Understanding the behaviour of design thinking in complex environments

A thesis submitted for the degree of Doctor of Philosophy

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Abstract

Design thinking is a term widely used outside of the design industry to describe the innovative and human-centered approach used by designers in their practice. Within the design industry, the term is both embraced and rejected. Design thinking has erupted outside of design practice as a new approach for innovation and transformation, piquing the interest of leaders from business, education, government, through to not-for-profit organisations. Design thinking is rapidly spreading through industries, increasing the spectrum of what is traditionally considered as design practice. Its most recent influence finds design thinking trending towards highly complex environments situated on a much broader and systemic scale. Yet, the wave of design thinking carries a sea of doubt over its success, applicability outside of traditional design practices, and above all, its definition. In order to sustain its credibility, research is required to investigate the behavior and effectiveness of design thinking applied in this emerging area of complex practice.

The primary research question that will direct this research investigation is, *What is the behavior of design thinking in complex environments*? The nature of this thesis is exploratory. The objective of the research is to contribute empirical evidence on the behavior and effectiveness of design thinking for tackling problems in complex environments. This thesis aims to make three contributions: first, it seeks to identify and explore the history and evolution of design thinking to date, synthesizing common definitions. Second, it seeks to contribute empirical evidence on the behavior of design thinking in highly complex environments. Third, the investigation aims to explain the underlying mechanisms that enable emergent behaviors to occur in the design process, contributing knowledge and understanding on how to apply design thinking in complex environments. Research into the practical implications on the way a designerly approach addresses, manages and shapes problems in complex environments is crucial to advancing both design thinking and society. This research will explore the behavior of design thinking as it tackles complex problems and examine how design thinking shapes, and is being shaped, by complex environments.

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What an exhausting three years. This PhD has had an impact on my life beyond that of just research. It taught me valuable life lessons that have shaped me into a stronger person through throwing me to the edge of emotion, fear and doubt.

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Lastly, to my Mum, Dad and brother, Adam. Their immovable and infinite support, belief and encouragement throughout my life and PhD has given me the strength to be where I am today. This thesis is dedicated to my family.

Declaration by student

This thesis contains no material that has been accepted for award of any other degree or diploma. To the best of my knowledge, this thesis contains no material previously published or written by another person except where due reference is made in the text. Where the work is based on joint research or publications I have disclosed the relative contributions of the respective authors.

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1.

Introduction

An interest in design thinking has grown since the establishment of the Design Thinking Research Symposium in 1991 (Cross, Dorst, & Roozenburg, 1992). Since then, design thinking has remained at the forefront of discussions in design research and practice. Today, design thinking has become a marketable process for increasing efficiency and innovation in industries outside of traditional design practice. The popularity and adoption of design thinking has expanded traditional notions of design practice. However, the evolution of design practice is fuelling debate over how to identify design thinking. Arguments over whether design thinking is a set of mindsets, methods, or composition of the two, persist in both industry and academia. Debates over the definition of design thinking is stirring confusion and skepticism over its usefulness and effectiveness in dealing with complex and wicked problems (Nussbaum, 2011; Norman, 2010). This debate will persist until more empirical knowledge is contributed on the nature and application of design thinking. The goal of the research question, *What is the behavior of design thinking in complex environments?* is to investigate and contribute much needed empirical research on design thinking in complex practice. This introduction serves to signpost critical topics explored in this dissertation, alerting the reader to fundamental developments and ideas. This introductory overview presents a summary of the research question, background, objective, methodology and contribution.

1.1 Research Background

Understanding the behavior of design thinking in complex environments

Driving design thinking is the capability to innovate. This feature has seen design thinking spread from conventional practices in graphic and product engineering to service, systemic and policy innovation (Design for Growth and Prosperity 2012; APS Innovation Action Plan 2011; DESIS Network 2012; Social Design Futures, 2014). Innovation has become integral to the force and identity driving design thinking across industries and towards higher and more complex project environments. The rapid rise in the adoption of design thinking in highly complex environments has surpassed current knowledge on *how* to apply a design approach in these contexts. In order to substantiate the proposed value of design thinking, research understanding the behavior, impact and application of design thinking in complex practice is needed and is the focus of this thesis.

The main research question, *What is the behavior of design thinking in complex environments?* seeks to contribute much needed empirical research and analysis on design thinking applied in complex practice. This research question will be supplemented with two sub-questions:

1. What effect does the position of design thinking to the project context have on designing in and for complex environments?
2. What are the underlying mechanisms that enable or disable designerly behaviours to emerge in complex environments?

The first sub-question seeks to understand if the position of design thinking relative to the project ecosystem affects the behavior of designing in and for complex environments. This analysis will focus on projects situated within complex environments that have different degrees of interaction and relationship to the project ecosystem. This question is inspired by, and builds upon, hypotheses presented by Sabine Junginger on the position of design practice relative to an organization (Junginger, 2011).

The second sub-question will investigate the underlying mechanisms that enable or disable design attributes to emerge when design is applied in a complex environment. This question aims to delve beneath “thick descriptions” of design activity to provide causal explanations for why particular behaviors emerge and what may hinder their emergence.

The analysis of the second sub-question is directed by a critical realist theoretical perspective in conjunction with a systems theory approach. Examining underlying mechanisms will provide a deeper analytical explanation on the behaviors outlined through discussion of the main research question.

1.2 Identification of key terms

1.2.1 What is design thinking?

Design thinking is heralded by some individuals as a new and innovative process for tackling complex problems (Brown & Wyatt, 2010; Äijälä & Karjalainen, 2012; Graham, 2013). Design thinking is commonly described as a mindset (Laakso & Hassi, 2011, p.4; Leinonen & Durall, 2014, p.108), method (Beckman & Barry, 2007; Lockwood, 2010), process (Benson & Dresdow, 2013, p.7; Von Thienen et. al., 2014, p.101) and attitude (Brown, 2008; Jones, 2010, p.226; Gloppen, 2009), that is unique to designers and design practice.

