interviews. The idea is that there is a productive interaction between the interviewer and interviewee, where experiences and understandings of the topic are jointly construed (Marton 1994).

Initially, semi-structured pre-research interviews were conducted with three expert designers and one account manager. Based on this, the research questions and the interview design were refined so as to achieve greater empathy towards the designers’ lived experiences, and better bracketing of the researcher’s preconceived ideas about: importing earlier research findings; assuming theoretical structures or particular interpretations; presupposing the researchers’ personal knowledge and belief; and, researcher concerns to uncover causal aspects, (which are not the objective of phenomenography) (Ashworth & Lucas 2000). These aspects of bracketing were held in mind both for the interview process and the analysis stages.

Fifteen highly experienced (with a minimum of eight years professional experience) visual communications designers were then interviewed for an hour to an hour-and-a-half. Some example questions are:

- Can you tell me about a ‘typical’ project you’ve experienced as a designer?
- Can you tell me about an ‘innovative’ project you’ve experienced as a designer?
- What do you think your client perceives your role to be during briefing?
- Can you give an example of a project where you have changed this understanding?

When asked about ‘typical’ and innovative’ projects, the designers essentially had to define their conception of the difference between the two in order to answer the question.

There was a conscious attempt to interview designers with seemingly strong abilities to reframe with clients. This appraisal was based on the degree of innovation shown in the formulation of projects, as evidenced by innovative design outcomes. The designers worked in small to medium visual communications studios of two to fifteen practitioners and worked predominantly on commercial projects for small to large clients. Small clients were often small businesses (of one to ten people) in a wide range of industries. In these situations, the designers were usually directly liaising with the business owner. Larger clients were either large companies or government departments (of ten to hundreds of people). In these situations, the designer usually dealt with someone from marketing or middle management who was responsible for the particular project.

This study is part of a larger project currently in progress. The findings offered are a preliminary exposition of outcomes based on a subset of the data. The data set that has been used is extensive (5 hours of transcribed audio).
2.3 Data Analysis

We followed the recommendation that for good phenomenographic practice, the interviewer do the transcription, to move from interaction to analysis (Dortins 2002).

For this paper, sections of data that related to reframing on projects were isolated from the transcripts for phenomenographic analysis. Analysis of the transcripts started very generally, looking for emergent descriptions of experiences and modifying the categorical descriptions to encapsulate sets of experiences articulated by different designers. The process was iterative, and the meaning of categories stabilised over several iterations. In terms of reliability, it is recommended that rather that the traditional approach of using ‘inter-judge reliability’ to validate data, (which has issues with procedural fidelity to interviewee conceptions and gives rise to methodological and theoretical inconsistencies within phenomenography), reliability be established as interpretive awareness, maintained through the reduction during analysis (Sandberg 1997). Both researchers were involved in discussing and validating the descriptions of the stabilised categories, comparing these with the data until agreement was reached.

We report on the sections of data analysed for this paper. We expect that once the study is complete, the conceptual framework we have identified here will be further refined and more detailed in its expositions. Additionally, the practice of briefing, as experienced by expert designers, will be reported on more comprehensively.

3. Results

3.1 Briefing as a Professional Phenomenon

In order to understand what designers consider ‘briefing’ as a particular professional phenomenon to be, we asked the designers about how projects start in their practice and about the content of briefing conversations.

In all cases, the designers saw briefing as a process of negotiation with the client—to define a ‘vision’ (mutually shared understanding) of what the project would be, an approach, and a shared appreciation of value to be achieved. The designers talked about multiple conversations with clients, briefing and re-briefing documents, and in some cases, aspects of the brief still being formulated once generative work began, indicative of highly iterative project formulation in those cases.

3.2 Briefing Modes

We asked each designer about what they perceived their role to be during briefing, as well as what they thought their clients perceived their role to be. We supplemented this by asking for concrete examples of good and bad briefing experiences that they’d had. All of the designers interviewed took a comparative approach to answering this line of questioning, outlining a number of ways of experiencing their role during briefing, and giving concrete example projects.

Category 1: Technician

The least favoured mode was where the designer was given a solidly defined brief and was expected to carry this out, only questioning to clarify particular aspects. For such situations, the client is accepted as knowing exactly what is needed, which the designer then carries out for them. The designer is brought in at the end of the project’s formulation.

An oft cited example of this was following brand guidelines to produce a document, with text and images supplied—mostly experienced when dealing with middle-management or market-
ing professionals. In these cases, the client solely frames the project with little to no negotiation about the problem or solution spaces with the designer.

**Category 2: Facilitator**

For the given situation, the client is accepted as knowing what they need but not what is required to achieve it completely. In this case, the designer advises on specialist aspects relating to making the solution space workable. The designer is brought in to the project near the end of its formulation.

Examples given of such a mode of practice were: designing a website where the functionality and content were specified but an overall way of integrating the elements visually and technically was needed from the designer; or, designing a book cover where the concept for the cover was mostly conceived but not visualised. In these cases, the client is largely responsible for framing the project but the designer is required to have input into the solution space, thus shifting the framing of the project relative to this. This was also viewed as an undesirable mode of practice.

**Category 3a & 3b: Expert/Artist**

A much more favorable case that was identified from the designers’ experiences, was where the client came with a partially formed idea of what they needed and the designer was required to use their expertise to negotiate a formulation of the brief that was workable with them. In these situations, the client is accepted as knowing what they need and the designer is responsible for framing the project with them to achieve a workable outcome. The designer is brought in midway through the project’s formulation.

The typical example given for this mode was where the client required branding or a logomark, and provided information about the business so that the designer could come up with a visual language to communicate this on their behalf, (3a). A special case of this mode was when the designer worked in an ‘artist’ mode—where the aim of the project was given by the client but the designer was free to frame the project in line with their ‘style’, particularly for largely image-based communications such as posters or music packaging, (3b). In these cases, while the client defines what the problem is, the way it is framed, (in terms of the solution space), is largely formulated by the designer.

**Category 4: Collaborator**

In all cases but one, the designers related the experience of working as a collaborator on projects from almost the beginning of its conception, as being the most desirable mode for project formulation. In these situations, both the client and the designer mutually worked on framing the project, both in terms of problem and solution spaces.

The examples of these projects were the most diverse, including interactive environments, experiential design, websites and branding systems. In these cases, the exchanges between client and designer were highly iterative, transparent and playful.

### 3.3 ‘Typical’ vs. ‘Innovative’ Projects

We asked the designers for examples of both ‘typical’ and ‘innovative’ projects in order to discern what the difference was to them. Each designer needed to define what ‘typical’ and ‘innovative’ meant, in terms of their practice. Once again, a clear hierarchy emerged.

Typical projects were defined as being either projects where they were behaving as a ‘technician’ or ‘facilitator’. These projects were seen as only requiring a sub-set of their expertise,
routinised and uneventful. They often occurred for repeat projects, as a roll-out of a larger project for a different application, or where the client was resistant to engaging with the designer’s expertise. Here, the designer was only able to elicit a client’s frame but not reframe. Essentially, the problem as given needed to be solved, indicative of a ‘rational-problem-solving’ mental model of design.

The designers reported on examples where they felt the need to challenge the client’s treatment of the project as such a problem-solving exercise. In cases where it became apparent that reframing was not possible in such a situation before work commenced, it is common for a designer to choose not to work on the project—to ‘walk’. If it emerged during the project that this was the case, generally the designer complied with the problem-solving request and completed the project, (although they often said that they haven’t taken further work from that particular client). “We’ve turned down projects because we can kind-of see the way they will go” (Designer_D 2010) [2].

Innovative projects were defined as being either projects where they were behaving as an ‘expert’, ‘artist’ or ‘collaborator’. In these situations, the designer was engaged in framing with the client in light of some problematic situation. Examples included changing the form that the design should take (e.g., from a website to an interactive experience), making salient or introducing the client to previously unconsidered approaches (e.g., creating a visual language that communicated the integrity of activities, rather than traditional marketing approaches to promotion), and being engaged in research on behalf and with the client to reframe the situation (e.g., user-centered design techniques revealing the situation, rather than conforming to a list of functional requirements).

In light of these elaborations, the briefing modes gain deeper significance, since it becomes clear that the given form, value/intent, content, and style (in the Bourdiesian sense) (Bourdieu. 1984 [1979]) are modifiers of a frame in visual communication.

3.4 Changing Frames

We asked the designers for examples where they negotiated to change the brief as given, in order to make the project more successful. Often designers described how the project’s formulation changed in terms of the outcome but rarely explained how they negotiated the change with the client. Probing questions were used to elicit the way they managed to reframe in these cases.

We find from the interview data that one clear way that designers manage to get clients out of a problem-solving mentality and then, to adopt new frames is through abstraction. Highlighting the uncertainty that surrounds a future context assists with steering conjectured ideas away from specific outcomes to deeper situational values. In this study so far, the use of metaphor and analogy, contextual engagement and conjecture, were three ways designers destructured [3] the situation with clients to allow for reframing.

Examples of metaphor and analogy given by the designers included both visual and verbal forms.

One example of an activity designers use to do this visually is mood board discussions. These are capable of creating more objectified conversation about a project, as the project is abstracted through both metaphor and analogy. This abstraction allows the designer to highlight desirable aspects for the outcome that may not have been a part of the initial frame, or at least held as much value in the way the client was initially framing the situation. “We create a mood board, which generally tackles a design brief, but not specifically. And that’s usually quite good because people find it easier to talk about unrelated things. And you both get a sense of what needs to be done” (Designer_D 2010).
An example of verbal abstraction can be seen through this designer’s analogy to ‘tone’:

It’s really easy to talk about physical things—graspable things—but tone is something that’s just really hard to grasp. And it’s the most important factor for me—it’s the thing that people read without reading. Even if they don’t read a single word of a document, they just pick up the tone of it—the feel of it. … So, we talk a lot about tone and try to get them into that headspace as to what tone can do (Designer_C 2009).

‘Tone’ relates to projected value, intention or quality. By conversing about tone, the designer is abstracting from a presupposed outcome, to talking about the values and qualities a desirable frame might have. This facilitates the adoption of new frames by creating awareness of desirable and workable attributes.

In order to objectify and create a mutually agreed, shared frame for a project, the interviewees all cited contextual engagement through questioning and exploring the situation with the client. There is a sense that the interviewees were curious to find out about the client’s world and incorporate that into the situation being framed. The contextual exploration is an exchange that shifts both the client and designer’s preconception.

So we’re really trying to get everything—that’s the ‘desk research’ phase. That’s so we don’t re-invent the wheel, or we don’t miss out on an opportunity that exists already from their content. It also helps us plan the workshop, because we were immersed enough to think about how the workshop should run—how it should be different (Designer_B 2009).

This example indicates that contextual immersion is not only to learn about the situation, but also to strategically understand how to create meaningful modes of interaction and helpful activities to facilitate reframing with the particular client (uncovering opportunities for the workshop). The contextually designed workshop would facilitate leaps through co-exploration of the situation—some leading the client to new frames, and others openly exploring the situation with the client to learn things that could produce new frames for the designer too.

Reframing (for both parties) was assisted by co-exploring abstracted, conjectured views of the situation—including areas of uncertainty. Multiple conjectures were often posed and were kept rough in description and/or sketching. Far-fetched or recognisable, the designers saw this as a way to ‘loosen’ fixation on a particular outcome.

3.5 Language Co-Creation

From the interview data, it became clear that the dynamics of conversation and the language that was evolved with clients was important to allow for new frame communication and for gaining acceptance on these new frames. In this study, the use of engineering a dialogical approach, using a context specific language framework and asking leading questions, were the three ways designers destructured the situation through language co-creation.

Every designer interviewed used the spatial metaphor of ‘a journey’, which implies a dialogical mode of interaction. A dialogical approach uses question and response as well as representation and reflected re-representation to create a shared horizon of understanding (Coyne & Snodgrass 1997).

And I always insist on starting with a meeting. … I can’t imagine ever hiring anyone to do almost anything for me without speaking to them! So, immediately I’m on guard when someone just emails and says, “Can you email me a quote?” I immediately think, “This isn’t someone that I’m going to be able to work with.” So, then at that point I’ll
just call them and try to start a conversation, (a dialogue), which can be difficult. (Designer_C 2009).

It is clear here, that the designer is recognising that it is prohibitively difficult to get the client to adopt new frames without dialogue. Additionally, all of the designers expressed that decision-makers need to be a part of the dialogical framing stages so that they too, adopt the new frame. "If you include them in that really casual way, and you can be conversational about these projects, they usually have a massive influence on what you do. And they hold the key to what will make you make the decision one way or another" (Designer_C 2009).

Imposing a language framework that has a specific and limiting agenda is unhelpful to communicate new frames. Clichés, jargon and buzzwords are key examples of this. The problem is that there are ‘default’ (Designer_E 2010) ways of thinking tied up in these culturally specific structures, whereas framing really needs to be explorative and interactively co-created, and needs a language that supports this. Such a language has to be iteratively co-created through dialogic questioning and answering. The key to understanding how to communicate new frames is by regular conversational interaction. Not only does this clarify meaning and intention more deeply, instinctively and fluidly, but also it allows for a shared language to evolve through ‘play’.

Clients can be close to what they are doing and the problem that they present may well need to be loosened up in order for reframing to take place. By asking good, targeted and leading questions, the client’s initial frame can be destructured such that it is possible for new frames to be adopted:

One of the things with meeting with a client and starting on a project is asking the right questions to get the right information ... because they’ll just sit down and tell you a lot of data. And it’s very data driven but I’ll often ask people, “Who do you think you are? How do you see yourself? How do you see your business? And how do you want to see your business? How do you want people to feel about you? And how do you actually behave? How would you like to behave? Would you behave differently?” (Designer_C 2009).

When the designer is talking about using questions to move away from the data focus, they are facilitating reframing by ‘revealing’ the situation in a different way through questions. In this example, the designer is trying to get the client to reframe in terms of value, identity and behaviour. These questions are highly strategic, aimed to divulge more desirable and workable features that a better frame may have. They are directional and intentional in character.

A co-created language also creates a level of trust that supports reframing. It was found from the interviews that a shared language with clients, built up over projects, was highlighted as a significant strategy for reframing.

4. Discussion

The briefing modes, ‘technician’, ‘facilitator’, ‘expert/artist’ and ‘collaborator’, translate into a hierarchy based on: the point of entry into the project; the designer’s involvement in the problem and solution space formulations; and, the level of iteration in the briefing process (see Table 1). Higher levels in the hierarchy are associated with a greater ability for the designer to reframe with the client during briefing.
Table 1: Briefing modes and ability to reframe during briefing

<table>
<thead>
<tr>
<th>Mode</th>
<th>Point of Entry to Project</th>
<th>Involvement in Problem Space Formulation</th>
<th>Involvement in Solution Space Formulation</th>
<th>Level of Iteration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technician</td>
<td>End of planning</td>
<td>No</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Facilitator</td>
<td>Near end of planning</td>
<td>No</td>
<td>Partial</td>
<td>Low</td>
</tr>
<tr>
<td>Expert/Artist</td>
<td>Mid-planning</td>
<td>Partial</td>
<td>Yes</td>
<td>Med</td>
</tr>
<tr>
<td>Collaborator</td>
<td>Beginning of planning</td>
<td>Yes</td>
<td>Yes</td>
<td>High</td>
</tr>
</tbody>
</table>

This outcome space is reminiscent of the model of service by Nelson and Stolterman (2003, pp. 56–59), with five distinct categories, hierarchically related. The major differences for our findings are: the order of the categories (which are based on increasing opportunities for the designer to reframe the problem as given, whereas it is unclear how Nelson and Stolterman identified their hierarchy); the names attributed to the modes; and, that we were able to identify critical components of variation between the categories of description. Reframing is best achieved with earlier entry into the project with the client, and co-evolution (Dorst & Cross 2001) of the problem and solution spaces during briefing as a highly iterative exploration of the design situation with the client.

There have been two dominant paradigms used to describe design thinking: ‘rational problem-solving’, as expounded by Herbert Simon; and ‘reflection-in-action’, as set forth by Donald Schön (Dorst & Dijkhuis 1995; Schön 1995; Simon 1984). It was clear from the interviewees that during the briefing process, rational problem-solving approaches were not apparent from the designers’ perspective and in fact, the designers deliberately and strategically acted to facilitate reflection-in-action approaches with their clients, when observing a problem-solving mental model of design. Higher briefing modes were indicative of a reflection-in-action paradigm of design.

The clear difference between typical and innovative projects was whether the project, (as initially presented by the client), was able to be reframed during briefing. Modifiers of a frame were the project’s given form, value/intent, content, and style. If a frame is created through a process of abductive reasoning (Dorst 2010), then it can be seen that the ‘what’ is the given form and content, the ‘how’ is the approach and style, and the ‘value’ is the value/intent (see Figure 1). It should be noted that style could also easily be a component of the ‘value’ aspect of a frame (see Stacey 2006), however, given the way designers were talking about it, style was more reminiscent of an approach.

![Figure 1: Modifiers of a frame](image-url)
The significant barriers to reframing, as experienced by the designers were: fixation [4] by the client on their initial idea for the project; a problem-solving mental model of design; and, resistance to journey. Abstracting from a client’s currently held frame is a significant way in which designers destructure a situation so that new frames can be communicated and adopted. The strategies given by designers to achieve this were: the use of metaphor and analogy [5]; contextual engagement through research [6]; and, conjecture, where reframing was assisted by co-exploring the abstracted conjectured view of the situation (see Figure 2).

**Figure 2:** Barriers and enablers to reframing during briefing.

Language co-creation that is capable of communicating new frames and facilitating reframing thinking frameworks, includes strategies such as: engineering a dialogical approach; using a context-specific language framework; and, using leading questions to facilitate ‘leaps’.

### 5. Conclusion

Reframing during briefing has the goal that both parties negotiate a mutually apprehended frame so that the project can progress. We have seen that designers strategically and actively modify and gain acceptance on more desirable and more workable frames with their clients during the briefing process.
Other disciplines wishing to employ the framing aspect of design thinking can learn from the ways designers have professionalised the reframing with non-designers. It is essential to discontinue viewing the situation as a problem-solving exercise, deconstruct presuppositions, and create dialogical ways of interacting with stakeholders and the situation. Activities that support new frames being adopted tend to abstract from the situation to allow for objectified exploration of the context. Successful communication of new frames is only possible by co-creating a language through the hermeneutic process of gaining common understanding. These preliminary findings make helpful inroads into understanding framing and reframing during briefing. A more full understanding will be obtained, once the study is completed.

Acknowledgements

The authors would like to thank Dr. Sally McLaughlin for her insightful feedback on this paper. Additionally, we would like to thank the reviewers for their careful critique. Finally, we wish to thank the designer-interviewees for their time and sharing their expertise with us.

Notes

1. Phenomenography is an empirically derived qualitative research methodology, which was developed at the University of Göteborg, Sweden, in the mid-seventies to investigate the qualitatively different ways in which people experience a certain phenomenon (Dahlgren 1975; Marton 1974; Säljö 1975; Svensson 1976). It has been used primarily in educational research to study conceptions of learning (Marton, Dall'Alba & Beaty 1993; Pramling 1983; Säljö 1982), and particular educational subjects (Lybeck 1981; Lybeck et al. 1982; Neuman 1987; Renström 1998), but has also been used to study conceptions of death (Wenestam 1982), conceptions of political power (Theman 1983), Nobel laureate views on intuition (Marton, Fensham & Chaiklin 1994), and recently conceptions of being a designer, design across disciplines and sustainable design (Adams et al. 1999; Adams et al. 2010; Daly 2008, 2009; Daly, Mann & Adams 2008; Mann, Radcliffe & Dall’Alba 2007a, 2007b).

2. Interviewees have been de-identified for the purposes of publication.

3. The designer will actively try to ‘destructure’ (Hekkert, Mostert & Stompff 2003) the frame in order to allow for adoption of new frames, if the initial frame stated by the client is deemed to be unworkable or unnecessarily limiting.

4. Fixation has been described in terms of designers’ during conceptual phases, however, not for clients (e.g., Jansson & Smith 1991; Purcell & Gero 1996; Youmans 2010).

5. Metaphors are an intuitive structure that can be useful to harness a client’s physical and social experience to provide understanding of less familiar ideas (Hey 2007; Lakoff & Johnson 1980). Analogy is a key way that designers have been found to creatively describe and generate new frames (Caskin & Goldschmidt 1999; Cross 1997; Dorst 2006a). It turns out that this is not just something they do themselves, but something they share with clients to allow for reframing.

6. One of the biggest barriers to getting clients into the framing mindset, (rather than problem-solving), is the strength of prejudice in their presupposition (fixation). Contextual engagement activities are a powerful way to help make this shift and also to clarify each party’s individually held frame (Hey, Joyce & Beckman 2007).
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**Design Process:** Similarities and Differences

**Vesna Popovic**  
School of Design, QUT, Brisbane, Australia

**Ben Kraal**  
School of Design, QUT, Brisbane, Australia

**Abstract**

The research is based on studying the early stage of the design process. It aims to identify differences in design approaches across two design domains. The research is based on the analysis of the observational data from the conceptual stage of (i) product and (ii) software design process. The activities captured from the analysis of the design process are utilized to outline similarities and differences across the two domains. This will contribute to a better understanding of the connections between, and integration of, design process variables, and to a better understanding of design expertise transfer to other domain (e.g., science or nursing).

**1. Introduction**

This research is a further development of work related to the study of strategic knowledge interaction with domain-specific knowledge during the early (conceptual) stage of the design process (Popovic 2004). The exploratory study presented here compares the design process of two different domains—product and software design. The main thrust of this paper is on the identification of similarities and differences within the design process within and between the domains. Two empirical studies were developed based on earlier work of product design process (section 3) and software design process (section 4). This paper will illustrate the findings based on observational data analysis.

**2. Observational analysis and coding scheme**

The analysis of the observational data on how the designers worked was conducted on a macro level for which a coding scheme was developed (Table 1). The coding schemes applied evolved during the analysis of the activity of each team and were identical for all teams. Noldus Observer (2009) was used to assist in the analysis of observational data. The observational analyses encompass eight codes: (i) problem exploration, (ii) market search, (iii) documenting, (iv) sketching, (v) exemplar, (vi) model details, (vii) story/narrative, (viii) UI Details. The observational data codes are summarised in Table 1 and are explained as follows:

- **Problem exploration:** The problem exploration code refers to the product/software designers’ approach to defining/exploring the problem in order to understand the various possibilities within the project. They tried to understand the project by decomposing the constraints into smaller ‘chunks’. The problem exploration occurred concurrently with the other activities for example, exploring the market, sketching or applying an exemplar or explaining how data flowed in the model by telling the story.

- **Market search:** The designers were searching for similar products already available on the market. This is a common approach within the product design practice. The designers aimed to assure that the design they propose will have competitive advantage in the market place.
Table 1. Product/software design coding scheme (observational data)

<table>
<thead>
<tr>
<th>Codes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Exploration</td>
<td>Understanding the problem and solution outcomes. Designers' approach to defining/exploring the problem in order to understand the problem and how to represent it; understanding the meaning behind the abstraction.</td>
</tr>
<tr>
<td>Market Search</td>
<td>Looking for similar products on the market.</td>
</tr>
<tr>
<td>Documenting</td>
<td>Silently documenting relevant points to help them understanding the problem.</td>
</tr>
<tr>
<td>Sketching</td>
<td>Sketching ideas.</td>
</tr>
<tr>
<td>Exemplar/Precedent</td>
<td>Reference to a previous design solution or experience.</td>
</tr>
<tr>
<td>Story/Narrative</td>
<td>Designers telling a narrative story about an aspect of their design.</td>
</tr>
<tr>
<td>UI Details</td>
<td>User Interface (UI) consideration.</td>
</tr>
</tbody>
</table>

- Documenting: The product designers were silently documenting relevant points from the Internet search or making notes in reference to brief to help them understanding the task. The documenting code by software designers is used when one designer is using the whiteboard silently, usually after a discussion, to document the outcome of the discussion. When the documenting code overlaps with another code, one designer is documenting while the other designer's behaviour is captured in the overlapped code.

