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Chapter 7

TRANSLATING DESIGN THINKING FOR SCIENTISTS

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ABSTRACT

Historically, design has been viewed as an activity for design professionals. Typically, the focus of design has been the intentional creation of products, structures, or systems to address the needs of firms and individuals. Why should scientists be interested in design? One reason is an ethical one, as twenty-first century realities may require the participation of everyone to have a say in our designed world. The overall purpose of this chapter is to raise the awareness of scientists and other readers to a form of thinking called design thinking. The term has been familiar to many design disciplines and most recently has been touted by members of the business community as a mindset for an entire organization. One of the sub-disciplines of design is that of design management, providing guidance on the use of design thinking across the entire organization. The first section of this chapter will review the design thinking literature across different levels of activity, including design and society, design and organizations, design and education, and design and the designer. The second section will suggest ways to help scientists

understand and use design thinking. What is a scientist to do with this information? This section will be organized in three sub-sections; namely, understanding design thinking, the relevance of design thinking, and envisioning the future.

Keywords: design, design thinking, design management, design studies, sustainability, socially responsive design, wicked problems (5121)

INTRODUCTION

Design thinking is an iterative process that enables everyone, not just designers to explore problems and creatively answer the question "How do we make it better?". People in all disciplines are capable of using design thinking, but it is necessary to understand what is meant by design thinking to be able to use it effectively. Historically design thinking has been situated in academic venues related to traditional design disciplines, such as those in architectural, environmental, graphics, interior, and urban design fields, as well as in engineering and product design. However, we are now experiencing an explosion of design thinking in business, organizational management, knowledge management, and education. New design fields include information design, service design, interaction design, and web design. We are also witnessing some companies attempting for the first time to integrate design thinking with their more scientifically based approaches such as Six Sigma to improve product and service offerings (Beckman, 2009).

Scientists have been engaged in discussions around design in the context of intelligent design for decades (House, 2008; Dembski, 1998; Morris & Parker, 1987). Intelligent design as referenced in scientific conversations relates to the natural world, and addresses design as a possible factor in the creation of life forms as we know them. Based on the writings, deep divisions exist among scientists regarding this topic. Design thinking as a term may be associated with intelligent design given the sharing of specific words, but our approach to design thinking deals exclusively with the man-made world. Design thinking in our view includes products, organizations, systems, etc., and does not delve into the realm of intelligent design as debated within many scientific disciplines.

The relationship between design and other fields of study has been a subject of discussion and discourse for many decades. The primary areas of study have come to be viewed as three overlapping disciplines (Cross, 2007);

namely, science, humanities, and design, each asking a different question along the continuum of knowledge. Science is situated in the natural world, and through experimentation, classification, and analysis, describes "what is". The humanities focus on the human experience, and through analogy, induction, and criticism, work to "portray 'it'". Finally, design concentrates on the man-made world, and through modeling, synthesis, and abduction, seeks to determine "how to make it better" (Cross, 1982). Based on the current understanding of the orientation of each of the major disciplines (science, humanities, design), we recognize the fundamental differences, but strongly acknowledge that within each of the disciplines, the "what, why, and how" informs the others.

VIEWS OF DESIGN THINKING

In this section of the chapter, the contemporary views on design thinking have been organized into four levels of concern, including that of design and society, organizations, education, and the designer.

Design and Society

Daniel Pink's (2006) popular book, *A Whole New Mind*, defines the coming of the "Conceptual Age," characterized by an "*economy and a society built on the inventive, empathic, big-picture capabilities…*" This Conceptual Age is a direct response to the Information Age and will require different skills and abilities, often associated with right-brain thinking, for survival and success. Pink challenges the reader to consider three questions: "Can someone overseas do it cheaper? Can a computer do it faster?" and "Am I offering something that satisfies the nonmaterial, transcendent desires of an abundant age?" The "Whole New Mind" refers to the ability to creatively and innovatively respond to those questions. This right-brain aspect of the "new mind" has the capacity for what Pink calls "senses," including that of design, story-telling, symphony (putting pieces together), empathy, play, and meaning. Design, Pink reminds us, is everywhere. We live in a humanly-designed world. Design is accessible to everyone, although business is actively embracing design as a business process. He believes that future success will go

to people who can move quickly and master these sensory abilities and apply them appropriately in today's culture.