Design thinking is a title that has been used widely outside of the design industry to describe the way designers work, with emphasis on the cognitive aspects that direct a design approach. Yet, the process and definition of designing, and design thinking, is elusive. In an attempt to define design thinking, practitioners, including scholars, have attributed the origin and development of design thinking with Peter Rowe's book titled, *Design Thinking* (Rowe, 1987; Dorst, 2010; Kimbell, 2011) and its methodology from design consultancy IDEO (Brown, 2010; Badke-Schaub, 2010; Blizzard, 2013; Terrey, 2012) or the Stanford D.School ("Institute of Design at Stanford", 2015). In contrast, other professionals have asserted that design thinking is an amalgamation of methods borrowed from practices such as business, marketing and the creative arts (Martin, 2009). This has spurred confusion over the definition and origin of design thinking, including speculation over whether the phenomenon is in fact intimately linked to design practice (Dorst, 2011, p.531). The definition, origin and development of design thinking will be addressed in the literature review. The literature review chapter will establish a brief theoretical foundation behind design thinking and conclude whether this 'new' and innovative process is in fact embedded within design history and practice. Furthermore, the literature review provides a consolidated view of contemporary descriptions of design thinking.

Through an analysis and synthesis of the history, development and contemporary descriptions, it is proposed that design thinking may be considered synonymous with the term *designing*.

1.2.2 What is a complex environment?

Complexity has been a topic of discussion throughout the history of design theory. Seminal design scholars such as Rittel & Webber, Richard Buchanan and Bruce Archer refer to complexity as part of design practice (Archer, 1965, pp.58-62; Buchanan, 1992, p.9; Rittel & Webber, 1973, p.162). However, there is little consensus in the design field over what defines complexity, or constitutes complex design practice; complexity in design literature is only vaguely sketched out.

Since Rittel & Webber (1973) coined the term *wicked problems*, complexity has become part of the characteristic repertoire of design thinking. Rittel and Webber established what has become the most notable and widely adopted reference to a definition of complexity in design, with their writing on wicked problems. Broadly, a wicked problem is inherently complex, and one that is “unique” and “ill-defined” (Rittel & Webber, 1973, p.163). A wicked problem has no definitive formula for resolution, but rather, can only be satisfied under current conditions, because “there are no ends to the causal chains that link interacting open systems” (Rittel & Webber, 1973, p.162). A complex environment contains ‘wicked’ problems. However, the term *environment* has been chosen in this thesis instead of *problems* as a complex environment may contain tame problems made complicated by *wicked* systems.

Systems are often referred to in conjunction with complexity “the process must be holistic and consider the artifact in a wider system” (Archer, 1965, p.58). It is this connection between complexity and systems which provides fertile soil to build a concrete definition of complexity for design theory and practice. References to complexity in design are not inspired by, or borrowed from, definitions of complexity established in other disciplines such as cybernetics, micro-economics or mathematics. Yet, complex design practice is often referred to as working within open systems. Thus, systems theory may lend a clearer definition of complexity that can be adopted for descriptions of complex design practice and environments.

This thesis has chosen to define complexity, and thus complex environments, using Peter Jones' description of systemic design (2014):

> A complex system refers to domains where it is nearly inconceivable that any single expert or manager can understand the entire system or operation. Typical systemic design problems are complex service systems, socially organized, large-scale, multi-organizational, with significant emergent properties, rendering it impossible to make design or management decisions based on sufficient individual knowledge. These include services and systems such as healthcare systems and disease management, mega-city urban planning and management, natural resource governance and allocation, and large enterprise strategy and operations. None of these are isolated "domains," as each of these are affected by unknowable dynamics in population and regional demographics, climate and natural ecology effects, political and regulatory influences, and technology impacts.

Hence, complex environments have been defined for this thesis as large scale, open and adaptive systems that require multidisciplinary collaboration for design development. This is because systems can be perceived as complex from both a structural (organisational) or cognitive (social) perspective where a high degree of uncertain variables are present. It is important to highlight that this thesis does not focus solely on organizational *institutions*, as commonly discussed in design management literature. The term complex environment has been chosen to allow for a broader context of study into new emerging areas of practice which fall within 3rd and 4th order domains of practice (explained in chapter 2. *Literature Review*) but may not be distinctively situated within the context of an organizational institution. Instead, the word organization is used in this thesis to denote the arrangement of elements to a whole. Hence, this thesis is not focusing on design capability or design thinking adoption in organizational institutions, but rather, exploring and documenting the adoption and application of design thinking in complex environments.

Complex environments enable changes in design thinking practice as the design approach adapts to this new context. Design thinking is in a constant flux of adaptive transformation; in re-designing the nature of the system where it is applied, design thinking shifts to adapt to the system it has changed. Designers are increasingly faced with complex issues beyond conventional practice. Design for complex environments is still a practice in its infancy and solutions may not adequately satisfy the needs of complex systems without sufficient research supporting the value of adopting a designerly approach for the resolution of complex problems (Jones, 2014). This dissertation aims to contribute exploratory research on design thinking in complex environments to aid the needs of both designers and professionals seeking assistance from the designerly way.

1.3 An alternative theoretical perspective for design research

This thesis utilizes and proposes an unconventional theoretical framework to guide research on design practice. Perspectives commonly prescribed for design researchers stem from subjectivist and positivist theory. It is proposed that these epistemological and ontological positions are inadequate for the investigation of wicked problems in complex environments. This thesis argues for, and utilizes, the adoption of critical realism for researching design thinking in complex environments.

Critical realism presents a theoretical position that ontologically acknowledges both social and natural realities (Dickens, 2003). This allows research to engage with subject matter that is inherently constructivist as well as positivist. The epistemological position of critical realism accepts a view of reality that is stratified, generating knowledge through causal analysis (Wuisman, 2005). Knowledge is produced via the vehicle of retroduction: a logical framework that translates the ontological position of critical realism into an epistemological theory (Oliver, 2011). Knowledge is generated by stratifying levels of reality, to 'dig' through observable and unobservable events in order to uncover underlying causal mechanisms that influence and affect the object of phenomena (Elder Vass, 2012). The aim of critical realism is not to provide "thick descriptions" of phenomena, but uncover causal mechanisms that allow for explanatory analysis.

Causal analysis takes place using a grounded theory methodology. As the research question is explorative, grounded theory affords the discovery of categories that describe and reflect the behavior of design thinking in complex environments. In order to comprehensively design for complexity, an understanding of the interconnected causal mechanisms affecting the design process, problem and outcome is imperative. As such, critical realist grounded theory has been used for uncovering causal mechanisms in order to understand how we can improve design thinking practice for complex environments.

1.4 Thesis structure

This thesis is divided into nine chapters. The first chapter, *Introduction*, outlines the research objective and structure of the thesis. The second chapter establishes a literature review tracing the history and evolution of design thinking, including current developments and definitions. This chapter guides the reader through fundamental movements in design theory, relating current research on design thinking to design history and methodological development. Historical references have been deliberately drawn from the design field in order to investigate if design thinking is derived from design theory and practice. This evolution is discussed in light of recent literature outlined within 2.3 *Current Practice*. The chapter will then conclude with 2.4 *Research Direction*, highlighting the need for empirical research on design thinking applied in complex environments before presenting the research question that will guide the focus of this thesis.