- Sketching: Sketching ideas played a significant part of the product design process. The designers used sketches to communicate design concepts and product details to each other. The designers used words, images and shapes to communicate concepts and represent the understanding of the physical world of artifacts.

- Exemplar: During the design process designers refer to an exemplar or precedent. In design practice previous experience or design solutions are represented, stored, retrieved in various ways. When this experience is related to physical products it is called design precedent or exemplar.

- Model Details: The model details code refers to the objects that designers grouped or regrouped into sub-models. For example: *So basically intersection is going to say to this road, you know R1, R2, R3, R4. The intersection is going to say, okay my light is green, R1...(Male 1, Team 3).*

- Story: The story code is used when the software designers tell a narrative story about an aspect of their design. For example: *Right, so tick happens and changes time, cop is watching time, for each tick cop has some set of rules...(Male 2, Team 1).* If the story code is used in conjunction with the model code, the designers are narrating how data flows through the model or are telling a story with the model in order to verify that the model reflects the world as they understand it. If the story coded interacts with the UI (User Interface) code, the designers are telling a story about the use of the user interface. When the story code is used at the same time as the problem exploration code, the designers are narrating an experience that helps them understand the problem. This might also trigger new requirements.
UI Details: The UI (User Interface) details code refers to the user interface (UI) details where software designers considered the interface and user interaction during the design process. This might occur concurrently during problem exploration.

3. Product design process

The analysis of the product design process is based on the work of three design teams who were working in pairs on the same problem. The design brief concentrated on a sustainable design task involving practicing designers working in pairs with experience from 3 to more than 10 years. The designers were asked to design portable CD or DVD data storage. The brief provided general design constraints and a list of online resources. The team approach was selected as this reflects better the design practice. Data collection methods were: observations, talk-aloud protocol and retrospective protocol. The teams were video recorded for 45 minutes.

3.1 Analysis

Figures 1, 2 and 3 illustrate the maps of the product design team activity. They illustrate the process over the whole session and demonstrate their approaches to understanding the problem. This analysis focused on designers’ activities during the overall project time. Only the selected episodes are described for each product design team. Problem exploration activity was occurring concurrently during the early stage of the design process. This was relevant for all three teams.

Product Design Team 1 (Figure 1) began at 00:00:00 by exploring the problem. This has been happening in various intervals during the process. The designers applied decomposition strategies and domain knowledge by starting to explore possibilities around the problem (P1: One size fits all type things maybe. P2: So, that’s really pretty much the brief I think. The rest is pretty standard, easy to clean, easy to maintain, be safe to use, be considerate of sustainable design, so.). Market search started at 00:03:00 and continued until 00:23:00. The team was searching on the Internet for similar examples of the product they were to design. The designers were documenting their findings concurrently with market search (P1: It will be interesting to see what sort of capacities there are I suppose. What products they...P2: Yeah, 24 there—So that’s like a material type hard material thing there, EBA.). Documentation was represented by small intervals. The first sketching interval began at 00:07:00 and finished at 00:07:50. The second sketching interval started at 00:24:50 and continued to occur in smaller intervals until 00:37:50. Designers were designing the product by decomposing and grouping constraints. Close to the end of the task their sketching activity intensified and became more fluent (00:39:00 to 00:45:00). During the process the designers referred to exemplars frequently (P1: File concept...Or, um, or a um, you know a lot of these ipods and that they have like sort of silicon skins and stuff...). The last reference was from 00:38:00 to 00:39:50 (P1: Could there be a, could this be a disposable cardboard type box?). The rest of the time was spent on designing the product. Team 1 spent 40.00% of time on problem exploration, 32.00% on market search, 04.00% on documenting, 14.00% on sketching and 10.00% on referring to an exemplar.
Product design Team 2 (Figure 2) began at 00:00:00 by exploring the problem and continued until the end of the task. The designers applied decomposition strategies and domain knowledge by starting to explore possibilities around the problem (P2: ...portable CD storage. To me that suggests that you are ... you've got a case for your CDs and your CD player is separate.). The traces of the process map were more fluid and the strategies stronger. Market search occurred from 00:29:00 to 00:32:00. It seemed that the designers were evaluating their ideas against the existing market. Documenting occurred at the start of the project (00:02:00 to 00:05:50). Sketching started from 00:03:00 and occurred in larger or smaller intervals and lasted until the end of the task. The designers referred to the exemplar at the beginning of the task (00:03:00-00:08:50) (P2: like a cassette holder or something like. P2: lets design an ipod case...) and in the middle of the process (00:21:50) (P2: Lets just say your concertina type arrangement.). Team 2 spent 62.00% of time on problem exploration, 5.00% on market search, 01.50% on documenting, 28.20% on sketching and 03.30% on referring to an exemplar.

Product design Team 3 (Figure 3) began at 00:00:02 by exploring the problem and continued until the end of the task. They referred immediately to the exemplars of the product they knew by referring to the brands. They addressed the brief by exploring it and making a decision on how to work (P2: Well, are we working together, do you want to talk about it or do you just wanna go crazy and do ideas? Pr: I'll just do ideas. P2: Ohhh. P1: Why, what do you want to do? P2: Well, I don't know, well, I think, we meant to just come up with anything?). This strategy was guiding the team and designers' interaction during the design process. They did not search similar products on the market. During the process the designers applied decomposition strategies and domain knowledge by starting to explore possibilities around the problem (P1: And ship. It doesn't say it has to be recycled, just sustainable, maybe we could design it just so that there's less parts to it. P2: What about um, yeah that's true, yeah I know it doesn't have to be recyclable but um, um, um, um. P1: It could just be like two shells that just clip together and then you can expand it or it could just be.). Problem exploration finished at 00:33:70. The remaining time was spent on sketching. Documenting occurred at the start of the project (00:00:50 and finished at 00:09:10). Sketching started from 00:00:30 and occurred in larger or smaller intervals and lasted until the end of the task. Team 3 spent 40.30% of time on problem exploration, 00.00% on market search, 06.00% on documenting, 50.20% on sketching and 03.50% on referring to an exemplar.
4. Software design process

The analysis of the software design process is based on the work of three design teams who were working in pairs on the same problem (Popovic and Kraal 2010). The design prompt was to design a traffic flow simulation program, and the broad constraints were given in the prompt. The design teams were video recorded for 1 hour and 50 minutes. The expected outcomes were that the teams would ‘design interaction that the students will have with the system’ and provide ‘a basic structure of the code that will be used to implement this system’. The designers were allowed to re-use an existing software package if they wished.

The designers were all expert software designers. Teams 1 and 3 applied a Model-View-Controller paradigm that represents a frame in which user input, modelling of external world and user interface are separated by three specialised tasks: the ‘view’ refers to the output (user interface), the controller interprets an input, and the model manages the data and behaviour of the domain (Burbeck 1992). Team 2 adopted a different approach in intending to build an Entity Relation (ER) Diagram to communicate and frame their concept. The coding schemes applied evolved during the analysis of the activity of each team and were identical for all teams (Table 1).

4.1 Analysis

Figures 4, 5 and 6 illustrate the maps of the software design team activity. They describe the dynamics of the process over the whole session and demonstrate the differences and similarities in their approaches to understanding the problem. This analysis focused on designers’ activities during the overall project time. Only the selected episodes are described for each team.

Team 1 (Figure 4) began at 00:05:19 by exploring the problem, before quickly moving to consider the model at 00:05:32 (Male 2: ...I’m thinking in terms of model-view-controller...). At this point, designers applied decomposition strategies and domain knowledge by starting to explore possibilities around the problem (Male 2 (00:05:3): Looks like basically two pieces: the interaction and the code for map that’s able to manipulate road systems with a whole bunch of detail. What accounts for that to me is, be able to accommodate at least six intersections, be able to control lights at an individual level...). Documenting the model began at 00:06:21 and ended at 00:06:32, before consideration of the model at 00:06:35. Male 1 (00:06:23) proposed the big picture strategy that seems to be hierarchical: We need to think about the big picture. That’s where I always like to start. How do you see the code being – just kind of the structure of it broken down? Male 2 (00:06:47) referred to the rules and how to organize intersections. As the designers continued to explore the problem, they began telling a story about the model. A long period of discussion of the model details began at 00:13:34. The designers worked through the model using the earlier story, and the discussion about the model ended at 00:20:47. During this period, the designers applied domain knowledge and strategies while exploring the problem. Design activities such as model detailing, documenting and providing narrative about the model were undertaken concurrently at various intervals during the early stage of the design process. Toward the end of the process, the designers discussed the model again.

In summary, Team 1 spent 73.29% of time on problem exploration, 28.27% on model details, 17.88% on narrating the story, 10.98% on UI details and 1.21% on documenting.
The Team 2 designers (Figure 5) began by exploring the problem at 00:06:18, before discussing the UI (through a story) from 00:08:08 to 00:08:21. (Female: Well, so one is you want to change the layout of the map...you want to run it, meaning little dots are moving, showing you how the traffic is flowing.) They returned to discussion of UI details from 00:09:12 to 00:09:36, and then began an exploration of the details of the model from 00:09:37. Discussion of the problem ended at 00:10:04, before resuming at 00:10:17. Discussion of the model ended at 00:10:19, followed by the end of problem exploration at 00:10:50. Exploration of the model resumed at 00:11:31 and continued to 00:11:55 (Male:...it could be like the left-hand turn signal here...It might not be for the intersection as a whole, maybe there's actually four objects here approaching intersection...), followed by a brief exploration of the problem from 00:12:00 to 00:12:16. Further discussion of the model and UI occurred, leading to a brief period of problem exploration. Discussion of the model re-occurred from 00:16:09 to 00:16:19. A period of documenting the preceding discussion began at 00:16:20 and led to a discussion of UI details. This discussion started at 00:17:08 and was followed by the end of the documenting process at 00:17:12. A brief story from 00:19:58 to 00:20:06 lead to further discussion of the UI from 00:20:06 to 00:20:33, followed by a longer story from 00:20:33 to 00:21:29 (Female:...ideally you would want to draw this out of the box with all defaults and some defaults setting based on some package...). Several episodes on model explorations and UI followed and discussion of UI finished at 01:28:32. Further exploration of the problem continued concurrently with model episodes. The team continued exploring the problem until the end. This team spent 47.56% of time on problem exploration, 23.43% on model details, 20.00% on UI details, 6.13% on narrating the story, and 2.76% on documenting.

The Team 3 designers (Figure 6) began (at 00:05:35) by exploring the problem. At 00:08:53, they explored the details of their model in the context of exploring the problem, before returning to only consider the problem. At 00:09:25, they considered the model in the context of understanding the problem. From 00:11:06 to 00:11:19 they worked on the model, again using it to aid and explore their understanding of the problem (Male 1: So we can sort of start with the hierarchy: intersections seem to have signals. N of those. Road have lines.). At 00:12:49, they told a brief story, stopping at 00:13:00. They then worked on the model again, still exploring and understanding the problem. Then, as they finished using the model to understand the.
problem (00:14:28), they told another story (from 00:14:27 to 00:14:34) to complete and illustrate their new addition to the model. They were still working on understanding the problem. They continued with exploration and, at the end of the project, they concentrated on the details of the model. The team spent 87.95% of time on problem exploration, 38.13% on model details, 20.73% on narrating the story, 1.64% on UI details, and 0.00% on documenting.

5. Differences and similarities

There were differences and similarities in the teams’ approaches within and across the domains. Product design teams’ approaches differ. Teams One and Two explored the problem until the end of the project, while Team 3 concentrated on sketching. The product designers transformed incomplete information into specifications and requirements. Team 1 and 2 did market search during the problem decomposition. The designers wanted to be sure that their designs stand out compared to existing products. They wanted to ensure that their designs would have competitive advantage. Team 3 did not do market search. Rather they applied an opportunistic approach and concentrated on ‘idea generation’. All teams were documenting, sketching and referring to exemplars (precedents) during the design process. Designers were also referring to product physical details in order to interpret its use. The designers made decisions at the various levels of problem decomposition (Figures 1 and 2); some of them did not carry them out until the end of the project. The strategies were not strong and the focus was on goal-limited strategies (Alexander and Judy, 1988; Popovic, 2004). The teams inferred from the expected solution (Cross, 2004; Popovic, 2004). All three teams demonstrated that sketching was an important part during the design process. The visual language that designers used might represent their thoughts and knowledge, or new thought generation and stimulates new creative and analytical thinking (Oxman, 2002; Popovic, 2004).

Table 2. Summary of differences and similarities across the domains.

<table>
<thead>
<tr>
<th>Similarities</th>
<th>Software design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem decomposition and transformation</td>
<td></td>
</tr>
<tr>
<td>Goal-limited strategies</td>
<td></td>
</tr>
<tr>
<td>(constrains grouping into larger or smaller partial solutions)</td>
<td></td>
</tr>
<tr>
<td>Inference from the expected solution</td>
<td></td>
</tr>
<tr>
<td>Mixed approach (opportunistic and systematic)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Differences</th>
<th>Software design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sketching</td>
<td>Narrative (scenario) to understand the context and experiences</td>
</tr>
<tr>
<td>Market search</td>
<td>Interface details</td>
</tr>
<tr>
<td>Interpretation of use by referring to product’s physical details</td>
<td>Reference to model(s)</td>
</tr>
<tr>
<td>Reference to exemplars (precedents)</td>
<td>Domain knowledge</td>
</tr>
<tr>
<td>Domain knowledge</td>
<td></td>
</tr>
</tbody>
</table>

Software design teams’ approaches also differ. Teams One and Three adopted a more structured combination of top-down and bottom-up approaches (prescriptive software design models) during the problem decomposition (Figure 4 and 6), while Team 2 adopted a more opportunistic and iterative approach (Figure 5) (Sommerville, 1981). The designers made decisions at the various levels of abstraction during the decomposition; however, some of them did not carry them out until the end. Guidon (1990) points out that, in the early stage of the design process, software designers transform incomplete information into the specification and requirements. The ill-defined strategies and goals prevented the emergence of strong strategies as the focus was on goal-limited strategies (Alexander & Judy 1988; Popovic 2004) with the emergence of constrains grouping into the larger or smaller partial solutions (Popovic 2004), particularly with respect to sub-models.

During the knowledge acquisition phase, sharing of knowledge was a significant activity during the software design process. It was noticed that the teams applied mixed-approaches—systematic and opportunistic. Most of the time they used backward reasoning. This concurs
with earlier findings about design activity and how designers work. Most of the time, designers infer from the expected solution (for example, Cross 2004; Popovic 2004). Software designers were using narrative (scenario) in order to understand the problem or how data flowed within the model or user experience. Table 2 summarises differences and similarities across the domains. The four major similarities across the domain are (i) decomposition of a problem, (ii) constrains grouping into smaller or larger partial solutions, (iii) backward inference and (iv) mixed approach. The major differences are based on the domain knowledge designers had. Product designers differ in (i) using sketching as main design idea generation tool, (ii) do market search, (iii) interpret a product’s use by referring to its physical details and (iv) use precedents. Software designers differ in (i) model inference and (ii) use of narrative (scenarios) in order to understand the abstraction. Use of narrative and reference to physical details are two significant differences coming out of this study. It seems that designers use details being tangible design elements to interpret physical objects they design. They use sketches and annotations to communicate this. However, software designers are working within more abstract systems. They relay on the ‘story’ to understand the abstraction and link this with the dynamic of the system. This seems to be a major difference between designing digital systems and physical artefacts. Due to increase of interfaces that cross between the physical and digital (Kraal & Popovic 2007) this finding demonstrates how an abstraction is understood within both domains. Both design domains demonstrated that they used partial structures to move from problem space to the solution space (Dorst & Cross 2001).

It is already said that major differences are dependent to the domain knowledge designers have. The domain knowledge they use distinguishes their expertise and how they solve a problem successfully. The designers use their knowledge to organise the overall solution process (Simon 1984). Both design groups demonstrated implementation of domain knowledge and skills in organising the design process.

5. Conclusion

This study has identified significant differences across two domains (product and software design) that contribute to better understand the early stage of the design process. Its significant contribution is in the potential to transfer this knowledge and design thinking to other areas of design and science and expand the theory around the design process. It also has potential implication to education where these differences and similarities can be built into the teaching of design, technology and science.

Acknowledgements

Results described in this paper are based upon videos and transcripts initially distributed for the 2010 international workshop “Studying Professional Software Design”, as partially supported by NSF grant CCF-0845840 (http://www.ics.uci.edu/design-workshop).

The authors gratefully acknowledge the participation of designers for the experiment. We also would like to thank Rebekah Davis for providing case of practicing product designers.
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Furthering interface design in services

Fernando Secomandi
Delft University of Technology, Delft, The Netherlands

Dirk Snelders
Eindhoven University of Technology, Eindhoven, The Netherlands
Aalto University, Helsinki, Finland

Abstract
This paper critically discusses ideas from the book Interface: An Approach to Design (Bonsiepe 1999) as a springboard for thinking through the design and use of services. We introduce Bonsiepe’s take on phenomenological philosophy of technology in his conception of the user interface. Next to that, we extend his interface concept to the field of services while expanding on it based on advances originating in postphenomenology. Our revision of Bonsiepe’s approach to interface design allows for a better integration of practices involved in the creation of interfaces, in services and possibly other domains of design activity.

1. Introduction
Designers have arguably been prime contributors to the impact of technology in modern societies. At a period of expanding consumer markets, industrial design emerged as a distinct making practice helping to organize the mass-fabrication of a myriad of goods that came to permeate everyday life. Moving past the initial influences of industrialisation, a growing part of contemporary life is becoming shaped by the exchange of services rather than goods. How can we understand the human experience of services? And how can we reconceptualise design in the present context?

In this paper, we look to the concept of the ‘interface’ as a departure point for answering the above questions. Pacenti and Sangiorgi already advanced the interface as a key concept for service design (cf. Sangiorgi 2009). Often used interchangeably with ‘touchpoint,’ both terms denote what is designable in services: physical products, environments, personal interactions, and more (cf. Mager 2008). In addition, service researchers from diverse backgrounds have adopted comparable concepts to describe the interaction between providers and clients when a service is delivered, such as ‘front-office,’ ‘service encounter,’ ‘servuction,’ and ‘tangible evidence.’

Elsewhere (Secomandi & Snelders, forthcoming), we have critically reviewed the service literature and argued that the interface is the domain where new services ultimately materialize. Critiquing the view that services are fundamentally intangible, we posited that the service interface is always available to the embodied experiences of people. Within this view, we believe it is more important to figure out how the user experience of services might differ from their experiences with goods, and the implications of this for design.

Here, we continue our inquiry by following a path that was laid out in the past. In a seminal book, Bonsiepe (1999) proposes an interpretation of design practice as dedicated to structuring the interface between technologies and their users. Bonsiepe is in the company of others in the fields of human-computer interaction and interaction design (e.g., Winograd & Flores 1986; Ehn 1988; Dourish 2001; Fällman 2003). Departing from Heidegger’s phenomenological philosophy of technology, these authors have taken situated use practices and embodied expe-
riences as the foundation for designing new interactive technologies. Bonsiepe is unique among them in extrapolating his insights beyond computer technologies, potentially to encompass services. He understood design to be a general human ability that could be exercised in several domains of professional activity.

Our purpose is to consolidate Bonsiepe's contribution in the field of services and to augment it based on advances in postphenomenological philosophy of technology (Ihde 1990). As we will show below, Bonsiepe's Heideggerian framework imposes a limited view of technology, whereby an interface is considered useful only when it is perceptually 'transparent' for people. This same conviction is held by the above mentioned authors who wrote about interaction design. Based on Ihde's perspective, however, we wish to demonstrate that this belief is inadequate and has invited Bonsiepe to consider design narrowly, ignoring relevant professional practices involved in the creation of user interfaces, especially as services are regarded.

For now, we will set these objections aside and explain Bonsiepe's approach to the interface in section 2. Next, in section 3 we introduce Ihde's postphenomenological account of technology, as well as our application of this account to describe user experience of service interfaces. In section 4, we return to Bonsiepe for a revision of his approach, in order to acknowledge more diversity in the way that services are used and designed, thus helping to promote the interface concept as central to design thinking.

2. Bonsiepe's approach to the interface

In the late eighties Bonsiepe accepted an offer to work as a designer for a software development company in the United States. This represented for him an opportunity to work in the then emerging topic of human-computer interaction. During that time, he rediscovered Heidegger's work under the influence of Hubert Dreyfus (Fathers 2003, p.51), who was a strong disseminator of the philosophy of technology and phenomenology within computer science audiences. It is likely he also came across Winograd and Flores's influential *Understanding Computers and Cognition* (1986) before, by the early nineties, forging his own phenomenological perspective to interface design. His ideas were presented in a series of essays collected in the book *Interface: An Approach to Design* (Bonsiepe 1999) [1].

Heidegger's early philosophy of technology had a decisive influence on Bonsiepe's approach. In an often cited passage, Heidegger described someone picking up a hammer to perform a certain activity, say, to drive a nail into the wall. In its ordinary use, Heidegger observed, the hammer does not draw attention to itself, but rather to what is reached through it (in this case, primarily the nail in the wall). It functions as a *tool*; it is useful, 'in-order-to', something that assigns the person to another aspect of the world. The hammer 'withdraws' in action and gains a sort of perceptual transparency for its user. It is, in Heidegger's terminology, 'ready-to-hand'. Yet, if the hammer breaks down or goes missing, the user's involvement in the activity gets disturbed. When that happens, the tool, along with its referential network (the project, the material it is made of, the nails, etc.) becomes conspicuous. The hammer now draws attention to itself, not as a useful object, but as an obstruction for the user. It becomes 'present-at-hand'.

Bonsiepe appropriated the insights above for his interface concept in the form of a tripartite 'ontological design diagram', which he describes as follows:

Firstly we have a user or social agent who wants to realize an action effectively; Secondly we have a task which the user wishes to perform, e.g., cutting bread, putting on lipstick, listening to rock music, drinking a beer or performing a root canal operation; Thirdly we have a tool or artefact which the active agent needs in order to perform this task effectively—a bread knife, a lipstick, a walkman, a beer glass, a high precision drill rotating at 20,000 rpm. (1999, p.29)
The interface, for Bonsiepe, does not rest exactly in the tool itself, but in the domain of interaction involving users, tasks and tools. This conception of the interface owes thoroughly to a Heidegerrian tool analysis, based on the following observations:

First, the interface reveals how users are connected to other aspects in the world, which in the case of software mainly comprises digital data:

The digital data stored (on a hard disk or a CD-ROM) are coded in the form of 0 and 1 sequences and have to be translated into the visual domain and communicated to the user. This includes the way commands like ‘search’ and ‘find’ are fed in, as well as the design of the menu, positioning on the screen, highlighting with colour, choice of font. All these components constitute the interface, without which the data and actions would be inaccessible. (1999, p.30)

Second, the interface defines a tool only in relation to a context of action. Consider his example of the scissors:

An object only meets the criteria for being called scissors if it has two cutting edges. They are called the effective parts of the tool. But before the two cutting edges can become the artefact ‘scissors’ they need a handle in order to link the two active parts to the human body. Only when the handle is attached is the object a pair of scissors. (1999, p.30)

Third, tools are made ready-to-hand when located in the interface amongst users and the world:

The interface reveals the character of objects as tools and the information contained in data. It makes objects into products, it makes data into comprehensible information and—to use Heidegger’s terminology—it makes ready-to-hand... as opposed to present-at-hand... (1999, p.29)

The design objective, according to Bonsiepe, is to organize the interactions of users, tasks and tools in order to enable the effective realisation of actions [2]. Before commenting on the relevance of this approach for service design, we will first elaborate on the interface concept with respect to the use of services along postphenomenological lines.