However, humans hold a narrow view of culture, of what "being human" means. Despite being in the era of cultural awareness, there still exists a lack of understanding and resistance to other cultures. Other peoples can be better understood *through* their culture, one aspect of which is their designed world. The benefit to such a stance can develop a true cultural appreciation by everyone, but also an awareness of the role in design in creating this designed world. Designers and informed laypeople have a role in sustainment. An unsustainable world, says Fry (2003), is a "failure of design" (p. 78). He cites a new kind of design knowledge that will be needed to inform education, practice, and economics. Design thinking, he says, "is not natural. It is learned in that unnaturalness we call culture" (p. 73). What is needed by designers, scientists, and others will be the ability to see the nature of things differently, carry on a global conversation among all peoples, and develop a stronger reflective capability. "What arrives last is a retreat into conventional design practice and the design of things" (p. 81). Some businesses are beginning to realize that the success of their products or services will depend on understanding the human experience, rather than manipulating the culture with products (Riley, 2003).

Richard Farson (2008) believes that design and design thinking are powerful tools to address our current social and economic problems. In *The Power of Design*, he discusses the need to develop a concept of metadesign, or "the design of design." Metadesigners include and transcend the traditional design professions, and according to Farson, have the capabilities of re-visioning major systems such as healthcare, education, and criminal justice. He sees metadesigners as leaders with the responsibility of using systems thinking to foster and manage innovation today. This text does not define design per se or identify working principles. However, *The Power of Design* is a big picture advocacy of design and designers is useful in exploring the implications for thinking about individuals as well as professionals taking on a larger role in society.

Design and Organizations

The terms design and design thinking have found their way into business firms, resulting in numerous books touting their value to their success. David Burney of Red Hat, an open source computing company adopted design

thinking because its ideas mirror the idea behind open source software. Burney says that design thinking involves everyone in design " because it makes it easier for those outside the design industry to focus the idea of design as a way of thinking about solving problems, a way of creating strategy by experiencing it rather than keeping it an intellectual exercise, and a way of creating and capturing value (Hyer, 2009)." The growing attraction of design thinking, according to Burney, is that it focuses on innovation rather than on traditional business processes, such as small-scale product improvement, efficiency, and top-down view of people, "need to know" attitudes and hidden agendas. Design thinking, according to Burney, is not a methodology, but a cultural way of thinking.

A key feature that cuts across most of these books on design and design thinking is customer involvement in the design. One example with a typical business title is *Do you matter? How great design will make people love your company.* (Brunner & Emery, 2006). The main idea here is that "Design establishes a *relationship* between your company and your customers." The authors cite the importance of designing a successful total customer experience, or risking total failure of the business. They discuss strategies for becoming a successfully design-driven business through awareness, commitment, implementation, and vigilance. Organizations must be designed from the top down, meaning that management must embrace the design process, as well as bottom up, embraced by everyone to be "design driven." Successful design, one focused on innovation, cannot be an add-on to existing products, spaces, or work.

IDEO is a consulting and design firm that is widely recognized as a firm on the leading edge of innovation. The author of *The Ten Faces of Innovation* (Kelley & Littman, 2005), Tom Kelley has developed a set of "human personas" that have been tested continually in IDEO's innovation work. He first identifies the "devil's advocate," the individual whose negativity ends all discussion of what is possible, as the most destructive role to innovation. Next, he describes three groups of personas that are highly effective in countering the negative effects of the devil's advocate. First, the "Learning Personas" are driven to continually expand knowledge and grow. Second, the "Organizing Personas" understand how organizations move forward and use that understanding to create a balance between innovation and realism, allowing for growth and forward movement. Finally, the "Building Personas" make innovation happen by using the knowledge from the "Learning Personas" and the organizational skills from the "Organizing Personas." According to Kelley,

when companies value and encourage these sets of roles, creativity, design thinking, and innovation will flourish.

Lockwood (2010) defines design thinking as a human-centered process for innovation and enablement. Key features are involving the consumer, collaborating in teams, creating prototypes, and visualizing concepts. A distinguishing tenet in Lockwood's view, integrates creative ideas with the traditional aspects of the firm. Design management and leadership are addressed in Lockwood's contribution to this book. He addresses the issues involved in moving a firm to a design thinking organization with a particular emphasis on service design, where the emphasis is on designing emotionally positive consumer experiences, as contrasted with the traditional focus on product design.

Complementing the Lockwood articles is Martin (2009), who identifies the "roadblocks" to the adoption of design thinking in the firm. These roadblocks occur in one or more of the three stages of what Martin calls the knowledge funnel, or the narrowing of mysteries of impossible problems to heuristics (i.e., rules of thumbs) to algorithms (i.e., calculable procedures). One mistake that firms make is to write off unsolvable problems at the mystery stage or to leave identified opportunities, the heuristics, in the hands of executives or specialists. At the algorithm stage Martin says some firms don't follow-through and free up human activity by actually coding an algorithm and allowing computing to take over the task. Human and financial capital is thus tied up with tasks that could be off-loaded to computing.