The third chapter is devoted to outlining the research framework. This chapter outlines the theoretical position, methodology, methods, research design and framework for data analysis that will guide the investigation of this dissertation. In this chapter an alternative theoretical perspective, critical realism, is proposed for academic research investigating complex design practices. The fourth chapter presents the first case study collected for this thesis. This case study focuses on design thinking practice in a service and strategic design agency where design thinking activity is conducted external to the project organization system. The fifth chapter follows with a case study on design thinking situated internal to an organizational system, The Australian Taxation Office. The sixth chapter presents a new perspective on design thinking practice in complex environments, with design thinking applied in an open-source, decentralized online environment that is OpenIDEO.

The seventh chapter is dedicated to a cross-comparative analysis of each case study. This chapter will present emergent themes common to each case and cross-compare the emergence of these themes in light of the effect that the position and relationship design thinking practice has to the project system. In addition, this chapter will propose underlying mechanisms that enable or disable themes to emerge. The eighth chapter, *Discussion*, will analyze the broader impact and perspective from the knowledge obtained in this dissertation. Finally, a summary of contributions and limitations in this thesis will be presented in the final chapter, *Conclusion*.

1.5 Research Contribution

The research aims to investigate the behavior of design thinking in complex environments, understanding how design thinking is used and whether it is an appropriate framework for complex 'wicked' problems. To answer the research aim, a three case studies have been collected from projects that have utilized design thinking in complex environments. These case studies have been selected for their representation of complex environments from three domains: public, private and open source projects. Furthermore, each case presents design thinking activity under three different conditions: design thinking operating on the periphery to the project and organized system, design thinking applied internally to the project and organised system and design thinking applied in a de-centralized system.

This dissertation makes four fundamental contributions. First, it has contributed knowledge and clarification on the history, development and definition of design thinking. Second, empirical knowledge has been generated on the behavior of design thinking specific to complexities of third and fourth order design practice. Third, it has contributed new knowledge on the effects that positioning plays on design thinking practice in complex environments. Finally, this thesis articulates underlying mechanisms that may be enabling or disabling effective design in and for complex environments.

This thesis improves our understanding of design thinking in complex environments. The knowledge generated in this thesis will help establish design thinking as fundamental to design practice through identifying the evolution and history of design thinking to date. In addition, this dissertation improves upon our understanding of the behavior of design thinking in complex practice; to further educate and support design researchers and practitioners when designing in and for complex environments. Furthermore, this thesis provides a unique and original contribution to our understanding on design thinking practice in complex environments with identification of potential underlying mechanisms that enable and disable designerly behaviours to emerge in these contexts.

2.

The Evolution of Design Thinking

Design thinking is not a new concept. The aim of this literature review is to uncover and trace the historical lineage of design thinking within design theory and practice. In doing so, this review will be structured in three parts: first, a brief history of design thinking; its evolution throughout design theory, highlighting key theorists and trends. Second, the development of design methods and new forms of practice, and third; a discussion of the common definitions and methods associated with a contemporary understanding of design thinking, including a critical analysis of its transformation and approach in current practice. Identification of the history, evolution and current definitions of design thinking is required in order to solidify and evolve its theory and practice.

Design thinking has gained sudden popularity in a relatively short period of time. Investigating the historical roots of this phenomenon is necessary in order to contextualize the success and definition of contemporary design thinking practice. The first section of the literature review, which covers the beginnings of design thinking, has been split into two sections: a critique on "first generation" design theory, in the period of the 1960s-1980s, followed by "second generation" theories from the 1980s to the mid 1990s. This brief outline on the fundamental movements in design theory is necessary in order to establish and develop a more informed understanding of where and how design thinking arose and where it may lead in the future.

The second section of this literature review will focus on the evolution and emergence of new design practices; how and why these sub-disciplines were constructed. The purpose of this second section is to develop a deeper understanding of the influence first and second generation theories had on the development of new design disciplines, distinguishing how the methods of these sub-disciplines differ whilst analyzing how this development has contributed to contemporary design thinking practice. The third section brings together current characteristics and definitions of design thinking in light of historical development. This chapter will conclude with an argument for further research on design thinking in complex environments and present the research question that will guide the focus for this thesis.

2.1 A Brief History of Design Thinking

1960s-1980s: Establishing Design Practice

The design methods movement of the 1960s marked the beginning of an ongoing debate over the process, theory and methodology of design practice. Scholars such as Bruce Archer, John Chris Jones, Peter Slann and Horst Rittel initiated a conference titled, *The Conference on Systematic and Intuitive Methods in Engineering, Industrial Design, Architecture and Communications*, in London in 1962, which later inspired the development of the Design Research Society (Jones, 2002). This conference sparked the beginning of a movement that aimed to define design on its own terms, theorizing proposals to professionalize and systematically distinguish design practice from art and craft. During this period, Herbert Simon pioneered research on a design science, whilst Horst Rittel and Melvin Webber argued against the rigid scientific lens through which to view design problems. Rittel and Webber claimed design problems are not fixed and introduced the famous term *wicked problems*.

Taking a different perspective, Victor Papanek introduced an argument for socially conscious design, advocating the need for innovative sustainable solutions that answer to fundamental human needs, whilst Bruce Archer championed for design to be seen as a third form of knowledge distinct from science and humanities. The focus of this section has been restricted to highlighting the fundamental theories of these writers, who each represent different ideologies on design during the first generation of design theory. These writers have been chosen for the impact their research has had on contemporary design theory today.

The history of design thinking can be traced through many different disciplines and sub-disciplines of design. In particular, design's closest cousin, engineering, may present its own lineage of the history of design and design thinking. For example, developments from figures such as Robert McKim and Rolf Faste who made contributions within the engineering discipline and resided at Stanford University. Similarly, fields external to design theory, such as business management, have gained traction towards providing knowledge on the history and development of design practice in managerial and organizational contexts. This literature review has explicitly chosen to trace the history of design thinking through fundamental papers and profiles from within design literature. In doing so, this review acknowledges the presence and potential influence of engineering and business management literature on the history and development of design thinking, but in the interest of scope, it has excluded deeper investigations into engineering and management theory. The focus on design theory provides a manageable boundary for the literature review and presents a lineage of evidence that suggests design thinking is in fact intimately linked to design practice.