3. A postphenomenological approach to the service interface

Heidegger is considered to be a key philosopher of technology, and the insights of his tool analysis were seminal in the advancement of a new style in phenomenology propounded by Ihde, named postphenomenology [3]. In Ihde’s (1979, pp.103-129) interpretation, Heidegger showed that a technology is never a mere object ‘in-itself’, but always conveys for humans special ways of acting within an environment and of revealing knowledge about the world. However, Ihde soon noted that in Heidegger’s hammer analysis the technological artefact was left largely implicit, and was only evidenced in a negative fashion, in situations where the hammer broke or went missing (i.e., became present-at-hand). In response to this, Ihde developed a less dichotomous consideration of the ways in which technology mediates human experience of the world, one where the conspicuousness of technology was not necessarily the result of a ‘breakdown’. His most extensive treatment of this topic is found in Technology and the Lifeworld (1990, pp.72-123), where four modes of human-technology relations are identified: embodiment, hermeneutical, alterity and background.
By applying Ihde's postphenomenological framework to services, it is possible to describe four different ways in which interfaces mediate user experiences of the world (see Table 1) [4].

**Table 1. Different types of user-interface relations in services**

<table>
<thead>
<tr>
<th>Relation Type</th>
<th>Interface-World Relation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embodiment relations</td>
<td>[user-interface] → world</td>
</tr>
<tr>
<td>Hermeneutical relations</td>
<td>user → (interface-world)</td>
</tr>
<tr>
<td>Alterity relations</td>
<td>user → interface{-world}</td>
</tr>
<tr>
<td>Background relations</td>
<td>user → (interface-)world</td>
</tr>
</tbody>
</table>

In *embodiment relations* users engage the service interface by ‘incorporating’ through it the world beyond. For example, visually impaired people with a guide dog can experience an obstacle in their path as they are led around it by the animal. A considerable period of adaption is necessary for such embodied experiences to occur. But once obtained, the interface mediates experience of the world as a projection of the user’s sensory capacities. The person holds the leash, yet the terminus of her perception is not precisely on what is held but in the obstacle experienced through the dog. Embodiment relation is the type of user-interface relation that sits most closely to Heidegger’s notion of readiness-to-hand.

In *hermeneutical relations* users engage the service interface by ‘reading’ through it the world beyond. For example, a car driver can experience arrival at his destination by checking a GPS navigation device. The driver’s vision is directed at the screen elements, but the experience is of his current location as presented by the device. In this case, the interface mediates perception of the world based on the user’s capacity to interpret conventional signs (such as the map, icons, words, etc.). Again, learning is necessary for the constitution of such relations; once accomplished, users perceive the world for what the interface signifies.

In *alterity relations* users engage the service interface by ‘interacting’ with it, while the world falls to a background position. We can imagine this kind of relation developing between a beginning skier who observes his instructor going down a challenging slope. The skier is fascinated by the instructor’s skilful display and immediately mimics his behaviour, never mind the steepness of the slope, the instructor’s oral advice or the necessary bodily skills. The interface dominates the core of perception for the user while the world falls to field position. But however totalizing the experience of the instructor may be for the beginner, some aspect of the world is reached and transformed through it: the slope is not threatening anymore. Needless to say, this is the kind of relation most clearly opposed to Heidegger’s readiness-to-hand. In alterity relations, the interface may be objectively present in a positive, useful sense.

Finally, in *background relations* users engage the service interface by ‘absenting’ it, while the world arises in a foreground position. A person dining in a restaurant might get so absorbed into talking to a close friend to barely notice the atmosphere created by music, furnishings, lighting and the murmurs of the other clientele. The tendency is to attend to the friend directly, while the ambiance becomes less distinct to the perception of the restaurant guest. Though in this case the world gets fore-fronted to the experience of users, the interface still mediates perception from a contextual position, for instance, by subtly influencing the person’s mood and sentiment towards the friend.

As a final remark, each of the user-interface relations described above is not necessarily rigid and static. The visually impaired woman can enter an alterity relation with her guide dog as an animal companion; the restaurant guest can switch attention to the wall decoration and observe, hermeneutically, that it conveys a Mexican ambiance; and so forth. Shifts away from embodiment relations are not always a sign of malfunction, as a Heideggerian might believe, but also indicate the great expanse of users’ experiential possibilities.
4. Interface design in services

In the introduction we presented two lines of inquiry for this paper. We have thus far mainly addressed the first by providing a framework for understanding the human experience of service interfaces. This leaves us with the second issue: How to think about the design of service interfaces? We must return to Bonsiepe, who, amongst the authors considered in this essay, has pressed in the most generalised form for an interpretation of design based on phenomenology. His thoughts on typography design are exemplary of this:

A typographer designing a book lay-out not only makes the text visible and legible, the interface work also makes it interpretable. Competency in handling visual distinctions like size and type of font, negative space, positive space, contrasts, orientation, colour and separation into semantic units makes the text penetrable to the reader. Typographic design is the interface to the text. (1999, p.59)

In another passage, he concludes boldly:

If language makes reality recognizable, typography in turn makes language visible as text, and is therefore a constituent part of understanding. It could be objected that the production of texts is the primary function. But the hierarchy is less important than the interrelation of two areas that are united under the arch of interpretation and understanding. (1999, p.52)

Seen against the backdrop of Heidegger’s insights, Bonsiepe is arguing that the creation of interfaces by designers contributes to giving shape to how people experience reality. For him, this skill is not restricted to the traditional design professions but is extendible, not without some observations, to other domains of human activity. He writes:

There is a risk of falling into the trap of vague generalizations like ‘everything is design’. Not everything is design, and not everyone is a designer...Every one can become a designer in his special field, but the field that is the object of design activity always has to be identified. An entrepreneur or a manager organizing a company in a new way is designing, though he probably does not realize this....Design is a basic activity whose capillary ramifications penetrate every human activity. No occupation or profession can claim a monopoly on it. (1999, pp.34-35)

Combined, the quotations above are timely remarks considering the hasty popularisation of ‘design thinking’ in managerial circles today. By stressing its relevance outside the realm of habitual practices, design thinking easily becomes a primarily cognitive operation that can serve as panacea for all sorts of business-related issues. Bonsiepe reminds us of the importance of grounding design thinking on the material actions of skilful practitioners.

We turn now to our critique of Bonsiepe’s approach to design. As stated above, interfaces for him should be designed to enable the effective realisation of actions: handles are to move the scissors’ cutting blades (1999, p.30); computer screen commands, to allow easy data navigation (1999, p.53); typography, to support the comprehension of texts (1999, p.52); etc. But the way interfaces facilitate action is somewhat peculiar; staying truthful to his Heideggerian background, interface experiences lead to a ‘withdrawal’ of the tool for users. This may be observed in his account on the design of an informational CD-ROM:

It is easy to formulate the function of the interface: it should permit the user to obtain an overview of the contents; navigate the data space without losing his way; and pursue his interests....Infodesign gives little opportunity to follow narcissistic inclinations. Moreover, one may assume that the public is not particularly interested in such
manifestations of the ego…It’s like looking through a pair of glasses. You don’t need to see the glasses—they are the tool for seeing. (1999, p.53)

In one blow, we are invited to look suspiciously to every other design practice whose products are primarily meant to stand out (fashion and jewellery design might be examples). More importantly, this approach to interface design seems inadequate even for the practices Bonsiepe selected for a closer analysis. Strictly speaking, we should interpret as ‘design activity’ the work of an infodesigner who organizes typographic elements on-screen (to facilitate reading), but at the same time overlook her careful placement of an advertisement banner amongst those elements (possibly, to the sacrifice of legibility). After all, it can hardly be sustained that the banner is ‘transparent’ for users when enabling the action of clicking on it.

To be true, Bonsiepe evades a restraining interpretation of interface design when he calls for a broader understanding of effective action:

To assess an action as effective, the implicit standards always need to be identified. To an anthropologist a lipstick is an object for the production of a temporary tattoo, which is applied as part of a pattern of social behaviour that we call seduction and self-representation. The criteria by which its effectiveness is judged are very different from those that would be applied to a text editor, a concert poster or a bulldozer used in road construction. There is no point in talking about effectiveness without also stating the scale of values by which a product is judged as effective for a certain action. (1999, pp.35-36)

However, different values for judging action are not considered by Bonsiepe in his detailed cases, and therefore those interface experiences where tools are more objectively present for users can be easily ignored.

What prevents Bonsiepe from recognizing other approaches to design could be a Heideggerian belief that technology must withdraw from the experience of people to be truly useful. And it is precisely on this point that his views on interface design can benefit from our postphenomenological amendment. In the previous section, we described in more nuanced ways how service interfaces mediate user experiences of the world. Based on that, we are able to acknowledge a wider range of practitioners who may be considered service ‘designers’, even though the interface they help to create is sometimes less ‘transparent’ to users: the trainer of dogs behaving as guides for the visually impaired; the software programmer who compiles the codes actualizing the car’s position on the GPS device’s screen; the ski coach who perfects the display of his skills for instructing beginners; and the operations manager who optimizes the restaurant’s resources to prevent overcrowding.

To conclude, by placing the interface concept at the centre of his theory and practice, Bonsiepe has presented a phenomenological interpretation of design which still has much to offer. Our intent has been to further advance this position in the field of services, while reflecting over contributions from postphenomenological thought. We believe these are important steps in making the interface a central concept in design thinking research. In addition, we need to investigate carefully the actual making practices of people involved in interface design in a world highly saturated by the exchange of services. Eventually, this will call for the integration of perspectives from professions with very long traditions, which have remained poorly represented in the extant design discourse. At least as service design is concerned, we might be able to learn as much—if not more—from the hairstylist as from the cabinet maker.
Acknowledgements
The authors gratefully thank Peter-Paul Verbeek and two anonymous reviewers for their comments on an earlier version of this paper.

Notes

2. This statement is actually part of a broader attempt by Bonsiepe to dissolve a wearied form vs. function debate. The particularities of his arguments are not of central interest here, but can be found on pp.132-137.

3. For a succinct introduction to postphenomenology, read Ihde (2009).

4. While Ihde presented embodiment and hermeneutical relations as unambiguous cases of humans experiencing the world “through” technologies, he also described alterity relations as those humans had “to” or “with” technologies and background relations as occasions where technologies were left “to the side”. Many postphenomenological researchers, e.g., Verbeek (2005), concluded that only the embodiment and hermeneutical relations were relations of technological mediation. To be sure, in his book Ihde highlighted the non-neutral impact of technologies in human experience also for the alterity and background relations. He furthermore stated: ‘Within all the types of relations, technology remains artifactual, but it is also its very artifactual formation which allows the transformations affecting the earth and ourselves’ (1990, p.108). In our interpretation it is precisely this artefactual quality of the service interface that evidences how mediation operates in all types of user-interface relations we describe.
References


Design Beyond Design: Design Thinking & Design Acting

Frido E. Smulders
Delft University of Technology, Industrial Design Engineering

Eswaran Subrahmanian
Center for Science Technology and Policy, India and Carnegie Mellon University, Institute for Complex Engineered Systems, USA

Abstract

In essence this paper seeks to answer the question: what are the essential elements of designing as a human activity that makes it possible to transfer these skills and attitudes beyond the world of design? The paper proposes to split the phenomenon of design into Design Thinking and its social dynamic counterpart into Design Acting. Design thinking is what designers do individually and in a collaborative setting of peer designers. The paper explores design thinking by reviewing literature aiming to discern some specific qualities that might be transferable outside the traditional field of design. We look at cases like Formula 1 designer Gorden Murray, architect Frank Gehry and industrial designer James Dyson in this perspective. The well-documented case of Edison and his invention of the telephone illustrate our discussion of design thinking. Design acting is described as the socio-interactive dimension of design, which places the designer in his social environment and promotes the design actor to an interventionist aiming to provoke change among the affected (non-design educated) stakeholders. The curriculum of the international master program Strategic Product Design at Delft University of Technology functions to illustrate the social corporate environment surrounding the designer and brings design to the fringes of the traditional scope of the designer's profession. This master program focuses on the fuzzy front end of design and on bridging the many gaps among the various non-designing disciplines involved. The paper shows that bridging gaps among stakeholders within product innovation processes is a process of change and interventions initiated and lead by a strategic design actor. A specific masters’ graduation project illustrates the necessary integration of design thinking and design acting beyond the field of design.

Introduction

The popularity of design thinking these days need not be substantiated by a long list of references. The very fact that the Design Thinking Research Symposium 8 is focusing on design thinking beyond the confines of the world of design is evidence enough. Design thinking has been there in practice long before educators and researchers started to explicitly mention it as a key asset of their educational program and as a subject of their research. The practice of design thinking has always been a practice of creating a new artifact, be it an axe, a plough, an armour, a shed, etc. People have been changing their tools and life environment by designing and creating for ages. The fact is that people can be good designers without having explicitly received any specific formal education. So, part of what design means in our lives is transferred to us genetically [1]. On the other hand, we don't want everyone to become designers of just new artefacts because we also want people to use their design sense in maintaining the existing artefacts. The flip side of creating and designing is sustaining or maintaining what is, sometimes also requires design thinking. If what we have is sufficient for our needs, should we engage ourselves in design processes? But history has proven that all that is sufficient changes over
time making artefacts obsolete and is subjected to serious questioning. What if ..., We might want to ..., etc. These questions aim to change the status quo and to create a ‘better’ status quo. The creation of the new state is sometimes an intentional process, sometimes a serendipitous process and sometimes an unintended process. Many breakthroughs come out of accidents!

This paper aims to shed light on what design could mean outside the confines of the traditionally accepted field of design. To do so we will split design into design thinking and design acting. Design thinking is what designers do while working by themselves and collaboratively with peer designers. This characterization of design thinking is well documented in literature. On the basis of this literature we will focus on the design problem and the design approach as potential elements that could be transferred outside the field of design. Design acting on the contrary is not well documented and covers design as a social process which can either take place among a setting of peer designers, the design team so to say, or in a multidisciplinary setting that includes large variety of stakeholders not educated in design or engineering. The latter activity forms our focus regarding design acting.

The reminder of the paper is structured as follows. First we will address design thinking by discussing the work of some remarkable designers from existing literature and discern some abilities that might be applicable outside the traditional world of design. As an illustration Edison’s design approach is then presented as a case of exemplary design thinking. The literature related to design acting forms the second theoretical introduction. It is then followed by discussion of empirical material from final projects of students following a master of science in Strategic Product Design. We will end this paper by discussing our observations in the light of design outside design.

Design thinking

Design thinking has been under investigation for as long as 50 years (Cross 1992). Most studies focus on industrial designers and architects although design as phenomenon has been discussed besides these two professions. Recently, design has become the hype for business actors and in business schools. They mix-match their curriculum with sprinkling of creativity and design issues. This raises a fundamental question; can you teach design thinking in a few courses? This effort cannot just be about teaching to be creative to solve well-defined problems. On the contrary, most design problems are ill defined and to address them is not mere problem solving. Of course, creativity is a condition sine qua non, but it is how the actor applies his/her creative potential makes all the difference. To what problem and in what context and with what aim and at what moment is the need for creativity action recognized, it is this contextualised application of creative thinking throughout the full length of the design process that could lead to a new design. This echoes the observation by Dune and Martin (2006) that designers treat problems differently than those trained in MBA. Authors like Boland and Collopy (2004), Gehry (2004), Weick (2004) and Buchanan (2004) point to the MBA-like educational programs as reason for the short-comings of the present dominant thinking in business. According to these authors a different form of thinking is needed and they refer to design thinking which covers creativity, toleration of uncertainty and bring an ‘And-And’ decision style instead of ‘Either-Or’. Either-Or-thinking polarizes the options in terms of one is good and one is bad and by that squeezes out all the solution space required for an approach aimed at realization of And-And.

It seems a matter of treating the initial situation or design problem. However, we agree with the observation by Dorst (2006) that the design problem is a problematic term in design science. According to him the design problem is too complicated to study since design problems are not knowable at any point during design, design problems evolve over time and the notions of the design problem tent to shift while designing (Dorst 2006). Cross (1992, p.8) for instance mentions that “designers habitually treat problems as though they are ill-defined” indicating that their normal behaviour is strongly related to ill-defined problems or challenging design
tasks. This is similar to the suggestion by Dorst (2006) that ill-structuredness is not a condition of the initial problem per se but related to the applied solution methods, that is the capabilities of the problem solver. In our view, the designer must see a challenge in the problem and if not the designer creates one by playing with constraints and goals related or inherent to the problem. Further, co-evolution of simultaneous development of problem and solution (Dorst & Cross 2001) adds to this notion of seeking a design challenge by looking for problem-solution pairs simultaneously instead of defining the problem first and then look for solutions. This characterization also fits with Braha and Reich's description of co-evolving topological spaces of requirements and solutions (Braha & Reich 2001).

To illustrate our thinking we will use an interesting example discussed in Hatchuel (2001). He compares similar situations faced by two groups of students seeking to entertain themselves on a Saturday night, to illustrate the difference between problem solving and a design task. One group looks for a good Saturday night movie and the other group wants to organize a party. Clearly the first group only needs to solve the problem by selecting from the existing movies in town. This doesn't reflect a design process. It is a mere selection among existing alternatives that are of the same type and the same level of concreteness. The second group has a different task that according to Hatchuel is more like a design project that implicitly has room for unexpected and infinite expansion of solutions. There are a variety of possibilities regarding location, sort of party, drinks and food to offer, people to invite, etc. All these elements require different selections and need to be integrated into a whole. While both groups want a joyful Saturday night, the first group has (implicitly) limited their solution space and have chosen to go for a good movie. The second group made a different choice of having a party that provides them an unrestricted problem and solution space. The constraints in terms of budget, time and capacity to organize, etc. make it a design project. The movie-situation could therefore be seen as a well-defined problem in comparison with the ill-defined situation of having a party. What we want to make clear here is that one of the elements that could bring design thinking outside the confines of its professional field is the designerly attitude of people (non-designers by education) to seek (consciously or sub-consciously) the ‘design’ challenge in situations that somehow are in need of resolution.

But what makes up a design challenge? A paper by Cross and Clayburn-Cross (1996) that reports of the design process of Formula One racing car designer Gordon Murray might be of help here. Murray frequently out-designed the competition by applying what seems to be a typical design approach. The authors mention that Murray's most important factor is to start by reconsidering the problem situation from scratch, and by 'looking back at fundamental physical principles'. To us that seems like a good strategy since looking back at the fundamentals is a process that overrules or bypasses the assumptions and underpinnings in present and preceding designs. Looking at the designs of the cyclone vacuum cleaner and the new Airblade hand dryer by Dyson and the Strida foldable bike by Sanders (Roy 1993) it seems that consciously or unconsciously this is what happened in arriving at a new principle. The conceptualizing that starts from the first physical principles (from scratch) leads to the creation of new integration patterns rather than the honing of existing ones (Cross & Clayburn-Cross 1996). It seems to us that this particular quality of looking for new forms of integration characterizes the (innovative) designer and could also characterize the non-designer acting as a designer within his/her own field.

Such a reframing of the initial situation is what designers often do to get a better starting point. Instead of accepting the constraints inherent to the initial problem definition another viewpoint is created by considering for instance the total system. A (total) systems approach could lead to circumventing the dead alley introduced by the initial framing. Systemic design zooms out of the present layer of concreteness that contains the constraints to a level that takes the whole system as a unit for design. Cross and Clayburn-Cross (1996) provide an interesting example of such a systemic approach and report on Murray's innovative idea of using refuelling
pit stops during a race with the ultimate aim of reducing the weight of the car during the race instead of reducing the weight by redesigning the car’s construction. Like him all other teams did focus on the construction but found themselves somewhat in a dead alley. By reconsidering this problem in the light of the total system of one race he realised that one way of making cars lighter during the race was to carry less fuel around. Making racing cars more fuel-efficient was not a real option at that point. So he realised that cars that only contain half the amount of fuel are lighter, have better acceleration and deceleration, smaller fuel tanks, less wear on tyres and provide a more constant handling during the race. Having less tyre wear and a planned pit stop made it possible for them to race on softer rubber compounds which improved the cornering speeds. However, pit stops until then were only used for emergencies of tyre punctures or light damages. Lifting the initial design situation to an abstracted level of considering the total race as a system implied that redesign efforts would be needed on the various elements within this newly defined system. Murray needed to develop a fast fuelling system, a new wheel-nut gun, rapid tyre change procedures and a tyre heater. The latter was needed to prevent the sub-optimal grip of cold tyres during the first two rounds after a tyre change. Making a tyre change part of every race implied that all unnecessary lost seconds before, during and after the pit stop must be squeezed out of the system, hence the tyre heater that didn’t exist before had to be created. All in all, the system approach here meant that the various elements were redesigned and integrated differently into a new and innovative system which made it possible for Nelson Piquet to win the F1 championship in 1983 (Cross & Clayburn-Cross 1996).

Interesting to note that considering the system level as starting point for design is already outside the scope of the actual design field and the consequences thereof are that much more need to be designed than just the car, like designing pit stop procedures for rapid refuelling and tyre change. There are no reasons to believe that the design approach of pit stop procedures worked any different than the design of a better-suited wheel-nut gun. On the contrary, in 1982 the new pit stop was already tested in the season. But also ‘prototype’ runs that were taped by a specially hired film crew that on play back informed the redesign of some procedures and are quiet similar to design thinking in the traditional field.

Another element that is frequently mentioned in the Cross and Clayburn-Cross paper is the carry-through of the initial idea until the very last detail. Designers envision the future new situation as an integrated whole which enables them to concretise the new situation. In the case of Formula One, there is no time to continue a process of reframing because of the time pressure exerted by the approaching next race or next season. Murray needed to carry on as fast as possible and develop and produce the new solution until the very last detail and until all ‘bullshit’ is out as he called it. Such a solution-focused strategy is similar to what Roy mentioned on Dyson and Sanders. Getting real and integrated as soon as possible and as close to reality as possible by numerous drawings, mockups, models, prototyping, etc. Such a strategic approach is best illustrated by “parallel working, keeping design activity going at many levels simultaneously” (Cross & Clayburn-Cross 1996, p.107). It seems to us that parallel working and at many levels favours the search for the new integration of elements.

Awareness of the vocabulary in use and the emergence of new/additional elements of the vocabulary in the project form a final element of design thinking. A paper by Boland et al. (2008) discusses the design practice of Frank Gehry and mentions that anyone involved in designing must be conscious of the project language and the characteristics and logics of his/her own language and vocabulary. Designers need to be open to the tension and constraints their vocabulary imposes “on the desire to create new and more powerful designs” (p. 14). Breaking out of such a circle requires awareness, reflection and possibly additional vocabulary, like the tyre heater in Murray’s case.

Although, Cross and Clayburn-Cross, Roy and Boland et al. focus their work on extremely innovative designers and compare this with other studies on innovative designers. They merely
draw out the extreme approaches and attitudes of a designer. Their characterization of designers will help us to define some of the elements that are similarly valid for designerly actors outside the area of product design.

Based on these observations in literature we found some characteristics of design thinking that are likely to be applicable outside the field of product design. First, it seems that design thinking related to how the initial (problem) situation is handled is more suitable for application outside the design field than the actual design process. Treating problems or initial situations as ill-defined in search of a suitable design challenge that provides opportunities for new integrations, even if the problem seems well defined at the beginning! Designers have the ability to work on the solution without having defined the problem properly. Considering the situation at either more abstracted and comprehensive levels (system) or more fundamental levels (principles) is another strategy that opens new pathways for the designer to challenge older assumptions and possibly circumvent them. We believe that these different forms of ‘situation handling’ are very much transferable to non-classic design fields. Second, apart from the tactics in design, there seems to be a strategic approach that aims at working at different levels of abstraction. The detailing of one particular design element runs in parallel to conceptualizing of another element. One part of the design is detailed out while another part stays at the conceptual level until later and until integration is possible. This brings us to the third characteristic of design thinking: (de-)integration. We believe that designers have a very fine tuned feeling for decomposing any situation into an opportunity to re-integrate differently. Integrating elements that as whole make up the (innovative) design goal are what designers look for and make them going.