Design and Education

The evolution of design thinking is sometimes represented as a series of generations (Bousbaci, 2008). The first generation of design thinking and design methods (1950s – 1960s) depicted the designer as rational and logical (Broadbent & Ward, 1969; Simon, 1996), a reaction to the early view of the designer as intuitive and artistic. Reacting to this systematic view in the 1960s through the 1980s was a second generation focus on participatory processes (Alexander, Ishikawa, & Silverstein, 1977; Cross, 1972) and a third generation attempt to understand a designer's thinking processes (Rowe, 1987). Moving beyond looking at designers in their traditional forms of practice, Cross (1981) and Schön (1987) advocated a reflective approach, seeing design in a broader context.

Design Thinking by Rowe (1987) is a collection of ideas, theories, and systems related to design thinking and design inquiry in architecture. The work is comprehensive, and the author provides a historical overview of the doctrines of problem-solving. Much of his discussion centers around the information-processing theory, the prominent approach at that time to creative problem-solving. Rowe describes the design process as episodes of heuristic reasoning within which problems are identified, defined, and solutions are explored. He discusses well-defined problems, ill-defined problems, and wicked problems, and discusses the influence of different problems on the design process required within architectural design. Ultimately this is a well-documented work providing a scholarly overview of design inquiry within the field of architecture.

Nigel Cross' articles on *Designerly Ways of Knowing,* published in *Design Issues* in the 1980's were expanded into a text (2006, 2007). Cross's work has provided a foundation for situating design into our educational systems as an equal to science and humanities. He identifies design as a valuable and necessary knowledge base that asks the question "how can we make it better?" in relation to science's study of "what is," and humanities' quest for "how does it affect me?" The major idea of Cross's work is that design abilities exist in everyone and that design should be a part of a general education. These "core features of design ability: include an ability to resolve ill-defined problems; adopt solution-focusing strategies; employ abductive, productive, appositional thinking (e.g., reason from function to form); and ability to use non-verbal, graphic and spatial modelling media. The value of such abductive, "what might be" thinking for individuals and for business and other institutions, is the ability to consider change and to move past what for business is only "incremental" improvement. For decades Cross has challenged us to reconsider the critical nature of design thinking in our culture. His message is particularly valuable today as we begin to create new approaches to our economic, healthcare, and international systems.

Another influential design practitioner book was Schön's *Educating the Reflective Practitioner* (1987), which was set in the architectural design studio. Here Schön discusses the reflective habits of new designers as they design or reflection-in-action. Schön reminds readers that technique and artistry are both necessary in the development of a design professional. Design thinking is most closely addressed in the chapter on the design process, particularly how one frames and re-frames a design process and brings past experiences to bear. Also, in the chapter on the paradox of learning to design Schön discusses the difficulty some students have with the demands of an architectural curriculum

and the challenges of having a dialogue with the instructor throughout. Educators, in particular, frequently cite this text, particularly those in teacher education, as the current academic image of the teacher is that of a reflective professional.

Design and Designer

According to Lawson (2005) in *How Designer's Think*, "design is a form of thinking skill, which can be acquired and developed." He presents an accessible discussion of design thinking set in the context of design process and practice, typically within the professions of visual design, including architecture, interior design, and industrial/product design. Designers, as he believes, must employ almost equal parts of convergent and divergent thinking to produce successful design solutions. Lawson talks about the historical progression from initial writing on the design process to evidence-based study in all areas of design. He acknowledges that the study of design thinking is in its earliest stages, and that much more work is necessary in this field. Finally, unlike most other comparable works, Lawson proposes a model of design activity and thinking based on Nigel Cross's earlier work, but expands Cross's ideas to incorporate new knowledge about the thinking and design processes, essentially problem solving for architects.

Brown (2009), the CEO of IDEO, characterizes design thinking as a means to leverage what humans already know to tackle a broader range of problems than before. The key for what Cross would label as abductive thinkers ("what might be") is that the outcomes of design must be *technologically feasible* and that the innovation must make *business sense*. Brown sees design thinking as a means to help skilled practitioners think like a designer, to couple one's technical abilities with a new empathic sensibility of what humans need. The key, according to Brown, is to balance possibility with reality.