2.1.1 Design is artificial

In his book, *The Sciences of the Artificial*, Herbert Simon describes design as a systematic process aiming to improve artificial environments into 'preferred' outcomes (Simon, 1996, p.111). In his description of the artificial, Simon (1996) draws on technical disciplines such as engineering, policy science and medicine; all of which he believes exhibit processes concerned with improving the artificial world:

> The intellectual activity that produces material artifacts is no different fundamentally from one that prescribes remedies for a sick patient [...] schools of engineering, as well as architecture, business, education law and medicine, are all centrally concerned with the process of design (p. 111).

Our world, as Simon sees it, is not natural but constructed from man-made artifice (Simon, 1996, p. 2). Simon's (1996) definition of the artificial represents objects created by man. This gave Simon reason to believe the professions that aim to produce or reconstruct the artificial reflect the act of designing "The proper study of those who are concerned with the artificial is the way in which that adaptation of means to environments is brought about-and central to that is the process of design itself" (1996, p.113). Simon's scientific perspective on the nature of design led him to evaluate the human brain, an object he views as the ultimate 'artifice'.

Simon draws comparisons between the processes of a computer and cognition (Simon, 1996, p. 74). He extends his theory into in-depth descriptions on the 'limitations' of both mechanisms (Simon, 1996, p. 59). The computer is a product of human cognition, and as such, its limitations reflect the limitations of the human brain. Simon argues that human thought is artificial (Simon, 1996, p. 76), using psychology and mathematical experiments to illustrate the limitations of computing (thought) processes of the brain (Simon, 1996, p. 66; Huppatz, 2015). This train of thought led Simon to believe that in designing solutions, cognitive limitations will construct boundaries that hinder our understanding of the complexity of our external environment requiring resolution. As a result, Simon proposes a theory of optimization through which one can only 'satisfy' than resolve problems (Simon, 1996, p. 27-119). Simon approaches what he describes as *poorly understood systems* (a reflection of Rittel & Webber's 'wicked problems') with scientific methods of prototyping (Simon, 1996, p. 18). Simon (1996) believes "To understand them, the systems had to be constructed, and their behavior observed" (p. 20). He describes simulation as an optimal method for creating solutions that satisfy, signaling prototyping as a source for generating new knowledge.

In a different argument, Simon approaches societal design with a unique perspective. Working with project problems of a large scale, such as social planning, Simon stresses the importance of representation and conceptualization of a common problem that is understood by all stakeholders. This method, he argues "Would facilitate action rather than paralyze it" (Simon, 1996, p. 143). In this instance, a correct representation was not the most appropriate approach. Understanding amongst all individuals is key to the cooperation and ultimate success of large-scale societal solutions. Simon (1996) addresses feasibility when defining limitations (boundaries) of the problem "Design problems often involve setting one or more parameters at values that will be neither too high nor too low" (p. 144). Simon's (1996) approach is pragmatic, arguing the importance of "Configuring organisations [and] our social interactions with others in our society", whilst designing for the future and making loose predictions on alternative scenarios to "Motivate activity which in turn will generate new goals" (p. 154). For Simon, large-scale problems, whether societal or environmental, require an evolving design process, one that is without final goals (Simon, 1996, p. 165). As a result, Simon concluded that the complex artificial environment we have created requires a design science that utilizes simulation techniques and a theory grounded in logic.

2.1.2 Design is complex

In one of the most influential papers in design theory, *Dilemmas in a General Theory of Planning*, Rittel and Webber (1973) identify 'wicked' problems through an examination of policy planning practice. When working with ambiguous and wicked problems, the designer can only resolve rather than solve the problem at hand. Solutions are instead determined as either good or bad "Assessments of proposed solutions are expressed as "good" or "bad" or, more likely, as "better or worse" or "satisfying" or "good enough"" (Rittel & Webber, 1973, p. 163). A wicked problem is unique, ambiguous and has no definite solution (Rittel & Webber, 1973, p. 161). Wicked problems are broad and cannot achieve finite true/false outcomes. Rittel & Webber justify their position, arguing that resolving an open-ended 'wicked' problem will introduce a new, complex problem and thus never finding a complete resolution.

Rittel & Webber argue that science cannot resolve problems that have open and evolving variables. The rigidity of science fails when attacking and resolving 'wicked', ambiguous problems (Rittel & Webber, 1973, p. 160). Their justification is that science is only equipped to deal with 'tame' problems "The problems that scientists and engineers have usually focused upon are mostly "tame" or "benign" ones...Wicked problems, in contrast, have neither of these clarifying traits" (Rittel & Webber, 1973, p. 160). A 'tame' problem is an issue that can be resolved with a definite solution, under finite, localized circumstances and could come to be resolved through trial and error.

This idea is similar to Herbert Simon's theory of satisficing through optimization. All three writers confess 'wicked problems' cannot come to any kind of true/false agreement, but designers can only 'satisfice' or resolve to the best of the solutions available. The ambiguity surrounding wicked environments led Rittel, Webber and Simon to highlight the importance of understanding the design process. These three theorists understood that the process of design aims to resolve problems "Between the state of affairs as it is and the state as it ought to be" (Rittel & Webber, 1973, p. 165). Furthermore, all theorists acknowledge the complex nature of designing for open, 'wicked' (evolving) problems that are often found within large-scale complex environments. There is no room for trial and error when implementing a solution for a wicked problem. It is for this reason that Rittel & Webber (1973) argue each wicked problem is unique, and therefore, so too is the process "Part of the art of dealing with wicked problems is the art of not knowing too early which type of solution to apply" (p. 164). Like Simon, Rittel & Webber (1973) discuss the significance of analyzing process methods for solution optimization "The information needed to understand the problem depends upon one's idea for solving it… since every specification of the problem is a specification of the direction in which a treatment is considered" (p. 161). This topic of design process and co-development of problem and solution is still at the forefront of debate to this day.

Through descriptions of policy planning problems, Rittel & Webber articulated the messy, ambiguous problems faced by designers in complex design projects. Their theory on wicked problems was embraced within the design community as it articulated the ambiguous nature of design practice (Buchanan, 1992; Coyne, 2005; Jonas 2009; Kimbell, 2009). Rittel & Webber's writing provided a method of reasoning and perspective on problem solving that supports the justification of design processes for tackling 'wicked' problems, setting the theoretical groundwork for contemporary design scholars.