All in all, designers manoeuvre themselves in a position regarding the design situation that opens for them the possibility for creating a design challenge that bears opportunities for searching new integration and possibly additional vocabulary. The next section considers the work and thinking done by Edison to illustrate this manoeuvring and way of acting outside the traditional field of design.

**Design thinking by Edison**

Edison is the quintessential designer and inventor who was good at the practice of design thinking. While everybody knows about a number of Edison’s inventions, his invention of the telephone is not as well known as the primary credit went to Alexander Graham Bell. The history of the invention of the telephone shows that there were many contenders including Edison. The notion of telephony was in the minds of many inventors after the invention and use of telegraphy. Most early expansion of the telegraph was to be able to send multiple messages simultaneously; multiplexing the messages. Edison was very active in this area of telegraphy and has sold duplex telegraphy to Western Union. Initially, Edison did not participate in the telephony research and development. Western Union had rejected Bell’s offer of telephony and was looking for an alternate avenue. Edison was brought into telephony by Western Union, who felt they lost out to Gould in letting Edison’s work on quadruplex telegraphy go to them. At this point the work on telephony was restricted to using discrete telegraphic signals with some variation in tonality to transmit voice. This approach to extending the current telegraphy into telephony was not something that appealed to Edison. His goal was to be able to faithfully reproduce human voice and pursue the detailed investigation of the relationship between electricity and sound. This meant his search for the solution had to go beyond simple extension of telegraphy. In this context, he sought to use research unconnected to telephony coming more from the Helmholtz experiment on synthesizing different vowel sound by combining sounds of different tonal sounds electronically. He also used the work of Reis on intermittent sound generation to understand human hearing and modified it to generate continuous sounds by using a variable resistance transmitter to get soft and loud sounds. Further, Edison wanted to improve on the magneto based single receiver and transmitter apparatus for the phone to a technology for both the receiver and transmitter whose performance was better than that of
Bell's magneto based receiver-transmitter. He spent time building this apparatus using carbon particles and a diaphragm and adding battery power to prevent the decay of current over long distances. He had to modify the diaphragm made of mica to other materials. In developing this receiver, Edison pursued several avenues simultaneously both as betting for one of them to succeed but also to generate knowledge that he could use later. At the same time he pursued avenues similar to that of his competitors and patented them to block them from achieving their ends. In realizing the telephone Edison used complex variety of experiments including use of number of materials such as plumbago, mica, oil and other materials. “The work Edison did was, as usual, infinite variety of methods as well as the power to seize on one needed element for practical success” (Dyer & Martin 2007, p.87).

If one were to look at Edison's work on the electric bulb, it is not just the bulb he worked on, but on the entire electricity system to go with it—his genius was not different from Gordon Murray in that he was always able to work on the part and the whole simultaneously.

The fundamental approach of Edison was to change the problem that was being solved by looking at problem-solution pairs that kept changing the problem at different levels of detail. Edison continuously challenged himself in the design of the telephone at all levels during his design process. Edison's designerly thinking was systematic but one that needed re-questioning at every stage of the problem. Edison was an exemplar of design thinking who continuously changed the problem being solved as he went about his inventions. He always created challenges for himself in designing things he invented while others looked at problems incrementally. Edison was also a clever strategist who continued work on intermittent telephony and kept patenting new ideas to keep his competitors off his track. In inventing the telephone, Edison kept expanding the vocabulary and language required to describe the invention to include those that were not part of the previous efforts. This included the notions such as continuous instead of intermittent sound propagation, variable-resistance transmitter and others. As in any design context, the necessity to bring additional terms continuously refines the artefact being designed and is an integral part of the design thinking process. The design concept often requires new terms to be brought together in its realization. The history of his work on telephone as directed evolution of ideas (Carlson 2000) is an excellent example of documentation of Edison's way of thinking that exemplifies the nature of design thinking discussed so far.

**Design acting**

So far we have concentrated on design thinking. In this section we will briefly address the socio-interactive counterpart of design acting. Designers don't work isolated from their environment but are engaged in a social system made up by many other disciplinary and functional actors or at least need to create such a social system if they are entrepreneurs and starting a business like Dyson and Sanders. With design acting we don't mean individually performed design activities like sketching, CAD drawing, model making, etc. but these activities and other activities related to the design process in a social setting of non-designers. It is here that the design literature is not very well developed, but as Hatchuel remarks this perspective is inextricably bound up with design: “we should not forget that understanding and designing the social interactions of a design process is an essential part of the design process itself” (Hatchuel 2001, p. 267).

Junginger (2008) argues that product development is about creating change and must be seen as vehicle for organizational change. She points to product development as means to bring and implement change to the organisation and even suggests that product development is to be seen as an inquiry into the organization and to transform it into a different unified whole. She mentions that human-centred product development could be a suitable strategy for bringing change to organisations. How such an inquiry should take place is not really detailed out. Here
we will set out a path that could serve as basis for describing in more detail the change dimension of product development.

Stepping away from the difficulties surrounding the design problem, Dorst (2006) looks at the underlying phenomenon which brings us close to the socio-interactive dimension of design. He proposes to describe the design problem and design process as multiple discourses that initiate conflicting and paradoxical situations in need of resolution. Discourses, according to Dorst (and he based his definition on Foucault (1969)), span “the complete breadth of human thinking” (p.15, italics in original) and human activity within a certain domain. This resembles the notion of disciplinary object worlds (Bucciarelli 1988) and disciplinary thought worlds (Dougherty 1992). Thus for discourses to become paradoxical more than one domain must be involved, that is, it requires more than one actor representing another domain. Dorst certainly proposes an interesting viewpoint, but we see his description of design as “the resolution of paradoxes between discourses in a design situation” (Dorst 2006, p.17) as the socio-interactive flip side of the rational-analytic dimension of describing design that was recently described as the growing content knowledge related to the artefact under development (Smulders 2010).

The involvement of multiple stakeholders in design is what makes up the conflicts in discourses and represents what we mean by design acting. What did the examples discussed earlier mention in relation to design acting. The Cross and Clayburn-Cross paper (1993) mentions that Murray frequently uses sketches and drawings for communication and to involve other team members in the design process. He even wanted a full size drawing on the wall to get the discussion going on the detailed level he wanted to address. Not surprisingly that Murray only hired engineers that were also ‘designers’. Meaning, he wanted engineers with a particular design mind-set that were also able to act critical on his ideas and ‘to bounce ideas off’, hence “the resolution of paradoxes between discourses in a design situation” (Dorst 2006).

In addition to the use of sketches and their likes designers also use physical models, mockups and prototypes for communication and discussion purposes, like the clay models in car design. All these representations of the artefact underdevelopment are to be considered as boundary objects as introduced in bio-history by Star and Griesemer (1989), suggested for design by Bucciarelli (2002) and empirically described in design by Carlile (2002), Subrahmanian et al. (2003) and Smulders (2006). Based on the recent literature we see an increasing interest among academics in boundary objects as tools that enable boundary spanning social interactions in multidisciplinary settings. Boundary objects form a common representation that can be interpreted by the different stakeholders along their particular line of reasoning and knowledge. In the discussion the paradoxes become apparent and need to be resolved.

Designers need to bring their message to other parties not only as transfer to the next in line downstream the innovation process, but also to synchronize during their design process with these downstream stakeholders in order to integrate downstream constraints and requirements in their design (Smulders 2007). Design acting in this sense is dominated by interaction with other stakeholders that brings it automatically beyond the confines of the traditional field of design. But, design acting seen from this perspective is not a one-side process but a two-sided process whereby both parties attempt to introduce the other to the understanding that belongs to their own discourse or thought world (Smulders 2006). Depending on the reason of boundary spanning conversations all actors acting in a design mode need to ‘design’ forms of intervention and it’s accompanying boundary tools, which is in line with what Hatchuel mentions: “the social interaction becomes both a resource and a designable area” (Hatchuel 2001, p.267).
In the next sections we will discuss the masters program in Strategic Product Design and a final project to illustrate the above socio-interactive perspective at the borders of the traditional field of design.

**Mastering strategic design**

Since 1969 the faculty of Industrial Design Engineering (IDE) at Delft University of Technology offers a multidisciplinary design program on bachelor and master levels (over 4000 MSc graduates). The philosophy underpinning the multidisciplinary program from its conception is that one cannot design a successful product without taking into consideration issues related to form giving, ergonomics, consumer needs and production technology. "Creating products that people love to use" is the IDE slogan that captures these disciplinary perspectives. In 2003, the faculty introduced three international master of science programs: Integrated Product Development (IPD), Design for Interaction (DfI) and Strategic Product Design (SPD). Here we will focus on the master of Strategic product Design (SPD) as the one that brings the students to the boundaries of the traditional field of design and therefore fits the focus of this 8th Design Thinking Research Symposium. SPD teaches students to become masters of the strategic steps surrounding the field of product design.

The program was developed because we recognized the need for professionals that are able to blend issues related to design, technology, brands, consumers and markets during the strategic stage of innovation, often referred to as the ‘fuzzy front end’. Therefore the SPD program focuses on branding issues, portfolio considerations, economic rationales and competitor evaluations because these play a major role on the strategic level of product design. Companies that take product design seriously need professionals that play a key role in filling the product innovation funnel on one side and in devising commercialization strategies at the end of the funnel. This need is in line with the reasoning of Roger Martin, dean of the business school at Toronto and a pioneer in bringing design thinking to business education & practice. He mentions that design thinking could bridge the gap between the analytical and decision-making style of thinking by MBA-ers with the intuitive and creative thinking of designers. He doesn’t realise that this interpretation of design thinking in fact is design acting. Of course, thinking precedes acting, but as we argued earlier, the thinking required for socio-interactive bridging of gaps between groups of actors is about designing the interventions and the social processes, hence it is design acting as presented here. We also realised that ‘pur sang’ product developers and engineers miss the necessary competencies (knowledge and skills) to operate on this abstracted strategic level. The need identified in the market raises the question posed earlier, will an MBA-type with rudimentary design skills be able to do the job or do you need a designer with basic MBA knowledge. Delft chose for the latter because a design attitude (thinking and acting) cannot be inculcated to students in just a few courses within one/two-year MBA program. We therefore developed a two-year international master program (SPD) that only allows students with a bachelor in product design because we are convinced such a base is essential to start from. We believe that somebody with an MBA background will for instance not be able to translate the intrinsic values as experienced by the users of a brand into new product concepts and a new product portfolio. This definitely requires a designerly approach.

On a more abstracted level the SPD program aims at teaching students how to bridge the many gaps that surround and inform the product development process. There are gaps between the user and the design brief, between a company’s abstract strategy and its more concrete but still strategic product development portfolio, between market needs and product portfolio, between investments and return by new products on the market, between marketing & sales and the potential buyer of the new product, etc. All these gaps need somehow to be addressed by somebody who is literate in product development and literate in the fields (and associated disciplines) mentioned as well as having transforming and translating proficiencies. Addressing such a gap is not just a few moments of interaction, but these are processes of
transformation and translation (Carlile 2004; Smulders 2006). Actors responsible to bridge these gaps need to apply design thinking and design acting. The design thinking is necessary on two levels: First, actors need to be able to visualize new product concepts for the purpose of using them as boundary objects in conversations with the various stakeholders. Not just presenting a sexy rendering of a new product, but incorporating this picture into the context of the future company and future competitive market situation. These presentations must be considered interventions that aim to change a certain status quo and bring that into a new situation (Cummings & Worley 1997) and not just a series of nice slides in a power point presentation. It is a process of social interactions that have a certain aim in terms of bringing the message across and convincing the stakeholders that they need to buy into the new ideas. Or convince the board to initiate a decision-making process aimed at assigning budget for starting a development project. This is the second level where design thinking is needed: the development of small and large interventions required to initiate change. Simon (1996, p.111) sees such interventions as design: "Everybody designs who devises courses of action aimed at changing existing situations into preferred ones."

The strategic design actor needs to treat the development of the interventions with delicate care since interventions are like spoken language: there is no second chance! However, the literature on this practical level of acting is still in its infancy. On the other hand design acting could benefit from literature on more abstracted levels like organizational routines (Pentland & Feldman 2008) and literature on change and interventions like the five colour theory of interventions by De Caluwé and Vermaak (2003). Like we contended boundary objects are supportive in bringing the message across. Boundary objects that strategic design actors might use are projectas (Buijs 2009), personas, scenarios, sketches, story-boards, mock-ups, models, launching customers, etc. But also boundary-spanning processes between users and marketers facilitated by the design actor, like context mapping, creative facilitation, focus groups, etc.

**Design acting in practice**

A recent Master’s final project of a SPD student illustrates these design activities as an integrated whole of design thinking and design acting. The project was for an international software company (here named SoftCy) with a yearly turnover of 200 million Euro that delivers accounting software to SME’s. Most of their products are software driven instead of user centred. Programming software and selling it to the intended class of users has worked fine and successful over the last 25 years. The software products were not very complicated at the beginning and worked fine on stand-alone computers or in small networks. However, over the years the complexity of the software increased in parallel to the growing tasks of computers as mainstream workstations. Because the users didn’t change too much in this time frame there was simply no trigger in that particular competitive arena to transform existing NPD to a more designerly form of NPD. But now a new generation of users (Generation Y) replaces older generations and different users might need different kinds of software products and services. Thus SoftCy realised that they needed to redesign their NPD process in order to comply with the new generation of users. The graduation assignment focused on developing and implementing an user centred design (UCD) approach within the existing NPD. The idea behind this was, that in the future users keep on changing and SoftCy will need to bring products to the market that continuously fulfill those changing needs of users. Reformulation of her assignment: What UCD approaches are suitable for the NPD process of SoftCy in order to make it more user centred? The student realised that her assignment pointed to a ‘Russian doll’ situation, meaning that for redesigning the existing NPD process she also needed to apply a user centred approach by involving the future users of the adjusted NPD process! This implied that the social setting of the existing NPD process became part of her development activities. It is here that design acting comes in: developing the social interactions of the adjusted NPD process itself (Hatchuel 2001). She knew that an abstracted development process without involvement of the future users, i.e., SoftCy’s NPD actors, was not going to work because that would cause implementation problems.
after she was finished. One cannot develop an adjusted (NPD) practice for other people. This needs to be done in a collaborative setting (Smulders 2006 & 2010). And this is not all. For the same reason she also needed to involve SoftCy’s board of directors in her development activities. The board at SoftCy forms in fact the internal client of NPD, so they are part of the present NPD routines and will also be part of the adjusted NPD routines, which will require different forms of social interaction between NPD and the board. Similar was true for NPD management and project leaders. The approach that she took was to use an existing product in need of a redesign as a carrier for her design acting activities. She planned to involve the three groups of internal actors (NPD, project leaders & board) in her process as well as the external future users of the redesigned product. She first developed a fledgling vision herself on a particular user group by desk research and interviews with customers and other representatives of that generation. She brought that first idea in an interactive session to the middle management of the company and requested for involvement of various disciplinary NPD actors for one of her next steps. Without going into details it is clear that she had to design this interactive session as an intervention aimed at provoking a decision. The request was granted and she developed series of sessions with representatives from marketing, service and product development as well as present and potential customers. These sessions were based on interventionist tools like context mapping and working with personas (Sleeswijk Visser et al. 2005). A much sharper description of the target group came out of these workshops and informed an impressive list of recommendations regarding potential improvements for the product that she had chosen as carrier for trying out the UCD approach. At the same time these sessions formed the base for further implementing the UCD approach within the existing NPD process. Finally she presented her findings to the board of directors, convinced them to implement her strategy (and was hired ...).

In short, what she did was designing and enacting a first version of UCD process with all future users within SoftCy to set the base for further embedding and routinizing the UCD approach in NPD. This example particularly tells us that design acting is insoluble embedded in a design process that crosses the borders of design itself. Furthermore this example illustrates that a designerly attitude very well fits in an environment that has never been worked in such a way. It also illustrates that design acting in terms of the socio-interactive dimension of design definitely is applicable outside the direct domain of design. Finally it shows that design acting still requires design thinking to devise a suitable course of interventions and by that promotes the designer to an interventionist aiming to bridge the various gaps surrounding the actual design process.

**Discussion**

We have seen in this paper that design could be divided in design thinking and design acting. The first is to be seen as the learning and exploration process of the designer and relates more to the content related knowledge that is cumulative during development. The second brings the less articulated perspective of the socio-interactive environment surrounding any design process into the picture. Both perspectives were elaborated upon and essential elements as found in literature were discerned.

We found particularly interesting that the design problem, or better the design situation, needed to get its challenging value from the (first) steps by the ‘designer’. Framing the situation in such a way that it opens up to new possibilities for integration might be a promising characteristic to apply outside the field of design. Designers start looking for solutions, or opportunities for betterment, even without having a clear definition of the design problem. Edison showed us that all of design are challenges to what is and what is known to what is not yet known through a variety of methods and experimentation in search of means to integrate what is known and what is discovered in uncovering the unknown. Further research on history of exemplar designs and engineers aimed at capturing strategies that describe how designers treat initial situations will illuminate our understanding of design thinking.
Design acting brings us into a completely different field of literature on change & interventions as possibly also the field of knowledge management that increasingly treats knowledge as being both a thing and a flow (Snowden 2002). The development of the content (= product) being more related to knowledge as a thing and the social-interactive site of knowledge creation being more related to knowledge as a flow.

Designers are interacting with a large variety of actors not educated or trained as such and are introducing change. In order to make the design thinking attitude contagious design actors need to become change masters. They will need a deep understanding of the neighbouring discourses within the system affected by (their) development activities and be proficient in designing change programs and associated interventions among those that don’t posses any of the mentioned design qualities. Design beyond design is creating a secure social context that enables fledgling new organisational routines to surface. Such requires a similar confidence in design acting as designers expose in design thinking: being comfortable in situations of extreme uncertainty. It would be their responsibility to bring the group together to create a joint thinking of the product or service (the common cause) that emerges through these social-interactions and explorations. Further research is needed to discern and describe low level intervention tools, techniques as well as the roles of the supportive boundary objects.

Edison’s drive to make things that are commercially viable—a business goal—was integral to both his design thinking and design acting. While design thinking that characterized Gordon Murray and Edison were emphasized, their design acting capabilities were no less important in making a success of their endeavour. Murray, Gehry and Edison are/were certainly people that were able to master both dimensions of design, design thinking and design acting and thereby were able to master the change that they themselves provoked. If we are to bring design beyond the confines of its traditional field then we must carefully train those involved in both dimensions to provide them with the ability to create and implement the change that serves society.

A world full of design thinkers and design actors is not what we envision. Convergent thinkers that treat situations as either/or and base their decisions on what seems the best solution at that moment in time are necessary to maintain certain present qualities. A meta-design approach to the world’s situation that calls dramatically for sustainability is having people with both qualities, the ‘either/or’ and the ‘and/and’ in a well balanced collaborative mix.

Notes
1. Creation of tools by apes and the existence of differences in the tools used by neighboring communities of apes have been recorded. These evidences show the innate nature of design that evolution has refined over time (McGrew 2010).
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Design Thinking Situated Practice: Non-designers—designing

Nina Terrey
Faculty of Business & Government at the University of Canberra

Abstract
The practice of design thinking or design attitude by organisational members who are not traditional designers is yet to be explored and understood in the design thinking literature. Is it possible for non-designers to think like designers? The argument proposed is that organisational members can in fact take on design thinking and apply it usefully in their everyday work. This paper explores six attributes which can be attributed to non-designers demonstrating design skills and strategies like traditional designers.

1. Introduction
The application of design is moving increasingly into non-traditional areas such as organisation “wicked problems” (Buchanan 1992; Cooper 2010, p.59). This presents the challenge who designs in these contexts? This paper aims to demonstrate through empirical data that non-designers can demonstrate the behaviours of designers and are doing so with legitimacy in the organisational context. This paper situates itself in the recent writings of “managing as designing” (Boland & Collopy 2004) which presents an intersection of management discovering design and applying design thinking and methods to the way they manage their work. The emergent literature about "design-led" organisations will be the way of the future (Martin 2005; Hippel 2007) means design thinking and design methods are increasingly applicable and viable ways to view organisational management and managing change (Liedtka & Rosenblum 1996; Liedtka 2000; Martin & Dunne 2006). The emergent discourse of “designing as managing” (Boland & Collopy 2004) presents arguments for the role design can play in the way business and management can approach and tackle the complexities and problems faced in business (Boland & Collopy 2004; Martin & Dunne 2006; Hippel 2007, Buchanan 1992, 1995). In this paper, drawing from an exploratory case study, the question being asked is—What are the attributes of non-designers in the organisational context?

2. Study design and organisation background
This exploratory study focuses on how the act of ‘design’ has become embedded as a management capability in one organisation: the Australian Taxation Office. The Australian Taxation Office has responsibility to “effectively manage and shape administrative systems that fund public goods and services and safeguard retirement income for the wellbeing of Australians” [1]. In its role statement the organisation states one of its values as “being consultative, collaborative and willing to co-design” [2]. This value espouses behaviours in the organisation to actively find ways to work with citizens and taxpayers in the community and to engage them in the design of the tax administration system. This study’s interest looks beyond these value statements to the actual practices of management by design inside the organisation.
Research Methodology

The main methods of data collection were organisational and media artefact analysis, organisational member exploratory interviews, observations of design teams and auto-ethnographic accounts of being a designer in the case organisation (the author/researcher was a previous employee of the organisation as a designer). In the process of data collection, the researcher visited organisation sites in three major city locations and spent time with designers in their spaces and work environments. Interviews were conducted with 25 key actors who participated in the introduction, development and practice of design as a management approach in the organisation, in some cases members have been interviewed multiple times through different stages of data collection. The methodological approach based on grounded theory methodology combined with situational analysis and actor network theory. These theoretical and methodological underpinnings suited the research aim of “how has design become embedded and adopted in a large and complex organisation?” and forced the researcher to look at the enacted nature and the multiplicity of actions, and situated practices of design, drawing out the human and non-human elements of importance.

The analysis and insights presented in this paper have been generated from a series of analytical steps:

1. Between 2007 and 2010 conducted exploratory interviews, observation of participants, collected organisational documents and media artefacts. Interviews were conducted with 25 key actors who participated in the introduction, development and practice of design as a management approach in the organisation. Questions in the exploratory interview process included the pathway of each designer into the organisation, to ascertain if they were classically trained as “designers” or had evolved as designers in the organisation.

2. Iterative coding of the data (transcripts, notes, organisational documents, media artefacts) using Charmaz methodology (Charmaz 2006). Initially started with open coding using NVivo codes of the data and progressively clustered into themes and categories. One of the early categories was “designer attributes”. Some of the common themes in this category are discussed in this paper.

3. To further tease out the relationships Clarke’s situational analysis methodology (Clarke 2005) was applied to create maps of all the human and non-human elements in the data. Using the data codes messy and organised maps were created to visualise the multiplicity of actors and non-actors present in the case organisation about the practice and performance of design in action (see Terrey 2010b).

This paper will explore the themes from the category called “designer attributes” found in the data. These themes help show that the people in the organisation who are designers, but will be called non-designers have a legitimate right to call themselves designers because they display skills and strategies commonly associated with designers.