Features of design thinking, as viewed by Brown, can be characterized in four ways. The first feature is a focus on people, observing them, developing empathy, and developing new insights on human needs. The initial focus has been for design to meet basic needs but increasingly to the designing of emotionally-satisfying experiences. A second feature of design thinking is a different view on problems. The constraints of problems are readily embraced by design thinkers who recast problems as projects. Constraints are not so much resolved as placed in an appropriate balance. The process to address

these opportunities is nonlinear. A third feature is the thinking processes employed in design thinking. Brown cites two paired sets of mental states that design thinkers work between. Convergent thinking is making decisions about choices, while divergent thinking creates options. Designers also move between analysis or studying the problem-opportunity with synthesis or extracting structure and pattern from the data. A fourth feature of design thinking is the range of tools to be used. These can include visual thinking, prototyping, storytelling, collaborating, and the physical and electronic spaces for collaboration.

DESIGN THINKING FOR SCIENTISTS

The second part of this chapter summarizes the information assembled from recent writing on the subject of design thinking and synthesizes it into topics to help both design and science professionals see relationships between the disciplines based on design thinking. This section is organized into 3 areas of discussion: understanding design thinking, the relevance of design thinking, and envisioning the future.

Understanding Design Thinking

Given the large number of design professions, the term design thinking is a challenging topic to address in a simple and cohesive fashion. Each design field tends to discuss the topic within its own parameters, making interdisciplinary collaboration and inclusion of "non-design" fields in the design thinking conversation difficult at best. Recognizing the lack of a comprehensive, inclusive definition of design thinking, we have attempted to provide an overview of current approaches through our discussion of the literature. Figure 1 provides a visual summary of design thinking based on current publications reviewed in the first section of this chapter.

Design thinking in the 21st century, based on the writings and apparent current trends, addresses all areas of the designed world, and indicates that everyone can be a "designer". Such a stance implies the need for design and an understanding of design process to be a part of the education of all people. Ideally design should be taught with the same commitment as the STEM disciplines (science, technology, engineering, and mathematics), and valued on

the same level. Design thinking is a different way to think about the designed world and every person's role in what our future designed world looks like. Those who think like designers tap very different skills and use very different tools. As the information in Figure 1 indicates, design thinking is inclusive, values innovation, balances divergent and convergent thinking, and is based on abductive logic to consider "what might be?" and "how can we make it better?". But the question remains: "what is the relevance of design thinking in relation to the scientific disciplines?".

Culture and society	All people have a role in sustainability; all designers have a role in the designed world.
	See how other cultures see the world and designed features.
	Design "re-visions" human needs (e.g., healthcare, education, communities, criminal justice).
Involvement of people	Design process spans all business functions.
	Design management and leadership are necessary business functions.
	Design process includes customer, client.
Focus of activity	Innovation over incremental improvement
	User need vs. business need
	Focus on consumer, client experience over product
	Problems/solutions are seen as opportunities/responsiveness
	Design must be technologically feasible and make business sense
How one thinks	Everyone has design abilities; promote in general education
	Use brain's right side senses: design, story, symphony, empathy, play, meaning
	Balance convergent (decisions) and divergent (options) thinking
	Visual tools
	Reflectivity
	Visual tools
	Heuristic reasoning
Design process	Collaborate in teams; physical and electronic spaces for collaboration
	Tackle impossible problems, embrace constraints
	Use abductive logic, or consider "what might be"
	Visualize concepts
	Develop and test out prototypes, iterate revisions.

Figure 1. Design Thinking Features.

Relevance of Design Thinking

Both science and design share goals of solving problems on various levels. The method each discipline embraces is different, and requires different skills and thought processes for success. It has been long-accepted that the scientific method centers around problem-solving to find out the nature of what exists; it is analytic. At the same time, design method is constructive, seeking to provide solutions through inventing things with value that do not yet exist (Gregory, 1967). Design is utility enhanced by significance (Pink, 2006), and it is critical to understand "what is" as a basis for providing utility. Products, systems, spaces…science contributes to utility by providing elements in both traditional (existing) forms, and in new combinations to form appropriate materials. Designers create ways to use these new combinations, or vision new (sometimes seemingly impossible) outcomes and rely on scientific and technological thinking to formulate methods to make the visions real. According to Lockwood (2010) "design is the key to bringing innovation to life" (pg. xv). Science is the key to discovering and recognizing what currently exists. While design provides the outlet for the use of scientific discoveries, scientific involvement provides modifications and improvements to allow for even more innovative products and uses. Collaborative efforts between design and scientific thinking provide unexplored opportunities for even greater innovation, and communication, understanding, and valuing between the disciplines is vital for this to occur.