2.1.3 Design is human

Concurrent with a movement that was concerned with the establishment of a design science, Victor Papanek released a book that introduced a moral perspective on the responsibilities of the designer. Focused on industrial design, Papanek first released *Design for the Real World: Human Ecology and Social Change* in 1972, with mixed reactions from his peers (Papanek, 1985, p. xvi-39). Papanek makes a statement throughout his book that the social and moral responsibilities of design stretch beyond product and profit reports. Much of Papanek's standpoint is in response to evidence that "Recent design has satisfied only evanescent wants and desires, while the genuine needs of man have often been neglected" (Papanek, 1985, p.15). Papanek's primary concern is drawing attention to fundamental societal needs and he advocates that designers need take into account wider moral responsibilities.

Reflecting Simon's idea that *everyone designs*, Papanek wrote "Any attempt to separate design, to make it a thing by itself, works counter to the fact that design is the primary underlying matrix of life" (Papanek, 1985, p.12). However, unlike Rittel, Webber and Simon, Papanek does not concern himself with extrapolating the details in process theories, methods, or definitions of design. Instead, Papanek frequently refers to innovation, a solution he believes to be the result of simplifying complexity "When we speak of an elegant solution, we refer to something that reduced the complex to the simple" (Papanek, 1985, p.26). Where Simon aims to 'satisfy' and 'optimize' solutions derived from a complex simulation of external environments, Papanek sources experience, knowledge and intuition for the resolution of problems in as simple a way as possible (Papanek, 1985, p. 151-186). In contrast to Simon and Rittel, Papanek highlights the intuitive nature of design "Design is the conscious and intuitive effort to impose meaningful order" (Papanek, 1985, p.4), but understands the impracticality of trying to tangibly describe intuition for the purpose of innovation. Instead, Papanek refers to traditional and practical process models, such as the function complex (Fig.1) as a method to measure the balance of tangible design products, whilst offering a list of innovative-idea-triggering techniques. These methods include brainstorming and prototyping methods, with emphasis on analogical thinking.

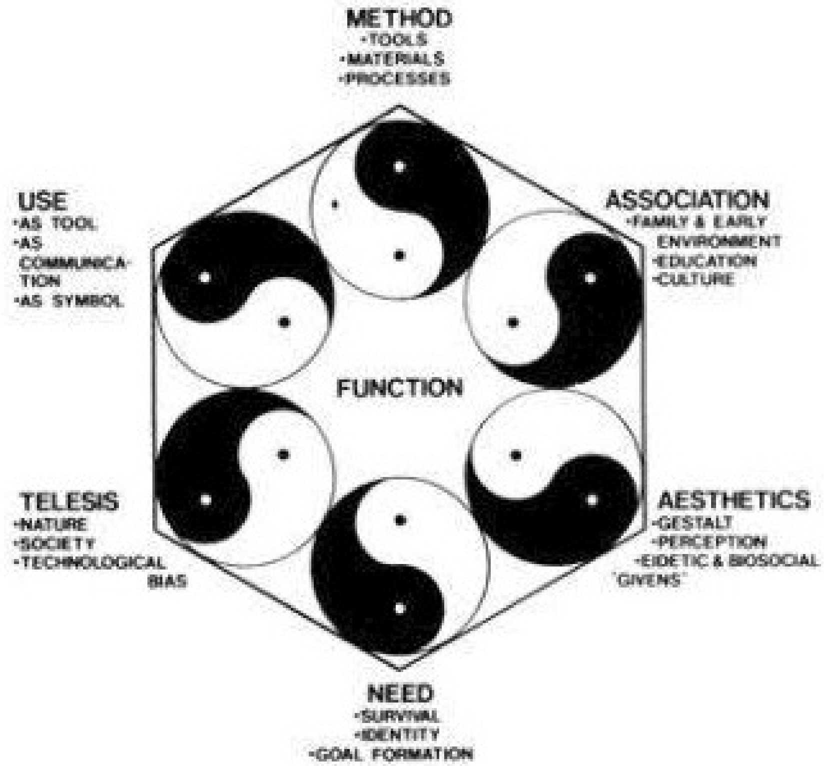

Fig.1 The Function Complex (Papanek, 1985, p.7)

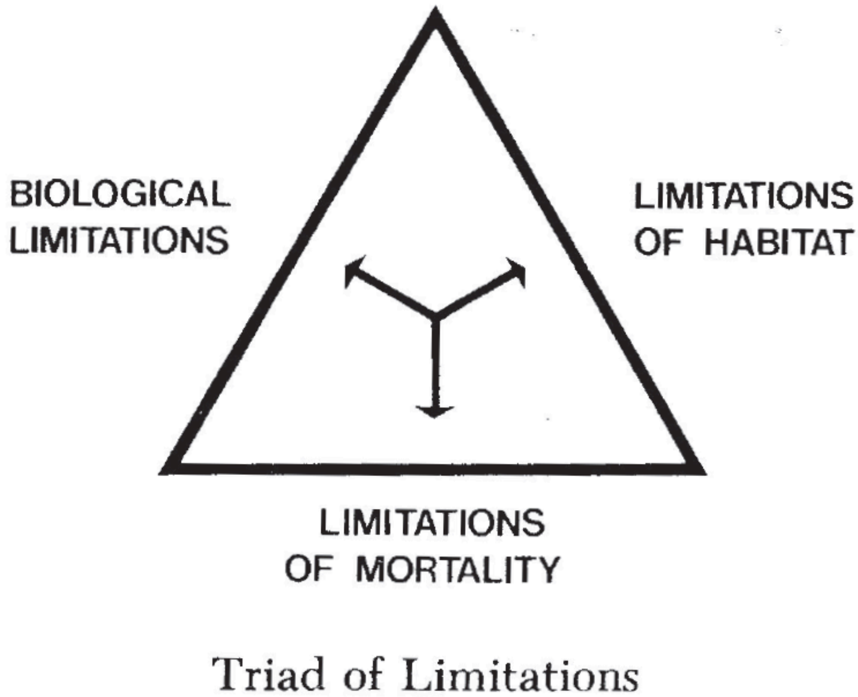

Fig.2 Triad of Limitations (Papanek, 1985, p.73)

Revising methods in light of human needs, Papanek proposes the use of a more theoretical model, the triad of limitations (Fig.2) (Papanek, 1984, p. 73). To measure innovative design solutions against complex human structures, Papanek states "We can now use the triad of limitations and see it as a primary filter to establish the social value of the design act" (Papanek, 1985, p. 74). In contrast to constrictive perspectives from Simon, Rittel & Webber, Papanek argues design must elevate beyond process methodologies and standard models of best practice, to concern itself with moral responsibilities and innovative simplicity.