3. Definitions

The premise of this paper is that there are such people as “non-designers”. In this study the definition that defines this group are those people in the organisational context who resolve organisational design problems, perform design activities and follow a design process but have not been trained or educated in the craft of a design discipline, such as attending a design school (Rylander 2009, p.10). This paper’s findings draw from an empirical analysis of participants who satisfy this definition. For example some of the management disciplines which participants in this study have come from include: Human Resource Management, Training, Economics, Business Management, Marketing/Communications, Business Analysis and Finance.
In comparison, for this paper we will define “traditional designer” as people who have been trained or educated in some craft or design school. They may have formal training in such disciplines as graphic design, interaction design, industrial design, architecture, interior design and so on. They are people who are trained to develop design skills and apply certain strategies to resolve certain types of design problems. So what might be a set of designer skills and strategies which we could use to compare? This paper will not attempt to provide an exhaustive list of studies or references, but rather try to take a sensible view of the field of design literature. Drawing from current literature on design thinking and design attitude the attributes commonly documented include: the ability to visualise the problem and solution (Rowe 1987; Buchanan 2004; Junginger 2007); prototype change through making (Coughlin et al. 2007; Buchanan 2004; Boland & Collopy 2004); display integrative thinking and develop alternative courses of action (Martin 2010; Fraser 2010, p.44); foster new insight through human centred perspectives (Lockwood 2010, p.86; Junginger 2007) and collaborate to generate design solutions that work (Brown 2008).

Before we move into discussing the analysis of non-designers attributes it is important to draw attention to the product or design problems that these non-designers are applying their skills. In this case study the sorts of design problems and products are what Leadbeater (2004, p.50) terms “fuzzy public service ideas”. These are ideas such as how do we design “payment of fair share of taxes” or design “voluntary compliance of the tax system.” These are very different problems to how we might design a chair for an elderly person? Or how we design a self-sustainable building? To make my point when reading “Designerly ways of knowing” (Cross 2007) the sorts of design problems that are referred to are typically manufacturing consumer related examples e.g., a bicycle luggage carrier, a sewing machine, a racing car. When I pick up “Design expertise” by Lawson and Dorst (2009) there are more examples of industrial design, architecture, engineering, civic space artefacts e.g., telephone booths; and in “Design thinking” Rowe (1987) draws examples from architecture and urban planning. There is no reflection about design thinking skills being applied to fuzzy public services. So this paper is working in that gap in the literature to add perspective to designing fuzzy public service spaces.

Can “non-designers” illustrate attributes of designers? This is important because design thinking or designer attributes are increasingly seen as important management skill sets, and as Peter Coughlin from IDEO suggested “there are not enough designers to solve all the problems in the world” [3].

4. What has the research found?

Non-designers attributes

Imagine you are in a large government organisation, and it’s filled with accountants and lawyers. Imagine many complex relationships and interactions with government and policy makers, government departments, organisations such as (not limited to) tax agents, superannuation organisations, software companies, third parties and almost every Australian as taxpayers from individuals to large corporates and other associations in the tax system. Imagine you need to design how to implement a new government policy? Or design a new organisation structure? Or design solutions to stop taxpayers behaving in non-compliant ways? In this study, the Australian Taxation Office has fashioned a management approach using a design method (Body 2007; Junginger 2006; Terrey 2010) that is inherently human-centred and interaction focussed. It has management arrangements with people in design roles e.g., design managers, designers, information designers, user centred researchers, design facilitators. Some of these designers come from non-design backgrounds. They act with legitimacy in the organisation demonstrating design skills and attributes. What might be the attributes of these designers? How might these compare to traditional designer attributes? In this paper we will draw on six attributes which have been thematically distilled from interviews and contextual observations
of organisational members enacting design. In the following 6 scenes the title "designer" has been given to those actors who are defined as non-designers. That is these scenes are based on those actors in the organisation who enact design expertise and have come from non-design backgrounds.

**Attribute 1: Strong Visualisation skills**

Scene 1: A senior leader just met with a couple of designers who worked in one of the teams he managed. He reflected on the meeting afterward: Senior leader: “I met with the team and they took me through some documents they’d developed, some high level views of how the X tax scheme worked. It was a bit of a shift from the way things were done for current taxpayers and new taxpayers. So there were a couple of elements to it. It just wasn’t simple. But I saw the designers take a pretty complex, administrative solution that involved moving people from a system that they knew and worked well and they could claim by phone and things like that to claiming on the quarterly business activity statement. I saw through the documents the designers bring together all these strands in a really simple design. It was really helpful for me to understand in arriving at that position.”

In this scene the designers demonstrated the ability to visualise and present complex information into a coherent document. The document was the product of design thinking by the designers and was used to mediate conversation between the designers and the senior leader. The creation of artefacts or documents is a common way that designers in the ATO demonstrate their ability to visualise changes and design of new products and services in the Tax system. In every interview references were made to either the creation or consumption of designers’ artefacts. These documents are often filled with diagrams and other visual representations. The visualisation skills mean drawing together many elements of a problem and synthesising these in ways that tell compelling stories.

**Attribute 2: Ability to work with complexity**

Scene 2: A core team of organisational expert participants came together in a workshop. The topic was to explore what would be involved in the administration of implementing a new type of tax. Each of the people attending the workshop came from an area of expertise—operations, tax technical, a business area and design. The designer positioned himself as the facilitator at the front of the room next to a printable whiteboard. The conversation started with the designer opening the topic and handing over to the business lead. The space opened into conversation and the designer documented the conversation on the whiteboard. Page after page was printed of key ideas explored by the group. The designer interjected throughout the process and pressed for ideas and comments from the group. The designer recalled the workshop: “There was vast amounts of information to get across from all the people in the room— we had to look at the past, what was happening now, to what needed to happen in the future with the proposed change. We had to cut across a whole complex system: we looked at the policy, the law, the compliance aspects, the transactional aspects and the taxpaying community aspects—all those elements that make up an administrative system. We asked questions like "how’s the community going to work with this? How’s business going to work with this? What’s the Tax Office experience? What role might third parties play?”

This is a typical scene in the ATO where designers operate. The designer embraces the multitude of elements which constitute the design situation. The designer exhibits an ability to work with complexity by drawing together people who hold different views on a subject. The art of working with a variety of information—both tacit and explicit—and to process this information progressively is a particular skill of designers in the ATO. This statement summarises this point well “So, you have to make sure that you can actually conceptualise what people are saying on the board so that the design forms in front of them and they can respond to it straight
away.” Underlying this attribute is a very rich dataset of the design questions designers ask to better understand the complexity of their design problems.

**Attribute 3: Ability to think strategically from a user perspective to change**

Scene 3—Designer: “We were presented with a new idea from a business area to change the way certain groups of taxpayers comply with the law. The idea was expressed as an internal business process and offered almost non-existent explanation of the user or taxpayer experience. We ended up getting 16 people in a room and plotted the taxpayer pathway. It became apparent that the consequences of actually implementing the idea meant the outcomes being sought would not be achieved. We showed that by registering to lodge tax returns a certain way, they were actually kicked out of another system which disadvantaged the taxpayers. The pictorial representation meant that it was really clear for the group and eventually the Deputy Commissioners to understand the impacts of what they were suggesting”.

The designer in this scene takes a strategic view of the outside in, or the user perspective. The reference to a pathway map is a common way for designers to model a strategic view of ideas and changes. It highlights the contextual view, not a technical or small scoped view that the designer brings to organisational thinking. The understanding of the whole builds the designers ability to judge and recommend business decisions. It is apparent in the data that user-centred and taking an outside in view was core to the understanding of design within the organisation. There were many references to pathways being used as strategic tools of influence in varied business situations.

**Attribute 4: Ability to engage and drive collaborative dialogue**

Scene 4: A team of designers travelled to a regional city. They went to a local conference centre where they set up a room of tables, clustered in three groups of five people. The room filled up with people from the community and once everyone was seated one of the designers introduced the day and thanked everyone for their time. The designer explained that the day was an opportunity to discuss and contribute to the design of some key products which they use in their tax experience. The tables were soon in chatter and people were talking and debating different points related to their experiences and the products they were helping to design. The designers were scattered throughout the room and once the tables got into the session the designers sat at the table groups and helped the group with their tasks. There were large sheets of paper marked up with ideas and comments.

The designers in this scene are active in engaging taxpayers in participatory design practices. They are facilitating the generation of ideas through dialogue. This skill of facilitation is used throughout the organisation. In the organisational role structure there are dedicated design facilitators. In the data analysis design facilitators are an active group of designers in the organisation. The analysis of the data showed that some designers were more comfortable facilitating than others. The art of collaboration is a hallmark characteristic, as one manager stated “those who want to do design facilitation, for example, well, most of the office probably thinks they're a bit odd really, let's face it ... frankly what they did was encourage and facilitate the process of talking to taxpayers and those outside the Tax Office around the process and working it through whereas previously you just struggled to do that because the framework was really absent”.
Attribute 5: Ability to problem solve through inquiry

Scene 5: A group of eight organisational staff and a designer came together in a workshop to explore proposed changes to the way they work. The group huddled around a table discussed the proposal between themselves and the designer.

Group participant: It’s just purely a workflow change, don’t worry about it.

Designer: Well sure, but what might the risks be?

Group participant: I’ve got this—we’ve got a review coming in and we’ve got this huge amount of work that’s going to impact on us.

Designer: Why is that a risk?

Group participant: It’s huge.

Designer: Sure. So what? Why is it a risk?

Group participant: Oh, I don’t have enough time to do it.

Designer: So why is that a risk?

Group participant: Well I’m going to be retiring.

Designer: When?

Group participant: In the middle of it.

Designer: Wow, there’s your risk. Who knows what you do?

Group participant: No-one.

Designer: What succession plan have you got in place?

This scene highlights the process of inquiry which the designer went through to get to the real problem that needed to be designed. Inquiry is the art of asking questions and abstaining from solutions too soon. This scene highlights a dialogue that uncovered management issues, not just organisational work process changes. The designer creates legitimate space in the organisational dialogue to explore the real problem. In the analysis the ability to question and search for the underlying systemic problem was a common way of thinking amongst designers in the ATO.

Attribute 6: Ability to prototype changed experience

Scene 6: The design team met in a room and positioned around a whiteboard. One of the designers drew a horizontal line on the whiteboard. The team discussed and mapped out the experience for a certain group of taxpayers who were to experience a new tax rebate. It would affect millions of Australians. They mapped out the pathway of change for a taxpayer. Over the next few weeks the pathway sketch that the team drew on the whiteboard was refined into a documented poster. The team organised a physical walk through of the experience they mapped. They organised an event and invited senior leaders from the organisation to come and “experience” the change which this new rebate would offer a large proportion of the taxpayering community. They printed huge posters of the pathway which they pasted to walls. “As people came in and looked at it, everyone got it as soon as they looked at it. They would
say yes—I see what this will mean for the taxpayer, for tax agents and the organisation”. The response was positive even to the point that the walkthrough highlighted where there were issues. “It was really obvious what we needed to do. It made it easy to make a design decision because you could really see where the problems were. It brought the problems to life”

This scene illustrates the power of generating prototypes of experience as a movement of artefacts from a conversation, through to a sketch, to a document, to a poster and a physical walkthrough and back to facilitating a conversation again! It shows the skills of designers to engage the organisation in the process of discovering important decisions through easy to understand mediums that focus on the end result—the experience of taxpayers and intermediaries such as Tax Agents allowing decisions to be focussed.

![Figure 2. Narrative of experience as a pathway](image)

### Table 1. Summary of non-designer attributes

<table>
<thead>
<tr>
<th>Non Designer Attributes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Strong visualisation skills</td>
<td>To synthesise written and verbal information into artefacts that communicate design problems and solutions to organisational members.</td>
</tr>
<tr>
<td>2. Ability to work with complexity</td>
<td>To tease out multiple dimensions of a problem and frame design challenges by exposing the complexity.</td>
</tr>
<tr>
<td>3. Ability to think strategically from a user perspective</td>
<td>To understand the impacts on the end user when introducing new or changing existing products and services.</td>
</tr>
<tr>
<td>4. Ability to engage and drive collaborative dialogue</td>
<td>To facilitate dialogue between users and the organisation in ways that build safe and innovative working environments.</td>
</tr>
<tr>
<td>5. Ability to problem solve through inquiry</td>
<td>To be inquisitive about organisational problems and define the underlying problems.</td>
</tr>
<tr>
<td>6. Ability to prototype change experience</td>
<td>To create models, maps, visualisations of the experiences to engage the organisation in meaningful and productive ways.</td>
</tr>
</tbody>
</table>
5. How do these attributes compare to traditional designer attributes?

We can make some direct statements of correlation, in a qualitative sense between these 6 discussed attributes of non-designers and those discussed earlier for traditional designers. The following four points capture some discussion.

First, the use of visual methods to represent problems and solutions was apparent in most of the scenes. It is a way these non-designers communicate and operate; it is symbolically different to the way the rest of the organisation communicates. Traditional designers also use visualisation as a key design strategy. In the ATO the designers use visualisation as a way to bring together and interpret complex information and they take pride in creating artefacts that are used by others. The nature of visualising a tax system is very different to a physical product or a poster for aesthetic appeal. This could be a skill that these non-designers have refined through application to fuzzy public service problems.

Second, the act of prototyping changed experiences is similar to traditional designers modelling new products and services by determining the desired experience for a product in action. It was found in this study prototypes of experience was used as tool to influence decision makers in the organisation. Traditional designers use similar approaches to encourage empathetic and engaging dialogue with their clients to enable decision making.

Third, engaging others in collaborative dialogue was inherent in most scenes and demonstrates the ability to lead others in the design thinking process. Traditional designers may also find themselves leading design processes with others to generate solutions. This skill of facilitation in the ATO is well refined and has nurtured the organisation to have meaningful collaborative conversations between themselves and community/taxpayers. To what extent traditional designers operate in a facilitative role and train in these sorts of skills is worthy of a debate.

Finally, the ability to work with complexity is common to both non-designers and traditional designers. In common the ability to tackle complexity by taking a user perspective and design from the user’s view is shared. In the case of these non-designers in the ATO this was a significant shift in thinking for the organisation to move from internal thinking to thinking about the taxpayer experiencing the tax system. The act of bringing the user voice closer to the decision making corridors of the organisation was significant in organisational mindset. The ability to bring to attention the human factors to solve problems and design solutions is a skill of designers, e.g., interaction designers.

6. Conclusions and questions?

This paper has presented argument that non-designers can demonstrate skills and strategies of designers. This claim raises important questions such as: how did these non-designers learn the skills and strategies of designers? How have these been maintained? Who has played a role in this? Are there materials mediating this learning? These attributes could be the result of experiential learning and knowledge (Austen 2010, p.21). Or: to what extent are these non-designers to be considered experts or novices? According to some studies expertise is attained by those who have at least 10,000 hours, or 10 years of experience (Lawson 2009, p.83). Is this a feasible concept when the organisation has only applied design thinking for about 10 years, therefore there would be some who meet that criteria but not all? In what ways does the nature of the design problem—design of fuzzy public services offer new knowledge about design thinking to traditional designers? It may be reasonable to argue that these design problems have created a situated refinement of design thinking which has come from learning from practice (Lawson 2009, p.280). Would it be reasonable to assert that the problems of these
non-designers are non-traditional? Could it be, what Professor Richard Buchanan discusses, the idea of a “new type of designer” [4], one that can design on more complex problems/systems such a tax system? This paper has attempted to contribute to the design thinking literature by extending the lens from looking at the skills and strategies of traditional, trained designers, to the emerging organisational designer. And by doing this, extend our vision of the possibility that non-designers can design and therefore play a role in creating preferred futures rather than futures by default or mistake.

Notes

1. www.ato.gov.au

2. See above

3. Peter Coughlin’s comments (as part of a panel on design management chaired by Richard Buchanan) at the Second Global Forum for Business as an Agent of World Benefit: Manage by Designing in an Era of Massive Innovation, held in Cleveland Ohio at Case Western Reserve University, Weatherhead School of Management, June 2009.

4. Richard Buchanan’s comments (as chair of a panel on design management) at the Second Global Forum for Business as an Agent of World Benefit: Manage by Designing in an Era of Massive Innovation, held in Cleveland Ohio at Case Western Reserve University, Weatherhead School of Management, June 2009.
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A Taste for Practices: Unrepressing style in design thinking

Cameron Tonkinwise
Parsons The New School for Design, New York, USA

Abstract

The current vogue for design in management and social change circles results in abstractions of the design process into a series of dot-point-able techniques. This paper begins by noting that conspicuously absent from those lists of design thinking techniques is: aesthetics, form. As designers have attempted to move up the consultancy food chain, they have tried to conceal the extent to which they are stylists. An instrumental privileging of functionalism that downplayed the aesthetic distinctions at the core of designing has now been replaced by claims to empathically researched universal human conditions.

The paper offers an explanation as to why design as styling is being repressed at the moment, and then explains what is being concealed. It theorizes that a key aspect of the agency of designing, as the creation of artifacts to facilitate activities, lies in this taste literacy of designers. Designing involves interpreting a target group's aesthetic choices for insights into that group's capacities for different kinds of interactions with the world; and vice versa, deciding to make possible certain interactions with (a designed artifact in) the world by translating those interactions into particular taste regimes (and not just aesthetically neutral 'affordances' or universally appreciated 'beautiful uses').

The framework for the argument of this paper is Pierre Bourdieu's notion of 'habitus' and the notion of 'style' as proposed by Fernando Flores and his colleagues. The paper argues that designers are, in essence, Bourdieusian sociologists, with capacities for reading taste regimes (if they remain within translatable distance of a designer's own taste regimes) for the possibilities of new styles of action. This explains why design education, through rituals such as crits, remains a process of inducting students into the habit of self-fashioning according to tacit and morphing rules of taste, and why new kinds of design, such as persona-based branding, results in practicable innovations.

1. Refashioning Design Thinking

It is strange that in all the current talk about “design thinking,” almost no reference is ever made to the work of the Design Thinking Research Symposium, which has been collating and initiating innovative yet careful and extensive research into the nature of the design process for two decades (though this may be shortly corrected when Nigel Cross publishes his Design Thinking with Berg in Spring 2011), or indeed any of the research published explicitly in relation to the cognition of expert designers—for example, Lawson (1980; 2004), Rowe (1987), and more recently Dorst and Lawson (2009). This evidences that what is being promoted as “design thinking” seems content to extrapolate from the internal reflective practice of a design firm (IDEO, in the case of Brown 2009) or from a selection of interviews and participant observation of design principals by management educators (in the case of Martin 2009). It is a shorthand for ‘designing for non-designers’.

What is lost in this exportation? It might seem that “design thinking” is design minus the material practice (Kimbell 2009; Burdick 2009). However, “design thinking” is foremostly defined as the sort of action research that comes from fail-friendly, iterative prototyping in contexts of immersive social research. Without referencing any of the research of designing, ‘design think-
ing” does acknowledge that this experimentalism does involve a kind of problem-definition/solution-proposition co-evolution—see for instance Jennifer Riel’s box-insert in Martin (2009, pp.94-5) on design as wicked problem-setting.

So, in the end, it seems that what must be removed from designing to make it appropriable by managers is: aesthetics, by which I mean, anything to do with form-giving, the pleasing appearance and feel of a design. Roger Martin’s Business by Design makes no reference at all to aesthetics. It quotes with approval Hugh de Pree discussing the authority granted to designers over the development of the Aeron Chair, now an iconic form, that “Designing... comes to grips with the very essence of a problem, from the inside out, as opposed to 'styling,’ which concerns itself largely with the distinctive mode of presentation or with the externals of a given solution.” (2009, p.113) Tim Brown’s Change by Design opens with a first chapter that is explicit about the need for strategic design to displace design’s aestheticism: “Getting under your skin, or How Design Thinking is about more than Style.”

At one level this is understandable. If “design thinking” is design for non-designers, then “design thinking” must be able to be done without becoming a designer, without having to adopt the lifestyle and working environment and habits of designers, their penchant for being concerned about fashionable appearances, their own and that of everything around them. But in another way it is strange that almost none of the 4-7 dot point lists circulating about what is involved in being a design thinker (see for example the compilations of Wroblewski 2006; 2007; 2008, which at least include pattern recognition and visual story telling) mention any of the habits of designers; forever browsing different media for a sense of different formal trends in different areas of design; making large collections of liked and inspiring examples (on this see Keller et al. 2009); constantly critiquing with a distinctive lexicon the aesthetic quality of the designed output of partners, peers and students (on this see Strickfaden & Heylighen 2010).

2. Constraining Styles

Even if current promoters of “design thinking” as strategic management had consulted the findings of Design Thinking Research, they would not have been clearly redirected toward the aesthetic side of designing. Style is a primary concern of Rowe’s, but as a morphological constraint of particular design disciplines and the cultures within which they are practiced, rather than as a variable that is distinctive to the problem-responding done by designers (see also for example, Chan 2001). Lawson has long argued that style is an imposition retrospectively read onto completed designs by critics rather than a concern manifest in grounded theorizing of the design process. For Lawson, aesthetic styles may be sources of primary generators, abductive ways of finding appropriate gambits, but these must then be reformed and validated by more functional requirements. Dorst mentions in Understanding Design that the (Design Thinking Research) knowledge-base around form-giving is weak (2003, p.36) but has an entry for “Good Taste” (p.181). There are however no index entries for aesthetics or style in Design Expertise (Lawson & Dorst 2009, though there is a discussion of form describing language used by designers as described by Tovey in relation to automobile design and Eckert and Stacy in relation to fashion and helicopter design; there is also a rather critical discussion of form-driven design in relation to the iconic work of Stark and Utzon). Journals such as Design Studies contain studies of consumer perception of product form (for example Crilly et al. 2004), but the theoretical framework tends to consider form as only one outer layer of a design, and consumer attitudes fixed constraints—though the exception is Janlert and Stolterman’s rich proposal to consider product design in terms of character or personality (1997; see more recently Desmet et al. 2008), a metaphor that is less layered and more integrated, and one that suggests that styling is a rhetorically variable aspect of interaction design and not just environmental constraint into which the design must fit. It could also be noted that communication design, and even moreso, fashion, areas of design practice that are especially concerned with styling, are rare

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foci for research of design (though in Design Studies on textile and knitwear design, see Petre et al. 2007, and Eckert & Stacey 2000).

Yet surely, if design is about changing situations into preferable ones, one of the main criteria, or at least a necessary if not sufficient criterion, as to what counts as preferable that is particular to designers, is increased aesthetic pleasure. Are we in a situation where all the attention being paid to design, whether researched or promotional, is nevertheless missing one of the primary aspects of designing? And does it matter if design is cast, by “design thinking” promotions or Design Thinking Research, as not primarily an aesthetic practice?

The following paper is motivated by these rough observations. It takes the conspicuous absence of styling from “design thinking” as a prompt to sketch out a realigned theoretical framework for future research of design, one that attempts to outline how it might be hypothesized that designers think through style, how they solve problems or find problems and improve situations by having a stylistic predilection.

3. Restyling Design

Why might “design thinking” be repressing design as styling? Current promotions of “design thinking” are clearly aimed at enhancing the power and earning capacity of designers. To move designers up the hierarchy also means moving them earlier in the process, extracting them from their position as last phase surface treatments of already prescribed product types. This back-ending of design appears to be a legacy of design’s original promotion, especially in the USA, by the Streamliners: Dreyfuss, Geddes, Loewy, Teague (see Miekle 1971—though this is a misunderstanding; Streamliners birthed design in the US as market-creating brand innovation, with rich modernist ideologies [Andrews 2009]). Styling is belittled in order to insist on design’s inclusion in business strategy development. In an era concerned about sustainability, repressing design as styling also frees design from implied responsibility for gratuitous consumption.

Aesthetics are also thought to be subjective. The managerialism that is interested in “design thinking” claims to be shifting to less algorithmic modes of operation, but it could be that the stylistic aspects of design remain too incalculable. It could also be that in a related way, aesthetics is too political. Sam Lardner has conjectured that “design thinking” is a way of concealing the politics of management (2009). Aesthetics, as inherently subjective, and/or cultural, foreground interpersonal politics.