Attempts have been made in the past to model design thinking on the scientific process. The rationale for these activities are varied, but are thought to include providing a greater perception of value to the design disciplines (Cross, Naughton, & Walker, 1981). Design cannot be reduced to a linear, formulaic approach. While there have been attempts to create this unrealistic approach to the design process, design is a fundamentally different way of thinking. It is not better or worse, simply different. Discussion continues today (Simon, 1996) but there is greater acceptance of the essential differences and resulting value of design thinking in relation to, not as a mirror of, scientific methods. This is an important concept to adopt since it will be the combination of all methods that will bring about true innovation and change.

The complicated nature of today's world has led to a preponderance of problems that reflect a level of complexity equal to those of the current world situation. Rittel and Webber (1973) identified human-centered problems as "wicked" in their early works, and identified characteristics of wicked problems that differ from the traditional problems often encountered by

scientists. Wicked problems are complex, dynamic, and open-ended. Often the problem is as dependent on the solution as the solution is on the problem. As one portion of the problem is solved, the problem reorganizes itself into a new and different problem or set of problems. Human perceptions of the problem change, stakeholders change, resources and priorities change, and the problem(s) morph as a result. Solutions are not clear, and continue to change throughout the process. Wicked problems defy scientific approaches since they cannot be bounded or clearly hypothesized, and are only solved when the solution is considered "good enough".

Science cannot function in isolation. The discoveries made about the natural world are part of the human-centered issues prominent today, and frequently become very complex, wicked problems. For example, scientific discoveries about the natural world's response to man-made intrusions influence human decisions about funding for more natural world exploration. Additional discoveries lead to changed perceptions, leading to more (or less) support for continued exploration. Political, social, moral, aesthetic, health, and other issues and influences impact this one simple example, leading the scientist squarely into a wicked problem scenario. Design thinking involves subjective assessments, as opposed to objective assessments valued by the science community. Responsible subjective assessments are different, but no less valuable in today's culture. They are credible and useful in addressing complex real world issues, as opposed to valid and reliable in normative science (McFall & Beacham, 2008). It is the subjective assessment provided by design thinking that most effectively addresses the wicked problems we face today.

Envisioning the Future

Design is about *radical innovation* (Lockwood, 2010), while science values incremental understanding and the resulting incremental improvement that is tied to reliability and validity. Design often relies on rapid prototyping, failing fast, and unbounded idea generation. Science is typically hypothesis driven and discoveries, approaches, and new knowledge is bounded or significantly influenced by current understanding of an issue in the formation of that hypothesis. Designers, while obviously influenced by current information, are continually looking to explore uncharted areas with few if any boundaries during the initial ideation or exploration process. The boundaries are acknowledged only after the idea-generation has produced directions for

design solutions. Scientific methods strive to discover characteristics by isolating them or "correcting for" outside influences. Design is holistic and seeks to understand contextual influences and perceptions as a part of the exploration and problem-solving. While these statements and the associated disciplines may appear to be opposite in every way, they are, in actuality, two sides of the same coin. They are interdependent, and finding and embracing the synergy between the activities is the key to a successful future.

While not all scientists may choose to engage in design thinking, it is important to realize that our culture is quickly understanding the value and importance of innovation, and design thinking is currently recognized as the primary method of fostering innovative and creative approaches. As a result, scientists will more frequently be tasked with collaborative opportunities to use their discoveries of "what is" to create a new reality that supports innovative solutions to wicked (or seemingly impossible) problems. By expanding the understanding of design thinking to professionals in the STEM disciplines, and acknowledging the value of collaborative design and scientific thinking, innovation and exploration can occur with far more effective results. True collaboration will only be possible if scientists have at least a preliminary understanding and grasp of design thinking. At that point, the collective efforts will provide the vehicle for scientists to harness the power of design thinking for new ideas in scientific discovery.

CONCLUSION

Our culture has historically come to highly value the incremental approach over risk-taking. Design thinking challenges the current traditional process, but is more responsive to the evolving culture we currently see globally. Change is happening. There is a place for all types of approaches, but before we can be truly successful, each discipline must find ways to value differing views of moving forward. Scientific approaches are critical in the understanding of the natural world, and provide a foundation upon which we must build to improve our quality of life. Design thinking provides the innovation required to address the demands of today's fast-paced, user-oriented, risk-taking culture. Science grounds us, design moves us forward. Both are vital. Both must be valued. Understanding between disciplines is the first step towards massive changes in the way design and science collaborate and re-envision a new world.

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