2.1.4 Design is a third way

Bruce Archer, a co-creator of the Design Methods Movement, championed for a revolution in art and design education. Archer believed that there existed a third area in education and of knowledge, one that was distinct from the sciences and humanities (Archer, 1979). For Archer this third area was design, and he subsequently spent 25 years devoted to developing design into an academic discipline at the Royal College of Arts in London.

Archer's contribution to design was holistic. He did not focus on any one particular characteristic in design practice but instead emphasized the nature of design methodology. Archer's ideas and discussions on design are innovative for they reflect the nature of contemporary design practice as it stands today.

In one of his earliest articles on design, *Systematic Method for Designers*, originally published in 1965, Archer provides one of the earliest accounts of the term design thinking. Archer, commenting on the changing landscape of industrial design, states:

> In the face of this situation there has been a world-wide shift in emphasis from the sculptural to the technological. Ways had to be found to incorporate the knowledge of ergonomics, cybernetics, marketing and management science into design thinking (p.57).

In this article, Archer attempts to present the design process through the scientific lens that influenced the first generation of design theory. Echoing Papanek, Archer (1967) articulates that design is "a goal-directed activity and the designer is trying to proceed in a direction called good" (p.50). In elaboration, Archer (1965) provides his own definition of design:

> Before we can look at the systematic methods of designers, we must know what we mean by 'design'. An architect preparing plans for a house is clearly designing. So is a typographer preparing a layout for a page of print. But a sculptor shaping a figure is not. What is the difference? A key element in the act of designing is the formulation of a prescription or model for a finished work in advance of its embodiment. When a sculptor produces a cartoon for his proposed work, only then can he be said to be designing it (p.58).

Throughout his article, *Systematic Method for Designers*, Archer builds upon characteristics that distinguish design from other related practices, concluding that design should be defined by 10 core elements:

1. A design must be based on the formulation of a model
2. The model must be embodied in/as an artifact
3. There must be a creative step in the design process
4. The process must be based on a purpose and favor intent over exploration
5. The process must be intuitive but not spontaneous
6. The process must begin with a need
7. The process must reconcile conflicting variables
8. The process must be holistic and consider the artifact in a wider system
9. Design problems are complex
10. Design must optimize between solutions (Archer, 1965, pp.58-62)

Archer suggests that design is human-centered, arguing for the account of "human values" (Archer, 1965, p.75; Archer, 1967, p.48) yet approaches problems through a theory of optimization four years prior to Herbert Simon's infamous design approach (Archer, 1965, p.62; Archer, 1967, p.50). In this list, Archer also acknowledged that design problems are complex; highlighting the concept of complexity in design practice eight years prior to Rittel and Webber's infamous article on wicked problems.

Furthermore, Archer makes statements that have only recently come to light in design theory and practice. Archer (1967) predicts that "time is rapidly approaching when design decision making and management decision making techniques will have so much in common that the one will become no more than the extension of the other" (p.51). Design management has recently come to the forefront of design thinking and, as Archer predicted, design thinking has become intertwined with management discourse in the design for organizational transformation today (Martin 2009; Liedtka 2000; Beckman, 2007),

In later years, Archer (1976) revised his perspective on design, candidly stating "In retrospect, I can see that I wasted an awful lot of time trying to bend the methods of operational research and management techniques to design purposes" (p.17) reframing his perspective and definition of design from that of a systematic process to one embedded in artistic behavior (1976, p.19). In the article titled *The Three R's*, Archer (1976) makes explicit that we need a third area of education, one that focuses on the making and doing behind human practice. This, he argues should be called Design:

> Thus Design, in its most general educational sense, where it is equated with Science and the Humanities, is defined as the area of human experience, skill and understanding that reflects man's concern with the appreciation and adaption of his surroundings in the light of his material and spiritual needs. In particular, though not exclusively, it relates with configuration, composition, meaning, value and purpose man-made phenomena (p.19).

In stark contrast to Simon's justification for a design science, but echoing the ideology of satisficing, Archer (1967) argues that a design methodology is grounded in approximation and "plausible reasoning" than upon "exact reasoning producing an answer which is logically seen to be the only or the best answer" (p.50). Bruce Archer discusses the problem-solution space in design practice, arguing that parameters must be defined whilst, at the same time, a description of the design solution must be calculated based on competing requirements (Archer, 1967, p.49). Archer (1979) suggests that during formative phases of design activity, design thinking is in a state of flux:

> The designer's attention oscillating between the emerging requirement ideas and the developing provision ideas, as he illuminates obscurity on both sides and reduces misfit between them (p.17).

In a poignant premonition of the current disruption in design thinking, Archer (1965) states that design is yet to reach the "use of an agreed terminology" (p.64). Furthermore, he adds that design is scattered with theorists who "each have their own favorite models, techniques and jargon" as has been presented in the first generation of design theory, and which persists in design theory to date (Archer, 1965, p.64). However, Archer (1965) also anticipates that a "certain amount of common ground is emerging" (p.64), common ground that this review aims to synthesize and present.

2.1.5 Conclusion

It is clear through investigation of the fundamental theories laid by Simon, Rittel & Webber, Papanek and Archer, that all five, albeit from distinctively different perspectives, understood the ambiguous complexity and inherent 'wickedness' in design practice. The combined knowledge of these theorists conclude that in light of our complex, 'wicked' and uncertain world, problems could at best only 'satisfy' rather than be definitively and logically resolved. The ambiguity and uncertainty underlying the question of *what* to solve, led to investigation of *how* we solve in order to attain success in design practice. After the breakthrough of first generation design theories introduced in the 1960s and 1970s, the focus in design theory began to shift towards reflection on cognitive design practices, as opposed to professionalising design as a subset of the sciences.

1980s-1990s: Understanding design cognition

After the inception of the design methods movement, design research underwent a revival in the mid 1980s to 1990s. Theorists in this period focused on re-evaluating the scientific-centric groundwork laid during the first generation of design theory (Cross, 2007, p. 2). This second generation of design theory brought forth an appreciation of design cognition, including the first formal account of the phrase design thinking through Peter Rowe's 1987 book titled, *Design Thinking*. At the forefront of discussions in this period was Nigel Cross, Donald Schön and Richard Buchanan. These key figures advocated for interpretations of design methodology that shift away from the formulaic logic behind a science of design established during the first generation of design theory. Instead, these theorists explored the cognitive aspects of the design process: the ambiguous, intuitive and human characteristics. These discussions lead to an analysis of the tacit intuition unique to a designer, or as Nigel Cross describes it, *a designerly way of knowing* (Cross 2001, p. 49).