4. Taste Practices

It is Pierre Bourdieu (1984) who has done the most to make clear that aesthetic judgments are inherently and forcefully political. Precisely because questions of beauty and taste appear natural, or universal, they are powerful ways of reinforcing hierarchical distinctions between people. They make visceral—in the disgust or desire one feels for what others wear, or like, or use—levels of cultural capital, in other words, which non-necessary values one has been able to afford, or afford to use, learn about or discuss. They comprise a competitive game with hidden and changing rules. Despite its commitment to failure-friendly iterations, perhaps the risks involved in styling are too much for “design thinking”.

Bourdieuian readings of aesthetics as political have reached design studies, understood as material cultural studies of design objects as they circulate in society (for example, Lloyd 1991; Julier 2007; Boradkar 2010). But they have not sufficiently reached the research of designing version of design studies.
Bourdieu’s *Distinction* (1984) is an entertaining and convincing read because of the empirical way in which it demonstrates homologies between different fields of taste. The numerous portraits provided throughout the book build up overlaid maps of people’s taste, so that the reader can begin to see parallels between someone’s literal taste, what they like and do not like to eat, and their taste in household furnishings, or the size and nature of their household book and music libraries, etc.

Bourdieu’s sociology in *Distinction* then appears as reflexive version of a expertise that we all more or less have as we attempt to read the financial, social and cultural capital of people we meet. Film art directors are exemplary Bourdieusians, finding ways of giving us rapidly comprehensive portraits of a character via the artifacts visible in a 5 second camera pan about that character’s room. Glimpsing that poster, those objet d’art, and these kinds of clothes, allows me as a viewer to make quick hypotheses about the person whose room this is, about their class, their level of education and financial standing, for instance—but also, especially if you are a (interaction oriented) designer, of what they are capable, their facilities with various kinds of activities.

In most uses of Bourdieu’s work, and indeed, in *Distinction* itself, the emphasis in these cross-field parallels tends to remain at the level of selections of signifiers. However, importantly, there are practical aspects too. *Distinction* suggests that people who select the same television shows from all that is on offer will tend to not only wear similar kinds of clothes, but will also have similar levels of knowledge about fashion. They will share ways of talking about fashion, and they will share how they go about buying and wearing clothes. In other words, taste regimes also manifest as practices, in this case the practice of being more or less fashionable.

Bourdieu makes this point when indicating that people from differing levels of social and cultural capital may ‘like’ the same image, but for very different reasons, or rather, because that image is part of very different practices of image appreciation. A black and white image of old woman’s hands can be liked for its formal compositional properties by someone practicing a kind a high bourgeois art historical appreciation, whereas it can be appreciated as a sympathetic portrait of suffering by someone practicing a kind of petit bourgeois empathetic humanism (1984, pp.44-5).

Bourdieu is acknowledged as having initiated the current ‘practice turn’ in sociology (Schatzki et al. 2001). However, as Alan Warde, in the context of sociologies of consumption (2005), has pointed out, the link between the kinds of taste regimes that Bourdieu maps in *Distinction* and practices, as I have just explained them, was not made clear by Bourdieu. Warde (2004) is forced to do some extrapolating to make sense of the formula in *Distinction*, “[habitus capital] + field = practice,” and finds it necessary to use Theodore Schatzki’s characterizations of practices as more discrete ‘teleoaffective structures.’ (2002) The work of practice-based sociologists such as Schatzki and Andreas Reckwitz is now being incorporated into accounts of design (Shove et al. 2007; see also the activity-theory work of, for e.g., Gay & Hembrooke 2004). With this, the connection between Bourdieu’s work on taste regimes and designing becomes clearer. Being adept at discerning taste regimes also affords you access to what could be practice regimes—fields of know-how. Understanding the aesthetic judgments of someone provides insight into what he or she can do, or could be helped or persuaded to do.

I am therefore suggesting that there is an expertise to designing which involves reading people’s taste regimes for their practice style potentials, or vice versa. A crucial part of designing is being sensitive to overlapping tastes, the habitus that enables those overlaps, and so the practice dispositions of people with such habitus. Designers are concerned with style, because style is a translator of people’s structured choices into action propensities.
5. Innovative Styles of Practice

To explain, let me broaden the notion of ‘style.’ Style most immediately refers to a look. However, the term equally applies to actions, to the modes or moods with which activities are undertaken. Any practice is able to be performed in various ways; not just in distinct sequences, but with distinct paces and pressures and mindfulness. For Fernando Flores and his Heideggerian colleagues, Charles Spinosa and Hubert Dreyfus (1999), style is more like the ground of a practice, that which coordinates actions and makes them meaningfully part of a practice:

There is more to the organization of practices, however, than interrelated equipment, purposes and identities. All our pragmatic activity is organized by a style. Style is our name for the way all the practices ultimately fit together. A common misunderstanding is to see style as one aspect among many of either a human being or human activity, just as we may see the style as one aspect of many of a jacket. Our claim is precisely that a style is not an aspect of things, people or activity, but rather, constitutes them as what they are (p.19).

The importance of this more ontological way of characterizing style becomes apparent exactly when Flores et al. describe encounters with new situations:

Sometimes finding a situation familiar means simply having an appropriate set of dispositions and having them respond on cue. No doubt people do form habits and find situations familiar, but there is another feature of familiarity that is different from, indeed, opposed to, this sort of habituation. One can find a situation familiar even when one has never experienced its like before. In such a case what makes a set of practices feel familiar is that they share a style (p. 19).

Now this is an important point worth dwelling over. Flores et al. are writing in a book about entrepreneurship. They are attempting to articulate the difference between a politics or managing that:

a. conserves present setups, perhaps with incremental innovation (or evolution)

b. proposes unfeasible disruptions to present conditions, and

c. generates significant innovations around which present situations can nevertheless realign.

The difference b) and c) is like the difference between art and design. The latter is concerned with use; the new that it creates must be practicable. Getting at the essence of design then, as opposed to some more radical or abstract creativity, means explaining not just how design manages to generate the new, but also how design manages to generate the not-so-new-as-to-be-unimplementable, Loewy’s famous MAYA—Most Advanced Yet Acceptable (see also Nelson and Stolterman 2003). For Flores et al., the secret concerns style, innovating but still within a style:

When people change their practices in meaningful ways, they do so on the basis of the style they already have. Style acts as the basis on which practices are conserved and also the basis on which new practices are developed… (p.20).

People who are very sensitive to the style of some domain are particularly good at making such adjustments. In fact, it is this characteristic that allows us to see a mastery in what they do… [Expert sportspeople] show their mastery of the game when they win by doing something that we would not have expected could be the reasonable thing for them to do given what we have seen before; but when it works out, we see,
in hindsight, that what they did was to respond to the new situation by staying within their style and doing something new that the style called for. (p.22).

The hypothesis that emerges then is that designers, as expert innovators, operate within discernments of style and their variability. This is what risks being ignored when design thinking avoids the primacy of the aesthetic in design.

There are 3 consequences that I would like to draw out. Each forms a hypothesis for subsequent research.

**A. Practicing Personas**

Much in vogue at the moment is the role of scenarios in user-centered designing (e.g., Carroll 1994). A key though still controversial component of scenario-based designing is the persona (Pruitt & Adlin 2006). This fictitious individual, somewhat accreted from market research, is designed to represent the user, quite literally speaking for the user during the design process. Yet a persona is quite literally a Bourdieusian profile; it is an inspiration board of tastes and activities. Alan Cooper who originated the practice of using personas in user-centered design research (2004) claimed that personas allowed designers to access user goals in design-motivating ways. But I would rather claim that personas disclose styles, precisely as the pivot between taste regimes and practices. Unless style plays this role, it is impossible to explain the effectiveness of personas, how they enable designers to move from an ‘is’ (a description of a target market situation) to an ‘ought’ (a design proposal for an improved situation). From a Bourdieusian perspective, personas are exactly like art direction in relation to film characters; demonstrations that designers are adept at reading practical traits from stylistic built environment decisions.

**B. Brand Afforded Practices**

The promotion of “design thinking” was made possible by the expansion of branding from integrated visual identity to experience design. Where the project of the former was merely finding marketing channels throughout the customer’s experience of discovering, purchasing and using the product, the latter attempts to use the look and feel of the touch points of a customer’s interaction with a company to facilitate the co-creation of value (Prahalad & Ramaswamy 2004). Branding is then no longer a one-way communication exercise, but an interaction design aimed at guiding the service providers (‘internal marketing’) and facilitating the customers in the service delivery (Neumeier 2009). This opens a space for strategic design (Verganti 2009).

Now, branding is very clearly a proactive version of Bourdieusian analysis. Conventional branding attempts to use the homologies of taste regimes to associate products and environments with the same levels of cultural and social capital. Experience design, as the convergence of interaction design, service design and branding, reintroduces the practice dimension to this Bourdieusian process. Branding becomes an exercise explicitly in styling, in the full practice-oriented sense of Flores et al.

There is almost no Design Thinking Research style work on branding-based design (though see McCormack et al. 2004 for an example of style-as-constraint/branding-as-marketing). More work is needed following the lead being taken by Megan Strickfaden in relation to analyses of the role of cultural capital in designing (for example, 2004; 2010). That work should be interrogating the role of branding in what Alan Costall identifies as “Socializing Affordances” (1995). To what extent are affordances stylistic, or of the same field as certain taste regimes? This is similar to Krippendorf’s Semantic Turn (2006), which calls ‘meaning’ the nexus of taste signifiers and use affordances. Krippendorf uses the model of language, suggesting the articulatability of these integrative meanings, whereas the more culturally-situated, embodied-action perspective of Bourdieu is deliberately designed to foreground the tacitness of many of these
actions, the extent to which they are habitual or structured rather than interpreted or even negotiated.

Validating these claims would entail introducing Bourdieusian profiles into usability testing. One would be seeking to correlate sets of users with similar symbolic capital with the immediacy of features on designs intended to work as affordances. One could hypothesize finding, as Lucy Suchman famously did (1987), that what usability engineers presume is a universally rational communication, is in fact highly situated within a particular ensemble of cultural capital and even taste regimes. Suchman insisted upon a more Schatzkian version of the bounded ecosystem that comprises a practice, but research should now be done on the impact of more Bourdieusian socio-economic variables.

C. Reproducing Modernist Practices

One of the important reasons for reconsidering style in relation to design thinking is because of the extent to which style remains central and pervasive in design education, in both the exoteric and hidden curriculum. Design education is exemplarily Bourdieusian:

The studio system is essential for socializing students with a cultivated habitus... By saturating students with the objects of architectural culture; by presenting them with role models, living examples of embodied cultural capital (hence the insistence on the importance of having practicing architects as teachers); by displaying in all the slight ways of manner, dress and taste that one is becoming what one wishes to be, the student absorbs that cultural capital in the only possible way, by presenting to the studio master's gaze their whole social being. (Stevens 1995, p.117)

This suggests that design education is not just about learning to play the game within the design field, but, since it is so explicit a form of reproduction, becoming adept at discerning the games of other fields.

Though this is exactly what needs to be evaluated: to what extent are designers capable of empathizing across taste regimes and classes of cultural capital (see for instance, Aspers’ work on global fashion supply chains, 2010)? Jan Michl has recently decried the continued hegemony of modernist styles of design (2007). When Neumeier, as the exception in promotions of “design thinking”, devotes Part 2 of The Designful Company (2009) to “The Rebirth of Aesthetics,” it is a celebration of elegance. It usefully demonstrates that a concern for aesthetics manifests not just in designers pursuing pleasing artifacts, but also pleasing solutions, artifact-enabled practices that have unexpected simple styles (on this see also Lowgren & Stolterman 2004 and Bardzell's project to develop an interaction design aesthetics, 2009). Neumeier recalls the oft-quoted Buckminster Fuller: “If the solution is not beautiful, I know it is wrong” (p.73). However, parsimony, far from being a universal truth, is a very particular modernist aesthetic, whether in organizational design as Neumeier mentions (see also Guillen 1997) or computer programming as David Gelernter discusses in Machine Beauty (1998). By way of contrast, consider Francois Jullien’s work on Ancient Chinese aesthetics of Detour (2004) and Blandness (2007). When Donald Norman claims in the first chapter of Emotional Design (2005) that “Attractive Things work Better” what design education taste regime is being reproduced?

6. Concluding remarks

I have been arguing that the promotion of “design thinking” has been replicating a tendency in Design Thinking Research to downplay the primacy of aesthetic in designing. This risks concealing the way in which designing is the designing in, with and of styles; styles that make possible existing and new forms of social practices. Concealing the practice-oriented nature
of styles in design in turn risks restricting design to only those styles to which modernism has naturalized us.

**Acknowledgements**

Many thanks to Lucy Kimbell for looking over this paper and providing crucial references, and the reviewers whose suggestions were more instructive than this edition of the paper evidences.

**Notes**

1. Double quotation marks from now on will signal the current popular discourse of design-based innovation and management, as opposed to research into the cognitive processes of designers designing.
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A Clash of Concerns: Applying Design Thinking to Social Dilemmas

Nynke Tromp
Delft University of Technology, Delft, The Netherlands

Paul Hekkert
Delft University of Technology, Delft, The Netherlands

Abstract
Design thinking is currently repeatedly promoted to play an important role when dealing with pressing social issues. In line with this, we witness an increasing interest among designers to take up these challenges that go beyond the regular design scope. However, understanding how design thinking can be applied to social issues and what value this might have, is still relatively unexplored in design research.

This paper reflects on two graduation projects in Industrial Design that explored how a designer would cope with a social problem rather than a user problem or an engineering problem. Analysing these projects on the basis of what has been described in literature as either design thinking or typical designer skills, we suggest that the designer’s integrative thinking and human centeredness are important when dealing with social problems. On the basis of the typical characteristics of social problems, we will show the value of these skills in this new domain.

Next to this, in reasoning from the complex social problem to an appropriate product aim, both cases represent a similar pattern. This pattern of reasoning, resembling what has been described in literature as systems thinking, seems essential in coping with the typical complexity of social issues. We conclude the paper with discussing whether this tendency of designers to take up social problems will bring unique value to this social domain.

1. Introduction
Although design thinking has never been precisely defined, the traditional turn in design thinking research has originally been to understand the designer’s reasoning patterns (Roozenburg 1993) what design ability is (Cross 1995) or what cognitive operations are used when designing (Stempfle & Badke-Schaub 2002). Regularly, this reasoning has been researched in relation to the type of problems designers aim to resolve, e.g., ill-structured problems (Simon 1973) or design paradoxes (Dorst 2006), and how they particularly go about this, e.g., by (re)framing the problem (Dorst & Cross 2001; Schön 1983), by generating solutions until one ‘satisfices’ (Simon 1969, p.64), or for instance by using visual representations.

However, in current practice, design thinking has been used to describe more than only the designer’s cognitive skills used to get from design brief to design. In the context of business and organizations, design thinking refers to an approach to take or a strategy to apply (Brown 2009). In this context, taking a human-centered approach or a systems view are said to be part of design thinking. Moreover a design thinker is ascribed a wide range of qualities like for instance being a collaborator, an experimentalist and an optimist (Brown 2008; Owen 2007). Although the term refers to a wide variety of concepts and processes, it mainly indicates that the role of the designer in practice is changing. And this change is of relevance to design think-
ing research. The notion that designers move from a tactical to a more strategic role (Brown 2009; 2008) opens up new challenges for understanding what design thinking is or can be.

In this paper, we reflect on two projects in which the designers took up a social problem to design for. We analysed both cases to see what particular design thinking skills are important or of value in relation to social problems. Next to this, we studied both cases to see whether reasoning patterns emerged that are not so easy recognized as typical design thinking, but do seem important when dealing with social issues.

2. Design for Social Problems

Before describing the two design cases in larger detail, two general aspects of both cases are described: the type of problem, i.e., social problems, and the design approach, i.e., Vision in Product design (ViP). We shortly discuss the typical characteristics of social problems and why they may be attractive to designers. Subsequently, the Vision in Product design method is shortly explained and why this approach seems appropriate when dealing with social problems.

2.1 Social Problems

Social problems are typically problems we face everyday in the newspapers. They concern us as society and therefore are called social problems. Immigration issues, littering, obesity, high unemployment rates or crime are typical problems of social kind. A core aspect to all these problems is that to resolve them, people substantially need to change their behaviour. However, behaviour change is not an easy goal in itself but even gains in complexity in the light of social problems.

Social problems often represent what are called social dilemmas (Van Lange & Joireman 2008). The typical characteristic of social dilemmas is the fact that they rise when peoples’ collective concerns (that often focus on the long term) and individual concerns (that are often directed at the short term) are clashing. Because people are more easily driven by individual and short-term gains, people can behave in a manner that is undesired from a social perspective. To give an example, we all know that driving to work by bicycle would be better for our environment. Still we often prefer taking the car, as it is a convenient, efficient and comfortable means of transport. Because a car addresses these latter individual concerns so well, taking the car becomes hard to resist.

Governments have limited means when dealing with social problems. At best they can change legislation or provide subsidies to actually stimulate behaviour change. But although legislation might be effective in some cases, not every type of behaviour allows for legislation. In most societies stealing is agreed as a deviant behaviour for which legislation exists, but going to work by car can hardly be considered deviant. For these matters, campaigns are being developed that aim to make people aware of the benefits of a particular behaviour change. However, campaigns appear less effective than hoped for (Rijnja, Seydel & Zuure 2009). The fact that social problems are complex problems, for which the government has few solutions, might explain partly why designers feel challenged to take up such problems.

2.2 Vision in Product design

The Vision in Product design approach (ViP) developed by Hekkert and Van Dijk (2010) puts emphasis on the need to think of the product’s raison-d’être before thinking of the product as such. Designers are driven to first understand what it is they want to offer to people and why, before they are supported in thinking of how this should be given form. By doing so, the method supports the designer to a large extent in taking a strategic position. ViP gained acknowledgement from both students and practitioners since 1992 onwards and is part of education at the faculty of Industrial Design Engineering in Delft, The Netherlands.
When taking up a social problem to design for, the actual product to-be-designed is not defined beforehand. This means that the designer is challenged to first decide upon an (product) aim, which is a strategic choice, before he can think of the product as such. The fact that the ViP approach offers guidelines in this strategic phase of the design process has been the one of the main reasons this approach has been applied in both graduation projects.

3. Two Design Cases

The projects that will be described next represent graduation projects in which two students developed a product with the aim to contribute to social change. Both projects represent graduation projects carried out at the faculty of Industrial Design Engineering at Delft University of Technology for the master program Design for Interaction. Both projects were initiated by the student and originate from a personal fascination for the topic and a personal drive to improve the situation. The issues, i.e., the 'failed' integration of immigrants (Tromp 2007) and the gender inequality on the labour market (Borgonjen 2009), have been proven hard to tackle with traditional interventions like campaigns and regulations. In the following sections we will describe first the steps that were taken by the designer to define the aim of the design, and second how the product was designed to realize this aim.

3.1 Case 1: Design for Social Cohesion

The first step in this project was reframing the social problem. This reframing was done to overcome the logical 'solution' to the problem of 'failed integration of immigrants', which is to design something to help immigrants integrate. Defining the starting point as 'social cohesion' stimulated thinking of new ways of living together that are desirable rather than focusing on resolving an undesired situation.

Defining the aim

In reasoning from 'social cohesion' to the aim of the design, Tromp took various intermediate steps supported by literature, interviews and observations. These steps represent reasoning that is reflected in a series of decisions. After each decision, Tromp asked herself: "OK, but how?" The sequence of decisions, including a short argument, are presented below:

1. Social cohesion
   Social cohesion is a double-sided sword: strong cohesion in a group inevitably means strong exclusion of outsiders. Therefore a 'light' version of cohesion is desired when a neighbourhood has to deal with newcomers from various backgrounds.

2. Number of relationships
   Simply put, cohesion is about relationships. Realizing cohesion thus means realizing relationships, in this case between people from various backgrounds. However, based on the 'light' cohesion aimed for, we do not aim for deep friendships but 'only' try to increase the number of starting relationships.

3. Contact Initiatives
   To realize relationships, one needs to realize contact in the first place. Realizing contact between people from various backgrounds has been the aim of several existing initiatives, e.g., neighbourhood barbecues. However, it has been shown that simply putting people from various backgrounds into contact with each other in a group setting often only increases stereotyping. Based on this insight, Tromp wanted to optimize the conditions for contact based on own initiative rather than to bring people into contact.
4. Acquaintance

Acquaintance is a condition for contact. People need to have a first impression of the other person before they will start any contact. Especially with people from different backgrounds, this acquaintance is hard to realize and is easily based on group identity. This means acquaintance can increase stereotyping. Acquaintance is gained through information gathering, but to avoid stereotyping, this has to be personal information.

Therefore the aim was defined as: **support people in exchanging intimate and personal information.**

Designing the means

Iterative testing of various concepts and ideas gave insight in where to realize this information change (supermarket, library or housing complex), through what medium (photo's, written text, objects or voice recording), and in what setting (group, dual or chain-like exchange of information). Based on the tests, Tromp got insight in what individual concerns to address with the design to effectively elicit information exchange.

The Gift Box

The final design is a box including audio recording. The box asks a resident of the area to put in a personal object that (s)he would like to present as a gift to a neighbour. Attached to the gift (s)he is asked to record a personal message that explains how the object is related to her/him. The service delivers the gift to someone living nearby, but who is unknown beforehand. Afterwards, the giver will receive a postcard explaining which address received her/his gift.

Receivers get the box unexpectedly which aims to trigger their curiosity and thereby persuade them to open the package. Receiving a gift from someone in the neighbourhood accompanied by a personal message should trigger people's reciprocity norm. This norm increases the chance that people will respond positively to the question to pass on a gift to someone else in the neighbourhood.

By means of the box, one resident is linked with two neighbours; one with whom he gets acquainted and one who gets acquainted with him. Thanks to the gift it should not only become easier to get into contact with each other, the gift also offers a concrete starting point for conversation.
3.2 Case 2: Design for Women’s Position at The Labour Market

In contrast to the often-mentioned phenomenon of ‘the glass ceiling’ that women who aim for top positions can be confronted with, Borgonjen focused on the so-called ‘sticky floor’. This term symbolizes the fact that women, even highly educated women, often get stuck somewhere halfway the company’s hierarchical ladder. This phenomenon was the starting point for her project.

Defining the aim

Similarly to the first case, the decisions made in this project were taken by continuously asking the question: “OK, but how?” The sequence of decisions, including a short argument, are presented below:

1. Career Mobility

Based on her research, Borgonjen found that women do not necessarily aim for top positions, but do aim for continuous personal development and challenges. She therefore wanted to increase women’s career mobility in order to improve their positions. She believed that by increasing mobility in general, mobility towards the top would be facilitated at the same time.

Borgonjen took a holistic view and recognized the influence of family on work choices. She, for instance, considered designing something that would increase the (male) partner’s commitment to family care to increase a woman’s career mobility. However, based on her conviction that women should be empowered to change their situation, she focused on women in their work situation.

2. Job Opportunities

Increasing a woman’s career mobility requires organizations to offer women opportunities to move within the organization.
3. Recognition
Before being able to offer opportunities to women, a company needs to be able to recognize and value female talents in the first place, e.g., a woman's talent to think holistically.

4. Visibility
Logically, perception precedes recognition. In other words, visibility of these talents is a condition for valuing them.

The aim of the design was therefore defined as: support women in audaciously communicating their visions for the company (e.g., for future directions of the company or projects to initiate).

Designing the means
Based on this aim, Borgonjen developed several concepts. By making mock-ups of these concepts and discuss them with future users, Borgonjen got insight in what women valued in each concept. Based on this feedback she chose a concept and used her gathered insights to optimize it. In order to understand whether the design indeed addressed the concerns she intended to address, she carried out a longitudinal user test.