2.1.6 Design is intuitive

Nigel Cross, with Norbert Roozenburg and Kees Dorst, initiated the first formal symposium dedicated to research on design thinking in 1991. This event solidified the significance of design thinking in design research and practice (The Design Group, 2012). Since its establishment in 1991, the design thinking research symposia continues as the leading conference on research into design thinking.

The Design Thinking Research Symposium aimed to unify both experimental and scientific research on the cognitive aspects that underlie design practice. Thus, the term 'design thinking' was used to denote tacit reasoning as designers proceed through a design process (Cross, Dorst & Roozenburg, 1992, p.1). Following this initial symposium at Delft University, proceedings were collated into a book titled, *Research in Design Thinking*. In this book, Cross discusses the relationship between design and design thinking, implying that design thinking is design:

> Therefore it seems natural that a major part of design research should be concerned with trying to understand just how it is that people do design. This kind of research is what we are calling "research in design thinking" (Cross, Dorst & Roozenburg, 1992, p.3).

Nigel Cross states that the process of design is intuitive. For Cross, this intuition was unique to design practice and need not build on historical theories from the arts or sciences (Cross, 2001, p. 55). Cross highlights that "Expert designers tend to emphasise the role of "intuition" in the generation of solutions, and "creativity" is regarded as an essential element in design thinking" (Cross, Dorst & Roozenburg, 1992, p.6). It was in this realization that Cross (1999) was able to establish a new theory of design. Supporting arguments laid by Archer, Cross (1992) claimed that design history and processes could stand independently from art and science:

> We have come to realize that we do not have to turn design into an imitation of science, nor do we have to treat design as a mysterious, ineffable art. We recognize that design has its own distinct intellectual culture; its own designerly 'things to know, ways of knowing them, and ways of finding out about them' (p. 7).

Cross placed the designer at the center of his theory, leading him to focus on the cognitive aspects of design practice. Cross' (1999) discourse of design focuses on understanding the intuition inherent in the designer "One immediate subject of design research, therefore, is the investigation of this human ability-of how people design" (p. 6). Cross' interest in intuition inspired him to investigate the mystery behind the 'creative leap'.

Conventional impressions of design practice assumed that spontaneous bursts of creativity, otherwise known as the 'creative leap', dominated the problem-solving process in design practice. Cross' investigation into intuition lead to a realization that the mysterious 'creative leap' is not so elusive after all. Cross (1997) conducted empirical research into the process of design and discovered "In creative design, it is not necessary that such a radical shift of perspective has to occur in order to identify a 'creative leap'" (p. 427). Cross (1997) elaborates that part of the design process is about building "creative bridges" connecting ideas to form solutions "The sudden illumination that occurs in creative design is therefore more like building a 'creative bridge' than taking a 'creative leap'" (p.428). Cross states that this process relies heavily on analogical thinking and abductive leaps; thought processes that connect ideas from unrelated domains.

Cross comments on the complexity of design thinking, referring to discussions on design presented during the first generation of design theory:

> At the moment, we seem to have a fairly rich picture of design thinking, but we lack a successful, simplifying paradigm of design thinking. Those simplifying paradigms which have been attempted in the past - such as viewing design simply as problem-solving, or information-processing, or decision-making, or pattern-recognition - have failed to capture the full complexity of design thinking (Cross, Dorst & Roozenburg, 1992, p.9).

Cross emphasises the human-centeredness underpinning the act of design, stating "Designing is something that people do. Animals do not do it, and machines (so far) do not do it. The ability to design is a part of human intelligence, and that ability is natural and widespread amongst the human population (Cross, Dorst & Roozenburg, 1992, p.3). In *Research in Design thinking* Cross (1992) acknowledges the contributions of design theorists towards developing design theory during the second generation (p.8). Donald Schön, Bryan Lawson, Peter Rowe and Bruce Archer are all cited as having influence on design thinking research, with Schön contributing to both the research symposium and the book's proceedings.

2.1.6 Design is introspective

In his 1982 book, *The Reflective Practitioner*, Donald Schön aggressively challenges Simon's justification of a design science. Schön (1982) defends Rittel & Webber's theory of 'tame' problems, adding in his words, that Simon "Proposes to fill the gap between natural science and design practice with a science of design. His science can be applied only to well-formed problems already extracted from situations of practice" (p. 47). Schön contextualizes Simon's argument explaining that, during this period, professions seeking a higher status such as design felt the need to ground their practice in science (Schön, 1982, pp. 21-51). Schön (1982) drills his argument further, adding "It wasn't until early 60s that society began to realize the pitfalls of a scientific driven society and that it didn't live up to expectations" (pp. 6-14).

Schön argues the importance of understanding the problem solving process of design. However, Schön's focus on problem solving is directed towards setting and framing the problem rather than analyzing the process. Schön describes problem *setting* as not just part of the process, but a way to frame and contextualize problems to inform the way designers approach their process. Schön (1982) justifies his position by stating "When ends are fixed and clear, then the decision to act can present itself as an instrumental problem. But when ends are confused and conflicting, there is yet no 'problem' to solve" (p.41) echoing Rittel & Webber's theory of wicked problems.

Schön extends on Rittel & Webber's theory, describing wicked problems as *swampy lowlands.* He defines in his own terms that the designers who involve themselves in these lowlands "Deliberately involve themselves in messy but crucially important problems and, when asked to describe their methods of inquiry, they speak of experience, trial and error, intuition, and muddling through" (Schön, 1982, p. 43). It is clear that Schön's theory of problem 'setting' is emphasized due to the intuitive and tacit nature of design. Schön elaborates by proposing the use of divergent thinking to tackle the swampy lowlands in design practice (Schön, 1982, p. 62).

It is evident that Schön (1982) is preserving the intuitive nature of design by focusing on framing problems as opposed to clinically dissecting the design process:

> Let us search, instead, for an epistemology of practice implicit in
> the artistic, intuitive processes which some practitioners do bring to
> situations of uncertainty, instability, uniqueness and value conflict (p. 49)

The design process for Schön is a personal and internal conversation between the object designed and the designer. This examination directed him to discuss the 'reflective' nature of designing. Schön (1982) argues that the personal and uncertain process of reflection in design is a crucial conversation to master and one that can be elevated to a status equal to that of rigorous scientific research "If we can develop an epistemology of practice which [...] shows how reflection-in-action may be rigorous in its own right, and links the art of practice in uncertainty and uniqueness to the scientists art of research" (p.69). For Schön, the process of reflection-in-action is the 'art' of tackling problem-situations of complex uncertainty.