Label
The final design is a product-service combination that supports women in developing a vision in such a way, that they feel challenged to work on it and feel confident enough to present it within the organization. The most important aspect of the design is that it supports women to develop their visions in a social setting. The product is a USB device including a camera and led-display. The led-display randomly shows a word related to the theme of interest and for which the woman wants to develop a vision. By visibly carrying the USB-device that displays the word, she and colleagues are triggered to discuss the theme of interest. By means of these small talks, she is encouraged to check her ideas with colleagues and subsequently to collect inspiration and arguments. The camera allows her to capture the moment in a visual manner. When the USB-device contains 5 pictures, the device indicates that uploading needs to be done.
When plugging in the USB-device, automatically a software program will be activated. The program allows her to structure the pictures in an intuitive manner, add labels to them to explain what was collected, and subsequently to either quit the program to collect more pictures, or to make a presentation based on the material.

The product supports women in pre-checking their ideas to strengthen their confidence for presenting; first, by verbalizing their ideas and checking whether arguments are sound, second, by creating a feel of whether her ideas are supported by colleagues. By making it challenging to work on a vision, Borgonjen optimizes the conditions for women to actually present it and to become more visible in the organization.

4. Analysis of Cases

An analysis of the process in both projects is done to understand what decisions were made, how they were made and on what grounds. This concerns the sequence of decisions made to decide upon the aim of the final design. Subsequently, both designs have been analysed to understand how they intend to realize this predefined aim.

4.1 Systems Thinking

In both cases a similar reasoning was shown to bring the large-scale complexity of the social problem back to a manageable aim to design for. Both designers converged the social problem to a design problem by intermediate decisions based on probability. A typical decision in case 1 was to increase acquaintance in order to make contact initiatives more probable to occur. Similarly, the visibility in case 2 makes it more probable that female talents will be recognized.
within the organization. Both projects aimed to optimize the condition for particular change to happen rather than directly changing the situation.

This chainlike reasoning is similar to what is done in the field of system dynamics and what is called systems thinking. Especially in businesses but also in other systems this reasoning is applied to understand and foresee so-called side effects of interventions (e.g., Sterman 2000). By understanding the relationships between concepts and by modelling these, it is tried to understand how an intervention might unintended change these existing relationships and thus produce so-called side effects. However, in such modelling the intervention often is known. In the design projects we described in this paper, we saw this reasoning was done backwards to understand what the intervention should be to realize a desired 'side effect'.

4.2 Integrative Thinking

What we recognized in both cases are the different perspectives that were taken to first define the aim of the design and second how to realize this by means of design. Both the aim ‘to support people in exchanging intimate and personal information’ and ‘to support women in audaciously communicating their visions for the company’ were defined with a specific social implication in mind. In the first case, this aim was defined to increase social cohesion and in the second case, to increase women's position at the labour market. These implications are typically based on concerns we have as society. Collective concerns about safety and harmony underlie the need for cohesion, and concerns about gender equality underlie the need for a better position of women at the labour market.

This social perspective differs from a user perspective that is more common in designing. Both aims, that refer to support of particular behaviour, are based on what we need as society rather than on individual needs and desires. Although the individual is part of society and therefore shares these collective concerns, the behaviours the design aims to support do not clearly address individual concerns as such. Even more so, the behaviours are said to occur too sparsely in current society, which means there are reasons why people do not display the mentioned behaviours. People simply do not happily exchange intimate and personal information with people they do not know or even fear. And women do not easily audaciously communicate their visions in a company culture that is masculine and in which prejudices about women's competences can still exist. In other words, the behaviours are obstructed by several individual concerns about competence, safety, acceptance or privacy. The proposed designs address different individual concerns to overcome these clashes between individual and collective concerns.

This skill of designers to handle conflicting perspectives has been described as a fundamental characteristic of a design thinker. According to Brown “the willing and even enthusiastic acceptance of competing constraints is the foundation of design thinking” (Brown 2009, p.18). Ever since we design products, the aim is to achieve the best balance between product aspects, e.g., usability and aesthetics. In line with this, Dorst proposes to regard design problems as paradoxes established by a clash of, what he calls, competing ‘discourses’ (Dorst 2007). In doing so, design paradoxes are not limited to product aspects, but can be formed by competing value systems of the various stakeholders in the project. Having incorporated this theory in a student design project, Hansen, Dorst and Andreasen (2009) show that these stakeholders can be the various people that are somehow dealing with the product in use, or members of the design team.

The idea of design as a means to overcome paradoxes caused by clashes of value systems therefore applies very well to the projects discussed in this paper that show that design can overcome clashes between individual and collective concerns.
**4.3 Human Centeredness**

Another important skill we recognized in both cases to realize the product aim, was the designer's human centeredness. To overcome the barriers to display the behaviour, both designers took a, what is often referred to as, human-centred approach. They gathered the insights to understand how to design a product that makes the behaviour nice, pleasant, comfortable, intriguing or normal for the user. In case of the Gift Box, the design makes use of people's reciprocity norm to give something back when something has been given. By first receiving information, giving information becomes simply a normal thing to do. The fact that the gift triggers curiosity and greed aims to make it a pleasant experience. And by providing the service as an in-home service, people are not physically confronted with each other and do not have to make effort to leave the house. In this way, barriers like being fearful or being unwilling to put effort have been overcome. In case of Label, the design provides an intriguing means to develop a vision for the company and thereby aims to make it a pleasant experience to do so. The fact that it stimulates social interaction amongst colleagues should support the development of sound arguments and social support for her ideas. These aspects should realize confidence to actually present the vision and thereby overcome concerns about competence or social acceptance.

![Diagram](image)

**Figure 3.** The two steps in the process when designing for social problems, i.e., defining the aim and developing the design, and the three important skills in this, i.e., systems thinking, integrative thinking and human centeredness.

**5. Discussion**

On the basis of these cases we would like to discuss whether designers bring unique value into this new domain of social issues. The Gift Box is currently being realized as one of the projects that social workers from Foundation 'Boog' offer to governments as intervention to increase cohesion. On the basis of an extensive pilot study on the effects of the Gift Box, the foundation saw the Gift Box appealed to many people including people who were not attracted by regular interventions. Anecdotes exist of lonely people who normally would be too anxious to visit public events, realized contact with others by means of the Gift Box. This feedback supports our idea that the capability of designers to be human-centered in developing interventions is a valuable skill in this domain.

Although we cannot proof these designs will eventually contribute to society as intended, the type of solution can be evaluated in relation to current solutions. As said before, design is unique in comparison to subsidies and legislation in both the form and the strategy it uses to change behaviour. Subsidies and legislation are top-down interventions that try to set the norm of what is ‘good’ behaviour in a very explicit manner. The designs, i.e., the Gift Box and Label, are product-service combinations that aim to optimize the conditions for particular behaviour.
to happen rather than explicitly propagating the behaviour. Based on what we know about how product influence can be experienced, the designs are seductive rather than coercive or persuasive, adding a pleasant experience to the behaviour (Tromp, Hekkert & Verbeek, accepted). The fact that design can thereby transcend clashes of concerns appears to be a unique aspect of the solution in comparison to other solutions that use the strategy of forcing or persuading people to act on the basis of collective concerns.
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Beyond Expert Design Thinking: On General, Descriptive and Prescriptive Models

Pieter E. Vermaas
Delft University of Technology, the Netherlands

Abstract
In this paper I order accounts of design thinking by the aims of demarcating general design, describing actual design and improving on design. I argue that accounts may relate these aims in a contradictory, conservative, progressive or futuristic way. The ordering makes visible ways to develop accounts of design thinking, which is demonstrated with the accounts by Cross and by Lawson and Dorst. These accounts are conservative by taking current expert design as good design, and may become progressive when they demarcate general design beyond current design and acknowledge future novel ways of good design.

1. Introduction
Design research is maturing and the results are shipped as “design thinking” inside and outside their disciplinary domain. Design thinking has become a product itself, with design researchers as the designers, and with users within and beyond engineering and architecture. Framed in this way, the results of design research can be assessed with criteria drawn from this research. Is it a well-developed product? Is design thinking ready for shipment? And if the answers are negative, at which design stage is the articulation of design thinking?

Design researchers have created a range of methods and accounts of design, and made available a richly filled design-thinking toolbox. It contains instruments for redesign, like QFD, rule-based methods for mechanical and electromechanical design, like Pahl and Beitz’s (2007), cognitive analyses of actual design, like the one by Visser (2006), and more broader accounts of design, like those by Cross (2006), Hatchuel and Weil (2009) and Lawson and Dorst (2009). But does this toolbox have a manual? Is there also an overall account of design on offer that integrates the different methods and more specific accounts, and tells users how and for what goals the various tools can be applied? Which methods and accounts are for describing design? Which are for doing it? And which are for improving design? Can or should the tools be used together? Is the box containing all that is needed for design?

The development of design thinking, when seen as the design of a product, is not yet finished as long as such an overall account is lacking. Shipping the results of design research is then at best a large-scale case of participatory design, in which users may test prototypes, eclectically compose and innovatively apply tools from the box, possibly to such an extent that design researchers do not recognise the resulting products as design thinking. Or shipping the results of design research is simply premature and violating basic standards of the profession.

In this paper I analyse the toolbox on offer in a rather coarse-grained and schematic way, briefly discussing some particular methods and accounts but remaining focussed on the broader picture. In section 2 I argue for ordering methods and accounts by the aims of demarcating design, describing actual design and improving design. I argue in section 3 that methods and accounts may relate these three aims in a contradictory, conservative, progressive or futuristic way. In section 4 I home in on the accounts by Cross (2006) and Lawson and Dorst (2009), in which descriptive models of expert design are taken as prescriptive models for good design.
These accounts are conservative by ignoring novel ways for improving design, but can be developed to progressive accounts.

This paper offers the conceptual means of my discipline of philosophy for developing design thinking, and posits that design research has its own means for doing so. Relating instruments like QFD with accounts of expert design may be challenging, yet by already doing a QFD-analysis of these accounts, it becomes visible how the product of design thinking may improve.

## 2. The toolbox

The methods and accounts that design research has created may be ordered by the types of design they are about. Methods and accounts may be for product design, architecture or, more recently, service design; and they may be for redesign, routine design or innovation. Such a categorisation leads to quick answers to the question how methods and accounts in the design-thinking toolbox are related. QFD and the method of Brown (2009), for instance, can be taken as tools that exist side-by-side since they apply to different types of design: QFD is for gradual product redesign whereas Brown's method is for innovative design of products and services.

In this paper I do not order methods and account by means of types of design, but focus rather on the aims methods and accounts have in capturing that design. I consider three aims. First, methods and accounts can demarcate design by defining general models of design. Second, they can describe design as it is actually done by giving descriptive models. Third, methods and accounts may aim at improving design by proposing prescriptive models that single out good design. These three aims are different: design in general may be an activity that is broader than design as it is nowadays done; and actual design need not be good design. Yet methods and accounts may endorse two or all of these aims.

There are different reasons to use the aims of demarcation, description and improvement for analysing the design-thinking toolbox. First, by looking at how accounts demarcate design, the relations between the various tools in the box become visible. The literature considered in this paper is quite diverse, and it may therefore not be presupposed that the methods and accounts discussed concern the same types of design. An analysis of how methods and accounts demarcate design will reveal to what extent they are about the same types of design. Second, the way in which descriptive and prescriptive models of design hang together within methods and accounts is unclear and problematic. Dorst (2008, p.6) argued that in design research the transition from description to prescription is often made too rash and without proper support; this transition can even lead to contradiction, as I will argue. Third, by analysing systematically how general, descriptive and prescriptive models can be related without contraction, one can characterise methods and accounts in a manner that make ways for developing them visible.

This alternative categorisation also leads to quick answers about how methods and accounts of design are related. QFD, Pahl and Beitz’s (2007) rule-based method and Brown’s (2009) proposal provide prescriptive models. Hence, when applying to the same types of design, these methods compete on how to improve design best. The accounts by Cross (2006), Visser (2006) and Lawson and Dorst (2009) generate descriptive models, hence compete but now on how to best describe actual design. Each account aimed at improving design can be taken as compatible to each descriptive account, and vice versa, as long as the proposed improvements are not yet instantiated in actual design. For instance, Brown’s proposal to apply design thinking to other problems than engineering ones, may be taken as novel, meaning that Brown’s prescriptive models do not yet define models of actual design. Hence, the descriptive models of Cross, Visser and Lawson & Dorst need not cover Brown’s prescriptive models. Yet, QFD and the Pahl-Beitz method are regularly applied in actual design, so their prescriptive models should be covered by the descriptive models of Cross, Visser and Lawson & Dorst. This last conclusion leads actually to a problem. In rule-based methods, like the one by Pahl & Beitz, functions are
playing a central role whereas functional reasoning is not prominent in specifically the models of Cross and Lawson & Dorst. There are two options for responding to this problem. First, one can argue that rule-based methods are covered by the descriptive models of Cross and Lawson & Dorst but accept that these latter models are at present formulated in a too coarse-grained manner to easily locate rule-based design in them. Second, one can acknowledge that rule-based methods are not covered by Cross or Lawson & Dorst, which implies that these accounts do not capture all types of actual design.

The categorisation of methods and accounts of design by their demarcating, descriptive and prescriptive aspirations thus make visible relations between these methods and accounts. The C-K theory proposed by Hatchuel and Weil (2009) demarcates design as broadly as possible as a reasoning activity in which concepts C, taken as propositions (about an object) of which the truth is undecidable, are transformed into knowledge K, taken as true propositions (about that object). If C-K theory is indeed demarcating all types of design, the descriptive and prescriptive models of other methods and accounts should be identified as special cases of C-K reasoning, a task that Hatchuel and Weil (2009) take up when they discuss the relation between C-K theory and other “pragmatic definitions” of design. The descriptive models by Cross, Visser and Lawson & Dorst should include all prescriptive models of methods aimed at improving design in so far these methods are applied in design. This sets the task for specifically Cross and Lawson and Dorst to incorporate functional reasoning into their descriptive models. The account by Cross and especially the one by Lawson and Dorst are themselves also aimed at improving design. Lawson and Dorst erect their models on the basis of analyses of actual design by novices and by experts, and give a clear prescriptive twist to their results. They, for instance, give advice about how novices should be educated to become experts quickly and in this way improve on their design. Hence, some of the prescriptive models advanced by accounts of design are prescriptive as well, which sets the task of making the, as of yet, problematic transition from description to prescription. Lawson and Dorst make this transition by selecting some descriptive models as prescriptive; their descriptions of design by novices are not proposed for improving design. This selectiveness saves them from contradiction, as becomes clear in the next section. In other accounts of design this transition is made less subtle by taking all descriptive models as prescriptive as well. In Gero’s (1990) FBS model this manoeuvre is adopted (Vermaas & Dorst 2007) and Roozenburg and Eekels (1995) explain this bold transition when they note about their descriptive analysis that

[This is the way design processes are structured. That establishment leads almost imperatively to the statement: effective design processes should be structured in this manner. The cycle, which is found descriptively, changes into a norm for effective designing. We can therefore also consider the basic design cycle as a prescriptive model for designing. (1995, p.93; original emphasis).]

A simple argument shows however that turning all descriptive models of an account into prescriptive ones leads to contradiction. The aims of description and improvement introduce different criteria that models have to meet, and meeting criteria for description may rule out that models also meet criteria for improvement. Descriptive models should be empirically adequate, and fail as soon as there are instances of actual design that do not fit the models. Prescriptive models should improve design, and fail as soon as bad design fits them. Models that are descriptive and prescriptive now should both cover and not cover instances of actual bad design: models should include these instances in order to be descriptive and they should exclude them in order to be prescriptive.
Categorising accounts of design by the aims of demarcation, description and improvement, thus raises questions about how general, descriptive and prescriptive models of design can be related. In the next section I give a logical and schematic analysis of these relations.

3. Demarcation, description and improvement

Assume that an account of design defines in principle three sets of models: a $G$-set with general models that demarcate design; a descriptive $D$-set with models that capture actual design; and a prescriptive $P$-set containing models that define good design. What types of design—product design, architecture, etc.—is focussed on depends on the account at hand, and the same holds for the way in which the distinction between bad and good design is given content; in this section I am merely interested in logically analysing the relations between the general, descriptive and prescriptive models within accounts.

An account need not specify all three sets: if Visser’s (2006) analyses actual design only, she specifies the $D$-set, but not the $G$- and $P$-sets (in her (2009) Visser seems aimed at fixing the $G$-set). But accounts may specify all three sets. A ‘toy-account’ drawn from the use-plan analysis of design (Houkes & Vermaas 2010) with a little help of Norman (1990), does so: the general $G$-models consist of processes in which a goal is translated in a plan containing actions with objects by which users can realise the goal; the $D$-models capturing actual design consist of such translations of goals into plans where the objects manipulated are described for their manufacture; and the $P$-models for good design consist of translations of goals into plans where the rationale of actions with the manipulated objects is intelligible to users.

With these sets of models an account of design can be characterised by its GDP, consisting of its demarcating $G$-set, its $D$-set describing actual design, and its $P$-set for singling out good design. In this characterisation, $D$ is by definition a subset of $G$, so one has $D \subseteq G$; it would be inconsistent if an account accepts models of actual design that are not accepted as design. Similarly, $P$ is a subset of $G$, so one also has $P \subseteq G$. By now systematically assessing all set-theoretically allowed relations between $G$, $D$ and $P$ one can determine which GDPs are possible for accounts, and characterise accounts by their specific GDPs. The two constraints leave ten possible relations between $G$, $D$ and $P$. Four of those possibilities are however ruled out if one assumes that there exist models of bad design, and if one assumes that some actual design is such bad design. The first assumption leads to a strengthening of the second constraint: $P$ is a proper subset of $G$, so $P \subset G$. The second assumption is stronger than the first and gives $P \subset G$ and a second condition that $D$ cannot be a subset of $P$, that is, $D \not\subseteq P$ cannot be the case.

Consider the GDP-sets by means of Venn diagrams. The first two constraints ($D \subseteq G$ and $P \subseteq G$) imply that $G$ is always the biggest diagram. There are ten possibilities for $D$ and $P$ lying within $G$, as depicted in the Figures 1 to 4. The conditions that $P \subseteq G$ and that $D \subseteq P$ is not the case, rule out the four possibilities given in Figure 1: $P$ should not be as big as $G$; and $D$ cannot be equal to $P$ or lie within $P$. The ruled-out possibilities represent accounts in which the $D$-models describing actual design are taken also as $P$-models for good design: Gero’s (1990) FBS model, for instance, falls under possibility 1 or possibility 2.
Two possibilities that are allowed are characterised by P lying within D, see Figure 2. These possibilities 5 and 6 may be called conservative, for in accounts in which P lies within D, a model for good design is also always a model of actual design; there can thus not be models for good design that have not yet been applied in actual design. When prescriptive methods, such as QFD and rule-based methods, are adopted in actual design, one has a case of possibilities 5 or 6: these methods then single out some D-models of actual design as P-models for good design, but they do not identify (anymore) P-models for good design beyond the D-models. In the next section I argue that the accounts by Cross (2006) and Lawson and Dorst (2009) are such conservative accounts as well.

Two further possibilities 7 and 8 are characterised by D and P partly overlapping, see Figure 3. Accounts that are instances of these possibilities may be called progressive, for in such accounts there are P-models for good design that are followed in actual design but there are also models of good design that are not (yet) followed in actual design. There can be progress: models for good design are available that are not yet applied in actual design. Brown’s (2009) proposal may be taken as an instance of possibility 7: practices of actual good design are extrapolated to other cases of good design that are not (yet) actual design.
The final two possibilities 9 and 10 are characterised by D and P not overlapping, see Figure 4. In accounts falling under these possibilities P-models for good design are not D-models of actual design, yet good design exists and may in the future become actual. Let us call these possibilities futurism. The introduction of the first design methods at the time artisan production dominated, may be reconstructed as such futurism: existing artisan models are discarded and novel models of design are made available as a route towards improvement.

The above exploration shows how accounts of design can have descriptive and prescriptive aims. They can when they acknowledge that some actual design is bad design, as is allowed by possibilities 5 to 10. Moreover, the exploration can be used to characterise accounts as conservative, progressive or futuristic, depending on how they relate their descriptive and prescriptive models of design. This characterisation makes in turn visible how accounts can be developed.

4. Beyond experts

Cross (2006) and Lawson and Dorst (2009) present their accounts as developed on the basis of observation of actual design in engineering and architecture. They differentiate between routine design and innovative design, between design by individual designers and by groups, and more importantly between design by novices and design by outstanding or expert designers. Both accounts take design as a process in which a problem, which is typically ill-defined, is brought to a solution through a search by a designer that has as input a conjectured solution-direction originating from previous experiences of the designer. This solution-direction lets evolve the original problem into a more well-defined problem, and guides the designer in finding a more detailed solution, amounting to a co-evolution of problem and solution. The search ends when the designer finds a suitable match between the co-evolving problem and solution (Cross & Dorst 1998; Cross 2006, ch 6; Lawson & Dorst 2009, ch 2). The way in which novices and experts proceed in this process is analysed in detail, and the expert's way is presented as the more efficient and productive one.

By their tight focus on observation, the models of design that both accounts define are D-models describing actual design. Of these D-models the ones concerning expert design are the P-models for singling out good design. Whether both accounts demarcate design by G-models that are broader than their D-models, is here left open. The P-sets in these two accounts are
Thus proper subsets of the D-sets, and these D-sets are equal to or proper subsets of their G-sets. Both accounts are thus instances of possibilities 5 or 6, Figure 2, which means that Cross and Lawson & Dorst make the transition from description to prescription without contradiction. Yet, since their P-sets are proper subsets of their D-sets, both accounts can be characterised as conservative: only the D-models describing how experts design nowadays, are singled out as good design. So even if Cross, Lawson and Dorst define G-sets containing G-models different to their D-models, then these additional G-models are not P-models: good design beyond current expert design is ruled out by the two accounts.

This last conclusion leads to a challenge to the two accounts, namely to defend that only current expert design defines good design, or to abandon this conservatism. The analysis given in the previous section shows that progressive accounts may exist as well (possibilities 7 and 8, Figure 3). And the accounts of Cross and Lawson & Dorst can be turned into such progressive ones, when they define G-sets that contain P-models of good design different to the D-models describing current expert design. On first sight it may seem obvious that this progressive turn is not available to Cross, Lawson and Dorst. Taking expert designers as the best designers seems tautological: how can design ever be better than expert design? Yet, on second thought this response does not make sense. One can imagine that design in a hundred years time has become much better than design by our current experts. One even need not wait that long to acknowledge this possibility of better-than-current-experts design. Brown's (2009) proposal to apply design thinking outside its traditional domain may change in due course also our current notion of design expertise. Moreover, pleas towards innovating design, such as the cradle-to-cradle vision by McDonough and Braungart (2002), go hand in hand with rejecting the current state-of-the-art. Presenting D-models describing current expert design as the only way towards good design indeed is conservative: it means educating novice designers by the standards of past generations, rather than by future standards.

For arguing that the accounts of Cross and Lawson & Dorst can (or should) be developed into progressive ones, the analysis given in the previous section is actually not needed. When taking these accounts as products of design, design research has its own means to argue for this development. A simple QFD analysis of the accounts will do. What requirements do the users of the accounts by Cross and Lawson & Dorst impose on these accounts? Determining these requirements may reveal what designers need rather than the advice to become like experts who have their roots in the past twentieth century. Even Cross, Lawson and Dorst have identified such needs of twenty-first-century designers. One cluster of needs arises from future design situations in which individual designers cannot manage the process of design alone, as in design in teams, in participatory design or in design by collaboration via Internet. Another cluster arises from changing and tightening specifications, as in design for sustainability, in design without risks to users, or in design of services. Accommodating these needs will change design beyond the D-models capturing current actual design, and this change will make visible new P-models for good design beyond the D-models capturing current expert design.

5. Concluding remarks

Design research has created a rich toolbox of design thinking, and design research is in a phase in which it can and has to integrate the box' contents. The accounts of Cross (2006) and Lawson and Dorst (2009) define a solid core describing actual design. By ordering these and other methods and accounts by their aims of demarcation, description and improvement, two challenges can be identified for developing the accounts of Cross and Lawson & Dorst. First, they should incorporate existing rule-based methods of design like QFD and the Pahl-Beitz method; rule-based methods are currently used and thus equally describing actual design. Second, the accounts of Cross and Lawson & Dorst should give overall characterisations of design, for demarcating all types of design and for becoming progressive accounts that also acknowledge future, novel ways of design as good design. Possibly Hatchuel and Weil's C-K
theory may help to meet that second challenge, arriving at an overall account of design thinking in which problems find solutions by reasoning processes that start by known solutions and end with knowledge of new solutions. QFD and rule-based design may be the most mechanical forms or such reasoning, and current expert design may give the most creative forms nowadays recognised; by integrating these forms of reasoning and providing room for new forms to emerge, a progressive general account of design thinking may be developed and put on offer.

Acknowledgements

Research for this paper was supported by the Netherlands Organisation for Scientific Research (NWO).
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Cultural Transformation: 20 years of ‘Design Thinking’ at the Australian Taxation Office: Some reflections on the journey

Michael York
Second Road, Sydney, Australia

Otto Wicks-Green
Second Road, Sydney, Australia

Tony Golsby-Smith
Second Road, Sydney, Australia

Abstract
There has been a lot of recent discussion about the importance of design thinking. However, in the case of the Australian Government’s principal revenue collection agency, the Australian Taxation Office (ATO), their unique ‘design thinking’ story stretches right back to the 1980s.

This paper investigates the role of the arts of conversation and design in transforming the culture of the ATO, and maps the trajectory of ‘design thinking’ as it became gradually embedded in the ATO. This intervention is an example of a new art of thinking that has proven effective in multiple other contexts.

An early event was an advanced personal thinking skills workshop that was conducted at the ATO for a small group of staff in 1989. The impact of this workshop resulted in design thinking approaches being elevated to the strategic level of the organisation as part of an effort to encourage voluntary compliance by tax-payers (by giving those pre-disposed to pay tax the best possible experience).

Another key event during the mid-1990s was a ‘triad’ collaboration between the Australian tax system, a management consulting firm specializing in ‘design thinking’ and a leading ‘design thinking’ university in the United States. This resulted in design thinking being applied to the drafting of government legislation in an effort to simplify and streamline the Australian tax system.

These streams of work ultimately dovetailed with the release of the Treasury’s white paper on tax reform in 1998 entitled ‘A New Tax System’ followed by the Ralph Review of business taxation. This review recommended the application of design to the policy, legislative and administrative aspects of the tax system. This resulted in the vigorous application of design thinking approaches at the highest levels of the Australian Taxation Office enabling a culture of design thinking to emerge in the heart of this government organisation.

1. Introduction
The Australian Taxation Office (ATO) as of 2010 has more than 20,000 employees. It is one of three key organisations that make up the Australian Taxation System (ATS). The other two
organisations are The Treasury and the Office of Parliamentary Counsel (OPC). The ATO is responsible principally for the administration of revenue collection. The Treasury is responsible for developing taxation policy together with the government of the day, while the OPC is responsible for the drafting of taxation law.

Around the mid 1980s, the ATO had reached a crisis point. Their prevailing approach of bureaucratic and rigid administration was ‘burying’ the organisation in paper and a ‘we’re right, and they’re wrong’ mind-set had created an intensely negative perception in the eyes of the Australian people (Godfrey 1994). People lived in fear of their punitive and seemingly capricious auditing of even slight unintentional mistakes, and individuals and companies responded with evasive strategies to target loopholes and gaps in the tax law (Boucher 2010). These gaps were fixed with cosmetic amendments to the legislation, adding layers upon layers of complexity to these already incomprehensible documents (D’Ascenzo 2002).

How then was this organisation transformed so it is now regarded as one of the most user-friendly and effective revenue authorities in the world? (D’Ascenzo 2010) The answer lies in the unprecedented application of ‘design thinking’ to a governmental context, as a tool to help solve the complex and dynamic problems and opportunities that had emerged.

Three key themes of action that began during the 1990s will be highlighted in this paper. These themes help to show why design thinking and user-based design became embedded in this large organisation:

- Design facilitation of large numbers of Strategic Conversations (Golsby-Smith 2001 & 2007) in the ATO throughout this decade
- Knowledge design of the Australian Income Tax Act
- Design thinking applied to the whole of the Australian Taxation System (ATS), coupled with a crisis that created a significant turning point.

2. Our thesis and methods

The liberal arts are not usually seen as useful and functional in our technological world. However, we have seen and experienced their power to challenge the ways we think about thinking and the way we think about organisational change (Golsby-Smith 2007). The integration of liberal arts skills with a variety of business situations and new digital technologies (Golsby-Smith 2001) has led to the invention of ‘new ways of thinking’. At the core of these methods is using liberal arts skills as a way for teams to ‘make’ new futures and products.

This interdisciplinary style of thinking and problem solving has been developed through theory as well as experience. This has been achieved by exploring and refining the organisational applications of the arts of poetry (the design and expression of language) and rhetoric/dialectic (creating arguments for change) (e.g., Kaufer & Butler 1996). This study has resulted in the outlines of a new ‘art of thought’, grounded in experience, but brought to light by the ancient arts of poetry and rhetoric (Golsby-Smith 2001 & 2007). The story of the ATO’s cultural transformation is a ‘canvas’ where we can share some of our understanding of this new art of thought.

Much of the cultural work done at the ATO involved developing identity and purpose as ‘fertile soil’ in which to nurture rigorous and effective action. Unlike Schein (2004), who acknowledges the importance of organisational culture on design and manufacture, but believes it to be an unconscious, tacit influence, or Uttal (1983) who sees culture as too elusive and hidden to be accurately described, managed or changed, Buchanan (1992; 2001) and Golsby-Smith (e.g.,
see 'cultivation' as deliberative and iterative, and culture as something whose founding principles and patterns can be designed.

The general conception of design emphasizes manufactured and tangible products. This understanding is overly restrictive, and focuses on what Buchanan (1992) calls the 1st and 2nd orders of design (communication & construction), but does not account for the power of the 3rd and 4th orders (processes & cultures). A shift of focus in organisations to the 3rd and 4th orders reflects a re-deployment of design to the earliest possible points in the product development process—the domain of the ‘pre-factual’ (Golsby-Smith 1996) where the primary interaction occurring is ‘conversation’ supported by visual mapping and heuristics. Here, through collaborative conversation and dialogue, fundamental decisions are taken regarding the ends to be pursued and the overarching purpose of the end result. To this end, the organisation’s stakeholders are key audiences who need to be engaged in order to participate with the organisation’s mission. The job of leaders is to construct ‘arguments’ with these key audiences that can persuade them to act.

The initial starting point for this paper was Golsby-Smith’s records, recollections and reflections about his work with the ATS over 20 years. Our method was to construct a timeline / boundary object (Carlile 2002) of Golsby-Smith’s involvement with the ATS. We then used this timeline and relevant artefacts as the basis for recent conversations with various ATS actors, agents and design thinking researchers, including some of Golsby-Smith’s former clients/sponsors.

A number of people have written about the application of design thinking in the ATO (e.g., Junginger 2006; Body 2007; Terrey 2009), but previous work has not covered in any depth the original implementation of the thinking processes that underlay and informed this practice in the ATO (rhetoric and collaboration). We assert that the early parts of a ‘human system’ story, including the wider context in which it occurs, are often swept away and overwhelmed by the scale of what follows, resulting in a deficiency regarding who was accountable. This difficulty is also the result of the fuzziness and intractability of this cultural work. The end results are visible and documentable, but the first causes are ‘pre-factual’ and invisible, and are often not awarded their due celebration (Cross 2007). If this important knowledge is lost from the consciousness of an organisation it weakens the organisation’s sense of its own narrative and efficacy (Bandura 2001). This also hinders those who seek to emulate its success in other contexts.

3. Laying the foundations

3.1 Cultural Innovation requires a leader

The Commissioner of the ATO from 1984 to 1993 was Trevor Boucher who brought a vision of cultural innovation to the ATO. The first step towards change that he implemented was a move towards a ‘self-assessment model’ for use by the ATO’s millions of customers.

From the very beginning he realized that there were huge cultural issues within the ATO against a move to a voluntary compliance model. The prevailing culture was of strict control and auditing, and what Boucher was proposing was unprecedented. Boucher was turning the ATO into a space fertile for design thinking and innovation and was willing to transform the old system. But the big question now was working out how the ATO could become a ‘learning organisation’ (Senge 1990; Godfrey 1994) and one that creates new strategic, desirable, useful and usable experiences for users.
3.2 Introducing a different way of thinking

A key catalyst for procedural and cultural change within the ATO came from a fortuitous encounter between John Landau and Golsby-Smith in 1989. Landau was First Assistant Commissioner at the ATO from 1987 to 1997, and was a keen exponent of open and free thinking as a way to tackle ‘wicked problems’ (Rittel & Webber 1973). He held regular training courses and workshops for his staff on topics as diverse as astrophysics, general relativity and plain English writing.

Golsby-Smith was, by chance, presenting one of these plain-English workshops on document design. This workshop was the beginning of Landau’s long professional association with Golsby-Smith. During the workshop the group immediately resonated with his unique liberal arts approach of encouraging exploratory thinking and visualizing-sketching of thinking using spider maps and models (Landau 2009, pers. comm., 19 Nov).

Golsby-Smith saw these up-front conceptual thinking and knowledge-shaping practices as key to clear English expression. The approach emphasised information architecture—that is, the overarching structural framework of text, in contrast to other plain English advocates whose approach was limited to matters of vocabulary and sentence structure. In many ways he used his workshops on writing as a Trojan Horse for bringing conceptual thinking (and with it design and strategic thinking) into the ATO. The power of Golsby-Smith’s ideas was in their broad scope of application. Brought in to improve writing technique, his tools and methods for thinking visually were eventually used to guide collaborative strategic thinking in the ATO (Strategic Conversations). The skills transferred were not content-dependant skills of technique but thinking skills, which are inherently malleable and applicable to a diversity of subject matters. This aspect was instrumental in the ideas’ journey upstream to the highest strategic forums of the ATO.

3.3 A theory to exploit—design and the new rhetoric

Golsby-Smith was motivated to visit Carnegie Mellon University (CMU), Pittsburgh in 1992 after hearing about its work in document design. It was during this visit that he was introduced to Richard Buchanan, a leading strategic design thinker, rhetorician and philosopher, in the School of Design at CMU. These new relationships began immediately to influence Golsby-Smith’s thinking about what he was doing in the ATO and how he could better frame this work.

Buchanan’s seminal work on the ‘Orders of Design’ had just been published, and this provided a rich framework for Golsby-Smith’s burgeoning insights (Buchanan 1992). The 3rd and 4th orders, design of processes and cultures, resonated with his emphasis on authorship (rhetoric & poetry) and thinking processes. This concept helped to deftly articulate the shift of focus that Golsby-Smith was emphasizing, from a linear input-output model, to a collaborative and user-based process of thinking and creation. The door was opening for ‘4th order’ cultural work, which would promise to align and cohere the ATO around a shared identity and purpose.

4. Key themes of action

4.1 Strategic Conversations in the ATO during the 1990s

Michael Carmody became ATO Commissioner in 1993. A review at this time led to the creation of a market facing ‘Business Taxes’ Division (later renamed Withholding Taxes). It involved around 4000 public servants (about a quarter of the ATO workforce and 70% of taxation revenue) and was a complex ‘conglomerate of bits’ (Landau 2009, pers. comm., 19 Nov). John Landau was appointed to lead this business line and he turned to Golsby-Smith & Associates (GSA) with a proposition—‘Can we use your up-front conceptual thinking approaches to clarify and make sense of this messy and complex Division for the sake of tax payers?’ And it was in
this complex situation that GSA's approaches really showed their value, leading to the creation of the dialogue-based Strategic Conversation process (Landau 2009, pers.comm., 19 Nov).

Strategic Conversations involved ATO leaders in shared conceptual thinking mediated through dialogue, visualization and heuristics. Using a large electronic whiteboard, the design facilitator captured the group's ideas in real time, engaging the group deeply in their collaborative thinking. This in effect turned them into authors who were writing their story together. This created a fluidity in the subject matters being explored allowing for rapid change in the midst of dynamic contexts. It provided leaders with the opportunity to think before deciding and enabled multiple perspectives on important issues.

The Strategic Conversation process and its outputs brought clarity to the highly complex business planning required for leading this Division and united them around a shared rhetorical argument (Golsby-Smith 2001). GSA went on to do a large number of Strategic Conversations in Withholding Taxes (c.1993-1997), working with John Landau's team, and the Small Business Division (c.1997-1999), working with David Butler's team.

After each Strategic Conversation the participants were given two documents. The first was a complete record of the conversation including all the conversation's whiteboards (e.g., Figure 1) and the other was a one page graphic synthesis of the conversation. These become rallying points in each Division and something that senior managers referred back to regularly (Landau 2009, pers.comm., 19 Nov; Golsby-Smith 2007).

Due to the complex and specialised 3rd/4th order objects of design being contemplated, Strategic Conversations were also used to train, coach and empower the ATO leaders so they could generate the best design hypotheses for change. This emergence of a novice internal co-design capability distinguishes the ATO design story from that of the IRS in the USA (Junginger 2006).

The good outcomes from these design thinking interventions resulted in Golsby-Smith being referred to the ATO Commissioner to run Strategic Conversations for the ATO's senior leadership team. The impetus for this was two-fold. Firstly, the ATO was looking at ways to better identify and deal with strategic issues (Body 2007). Secondly, there were major ATS changes coming due to the Federal Government's decision in 1998 to introduce a broad-based goods
and Services tax (GST). Golsby-Smith ran a long series of Strategic Conversations for the Commissioner known as the Corporate Design Forum (CDF) between 1998 and 2000 that created all the main ideas for a ‘new’ Tax Office (e.g., Call Centre, People strategy etc) in this period of turbulent change and reform. As part of this process, the top executives of the ATO would meet for a full day Strategic Conversation every month to keep their fingers on the pulse of change and to share key ideas.

The CDF brought strategic design thinking to the ATO at the highest levels. The quality of strategy developed benefited from the collaborative and evaluative diversity of inputs (DiVanna & Austin 2004). It also ensured that those involved in its implementation gained a sense of ownership of shared intent (Riis, Dukovska-Popovska & Johansen 2006).

The power of the Tax Office’s CDF was that it enabled an understanding of the situation to crystallize. And the understanding of the situation was a ‘work of art’—it was not a case of right or wrong. It enabled the profundity of imagining different futures and making good decisions which then became prime causes for transformation.

Unlike traditional thinking tools, which focus on what ‘is’ or ‘must be’, this integration of design thinking opened up the problem space to what ‘may be’, and allowed a more open-ended process of conceptual thought—a progression from discovery of what is, to invention of different futures (Liedtka 2000).

Roger Martin refers to this dichotomy as the difference between induction or deduction and ‘abduction’ (Martin 2009). Induction and deduction are rigorous logical tools for drawing inferences or proofs from past data. Statistics and other analytical tools are instruments to further furnish this style of thinking. Abduction however is the logic of new ideas. It is a pragmatic way of generating ideas about what the future could look like. Nothing is proven abductively, just posited. Restoring the balance between these two modes of thinking was a radical re-discovery of collective human agency within the ATO. It was a recognition of the value of dialogue and of the nature of rhetoric and dialectic as arts that are useful in ideation, and in shaping human affairs (Buchanan 2001).

4.2 Knowledge design of the Australian Income Tax Law

In 1994 GSA had an opportunity to work on a project to rewrite the Australian Income Tax Act 1936, working with the Office of Parliamentary Counsel (OPC) and the Second Parliamentary Counsel, Tom Reid. This project was called the ‘Tax Law Improvement Project’ or TLIP (Golsby-Smith 2001). TLIP was begun during Boucher’s time as Commissioner as one way to start addressing the complexity and ‘user-unfriendliness’ of Australia’s Tax Legislation.

Tom Reid has stated that when Golsby-Smith joined the project in April 1994, he brought a powerful hypothesis to the fore. ‘The real leverage when it comes to readability of a document is not at the ‘word’ level, but at the ‘architecture’ level of a document’ (Reid 2009, pers.comm., 19 Nov). This ‘architectural’ approach provided the OPC with a way to create and explore different models/prototypes of the Act including the use of diagrams. These were tested through exploring the reader’s interactions with the text enabling the creation of thoughtful designs of the document. Golsby-Smith realised at this time that the input of his friend Buchanan and his colleagues (CMU) would be of significant value to this massive project, not least through the credibility that their involvement would add (the project had many critics who were wedded to the status quo!).

Golsby-Smith gained approval from the TLIP Project Leader to invite the team from CMU to conduct the ‘product testing’ using their ‘Reading Aloud Protocol’ technique (Nolan & Reid 1994; Golsby-Smith 1996). This technique identifies what is going on in the mind of the reader.
as they grapple with the text. Using this data the team can identify what devices actually work and even why they work.

This is an example of the tacit embedding of design thinking in a key ‘operating manual’ (Income Tax Act) of the ATS. The ability to prototype and reflect based on CMU’s product testing enabled a more adventurous compositional mindset, which created space for creativity. The frequent readability evaluations formed a ‘safety-net’ above which people were free to experiment more freely with their communication (Golsby-Smith 1996). The rewriting of the Australian Tax Act was a significant milestone for the ATS and was celebrated publicly by the Commissioner of Taxation, Michael Carmody (1997).

The ATO now considers that users should be the starting point in any collaborative design process, and employ regular testing of informational concepts and presentation prototypes. The process is one of progressive refinement and improvement through community collaboration (Martin, Gregor & Rice 2008). User participation and involvement is a crucial part of actively and accurately synthesising experiences and viewpoints.

4.3 Design Thinking applied to the whole of the ATS

Golsby-Smith had a unique perspective of the ATS during the 1990s through his engagements with the ATO, the OPC and, later on, The Treasury. What he saw firsthand was a series of activities that should have been working together (policy, law, and administration), but instead they were ‘siloed’ and operationally independent from each other. He worked hard over many years to establish an appreciation for applying the design mentality to problem solving in these three parts of the ATS. This was no easy task, as there was suspicion amongst the organisation’s leaders that, as promising as the design approach sounded, it would fall apart when applied to organisational realities.

‘The ATO is full of accountants and lawyers, investigators, systems builders. They are very pragmatic people. If they cannot see how to convert new ideas into better outcomes in what they would call ‘the real world’, they drop them’ (Interview with Senior Tax Official in Junginger (2010))

Notwithstanding the challenges of working in a political environment, Golsby-Smith’s intent was directed towards preparing the ground and ‘joining the dots’ for these three bodies to work together in order to deliver the best possible experience for users of the ATS.

The policy initiative for a GST, outlined in ‘A New Tax System’ (ANTS) was birthed in The Treasury in 1998 at the direction of the Treasurer (Peter Costello) and announced in August 1998. At that time the Secretary of The Treasury was Ken Henry with Alan Preston as his Deputy Secretary. Golsby-Smith and others worked with Treasury around the information architecture and design of the ANTS policy. During that work Preston grew strongly in his advocacy of the power of design thinking.

Preston took his growing appreciation of the power of design thinking into his work as part of the Ralph Review of Business Taxation. A key recommendation of the Ralph Review was a call to implement ‘Integrated Tax Design’. Preston was appointed to lead the development of this initiative in the ATO (Preston 2004). This was a critical step if policy and law were to benefit from being close to the voice of the user/customer.

The Review of Business Taxation called for a major change in operational dynamics of the ATS and Buchanan and Golsby-Smith proposed that a ‘Design Centre’ be established in the ATO. The purpose of the Design Centre was to ensure ongoing dialogue (including design research
and development) around the customer that in turn would point the way to institutionalizing design in the Tax Office.

Many have written about this climactic phase of the ATO's design thinking journey (e.g., Preston 2004; Junginger 2006). Key outcomes achieved at this time and later on included:

- Codifying ‘design’ into project management, ensuring design was written into the organisation's procedures. This resulted in the development of ‘the wheel’ design process (Figure 2) and its ongoing deployment to the current day, supported by a set of formal design principles to guide its future work.

- The highlighting of the importance of and transfer of skills to support user research. Key early work on this was user-based design of the Simplified Tax System for small businesses performed by Golsby-Smith and others (D'Ascenzo 2002).

- Golsby-Smith was involved in running multiple training courses on dialogue, visual thinking and design practice. This work was directed towards the goal of establishing the ATO Design Centre on a firm foundation. The ATO Simulation Centre in Brisbane is the current manifestation of this initiative.

- The design conferences sponsored by Dr Alan Preston in 2000 and 2001 that included key presentations by Buchanan from CMU, Golsby-Smith, Jim Faris, a renowned interaction design practitioner, and Darrel Rhea from the design research firm Cheskin.

- The retaining of Golsby-Smith and his colleagues from 2002 to 2005 to implement strategic reporting systems in the ATO to ensure efficient knowledge architectures are used to measure and report on the health of Australia’s taxation systems (Jenkins 2008).
4.4 A crisis moves design thinking in the ATO to centre stage

In the midst of all the changes happening in the ATO at the turn of the century, a crisis emerged soon after the GST was implemented in July 2000. The new requirement to submit a Business Activity Statement (BAS) quarterly created significant pressures for small businesses around Australia, in particular for businesses like cafés and mechanical workshops. An estimated 25% of small business hated the BAS at this time! (O’Brien 2001, para. 1)

Around April 2001 a very distressed ATO leader asked Golsby-Smith and his team to write a review on the BAS. The BAS form had not been developed using the ATO’s user-based design capability (which at this point, as Junginger (2006) has demonstrated, was still at the edge of the organisation). The Government was concerned about the political fallout from the BAS, and
on this occasion the ‘customer experience’ was a key worry for them, particularly for the ATO. It was a huge strategic issue for them given their self-assessment model.

As part of the review process, Golsby-Smith and his team conducted ethnographic research on the experience of users filling out the BAS, including video footage. They worked with women, for example, who dutifully and carefully did the books of their small businesses after hours. They were the kind of people who were 100% committed to complying with the tax laws. But they couldn’t fill out the BAS and one of them was moved to tears because of the experience!

The ATO leadership was influenced strongly by the review, the video and follow-up workshops that all demonstrated the power of user research. This incident with the BAS became a cautionary story within ATO folklore about the strategic consequences of treating customers insensitively. This led to tactical user based design becoming embedded in the culture of the ATO. The mantra from then on, for any and every initiative, was ‘do design always!’ resulting in the ‘Design Centre’ concept being moved to the centre of the organisation’s approaches to product development.

5. Concluding remarks

The essentially unstructured and ambiguous ‘cultural work’ around purpose and identity that is talked about in this paper is in stark contrast to what is valued by most management and executive teams in business, government or otherwise. Like most design work, it is integrative, rather than analytical, humanistic rather than mechanistic and ‘outside-in’ rather than ‘inside-out’. It is primarily about invention rather than research (Golsby-Smith 1996) with an openness to embrace the ambiguity and opportunities that exist in dynamic and political environments.

This distinction between modes of thought is powerful, and has a long history. Golsby-Smith has developed a ‘two roads’ story to highlight two different ways of truth making (Golsby-Smith 2007). The first road is the road of logic and analysis while the second road is the road of rhetorical argument and the liberal arts. The ATO has chosen to invest strongly in the design thinking road that we call the second road; the road that serves thinking about possibility and transformation. As a result, despite some recent problems with the implementation of new IT systems, Australia is well served by having one of the world’s most highly regarded taxation systems (D’Ascenzo 2010). This has encouraged self-assessment and voluntary compliance by tax payers, contributing to Australia’s status as one of the world’s strongest economies.

Notes

1. The authors gratefully acknowledge the participation in this research of senior ATO leaders and also John Landau, Dave Kaufer and Tom Reid. We are also grateful to Sitra (Finnish Innovation Fund) who visited us in 2009 in their search for practical examples of ‘strategic design’ in a governmental context, thus stimulating our paper.

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