2.1.7 Design is innovative

Richard Buchanan discusses the concept of design thinking in his widely influential 1992 paper, *Wicked Problems in Design Thinking*. Buchanan describes design thinking as a liberal art with a uniquely flexible practice (Buchanan, 1992, p. 5). He addresses the interdisciplinary nature of design thinking and the importance of integrating disciplines for the purpose of "enriching human life" (Buchanan 1992, p. 6). Buchanan builds upon Rittel & Webber's description of 'wicked' problems, but rejects proposals from first generation theorists such as Simon who address design as a science. Instead, Buchanan predicts that design is transforming into a profession that is "Exploring concrete integrations of knowledge that will combine theory with practice for new productive purposes" (Buchanan, 1992, p. 6). Buchanan believes contemporary culture is turning to design thinking for insight to resolve (Rittel & Webber's) 'wicked' problems.

Like Simon, Papanek and Archer, Buchanan acknowledges that design is a process exhibited in daily life. Rather than stating everyone is a designer – or design thinker – Buchanan (1992) argues design and design thinking is a skill that is only “Mastered by a few people who practise the discipline with distinctive insight and sometimes advance it to new areas of innovative application” (p. 8). Buchanan connects design thinking to innovation, explaining that the creation of innovation is when “The initial selection is repositioned at another point in the framework, raising new questions and ideas” (Buchanan, 1992, p. 11). This proposition of re-contextualizing reflects Cross’ analogical ‘creative leap’ and Schön’s description of framing as methods to generate innovative solutions.

Buchanan’s biggest impact was his theory on the expansion of design practice. He suggests four primary ‘orders’ where design thinking inhabits, regardless of whether design is at the core of its discipline. These orders are:

1. Symbolic and visual communication
2. The design of material objects
3. Activities and organized services
4. The design of complex systems or environments for living, working, playing and learning (Buchanan, 1992, p. 9).

This list represents one of the first accounts of explicitly identifying design thinking as a typology of practice. Buchanan’s theory of the four orders of design practice provided a revolutionary framework that has guided the expansion of design thinking and design practice.

2.1.8 Conclusion

The first and second generation of design theory outlined thus far highlight fundamental ideas that have provided the foundation for design thinking and practice. Despite divergent perspectives presented by scholars throughout this history, three common themes have emerged. The first theme is the understanding that design is human-centered; it is created by humans and its purpose is to improve upon human needs. Furthermore, design is fundamental to human activity and is a process that is exhibited in every day life. Second, the argument for design as a discipline distinct from arts and sciences was established during the first and second generation of design theory. It has been made clear that design is a unique way of working and proven justifiable for owning and creating its own distinct history and practice. Finally, design practice deals with problems and issues that are complex and ambiguous. It has been made evident that each theorist acknowledged the inherent complexity that underlies design problems, and that the purpose of design practice is to satisfy evolving constraints as opposed to determining finite solutions.

2.2 The Evolution of Design Methodologies

Following the first and second generation of design theory was a focus on the development of new design methodologies. Grounded in practice, new design disciplines began to emerge and design practice and thinking evolved into new sub-disciplines. Concurrent to debates focusing on design cognition that dominated academic circles during the second generation of design theory was the development and evolution of design practices that would cement Buchanan's four orders of design as established design disciplines. Before continuing with this section, it must be noted that multiple accounts and contexts of design methods and practices have been recorded throughout history, and across many diverse disciplines (Sless, 1997). To account for all diverse interpretations is beyond the scope of this review. Outlined here are fundamental design methodologies articulated across multiple sources: participatory design, user-centered, service and human-centered design. These fundamental methodologies have been chosen for their evolution towards contemporary design thinking practice.

2.1.1 Participatory Design

Community participation in the development of political policies, urban societies and grass roots democracy is an established ideology for the creation of a civil and harmonious society that traces back to Plato's Republic (Sanoff, 2006, p.131). Developments in user participation have long been used as a method to resolve conflicts that affect communities, such as urban planning (Steinø, 2003, p. 190). The origin of participatory design is widely acknowledged as the result of Scandinavian research into design methods during the methods movement of the 1960s (Sanoff, 2006, p. 140; Holmlid, 2009, p. 3). Also known as the 'Scandinavian Approach' (Asaro, 2000, p. 257), participatory design methods aimed at integrating end-users into development phases of projects (Asaro, 2000, p. 257) ranging from computer systems in the workplace to adult education and rural development (Sanoff, 2006, p. 132; 140). In addition, participatory practice was further fuelled by social movements (Sanoff, 2006, p. 131) and was also referred to as belonging to broader co-operative design practice (Holmlid, 2009, p.4).

System design and technical advancements in computing during the late 1960's formed a major platform for participatory design thinking (Asaro, 2000, p. 260). Prior to participation, system design was the main methodology for technological development. Peter Asaro (2000) argues that participatory methods "Sought to reform or replace" (p.260) basic methods of system design during this era. During the development of new technologies, participatory design focused on including the user in the creation and development of specified products. Participants were invited to offer insights into the particulars and functionality of artifacts (Holmlid, 2009, p. 7).

Participatory design had developed as a mainstream methodology used in ergonomics and socio-technical systems at the peak of digital development in the 1980s (Love, 2011). Methods included: prototyping, mock-ups, role plays and most importantly, usability testing methods borrowed from science methodologies (Johnson, Salvo & Zoetewey 2007, pp. 330- 321). These methods aimed to uncover the problems faced by a 'user' (Asaro, 2000, p. 260) to enhance efficiency and usability of a product or product system.

Many pitfalls of traditional participatory user-testing methods were encountered. Neglecting user experience and stakeholder input, (Steinø, 2003, p. 187; Krippendorff, 2006, p. 228) emotional responses to a system or product (Holmlid, 2009, p.5), battles between authorities, selection of participants and stakeholder disapproval of user decisions (Steinø, 2003, p. 188) all contributed to failed outcomes or even the abandonment of user input. Furthermore, at its core, participatory design's aim was to be used as an emancipatory framework. The socio-technical fields that widely adopted participatory design resulted in a trend where "the cooperative and participative nature have been reduced and institutionalized under a logic of technology development" (Holmlid, 2009, p.5).

In response, discussions about user-collaboration, or 'co-design' (Holmlid, 2009, p. 9) began to emerge (Sless, 1997). Co-design had been developed with a more emphatic approach in mind, "The early research interests in interaction design and usability were widened with studies that considered design for experiences and tried to capture a more holistic picture of the 'user'" (Mattelmäki & Visser, 2011) and aimed to change passive users into co-operative designers (Sanders & Stappers, 2008, p. 6). However, the most significant shift in user development was put forth by design theorist, Donald Norman.

2.1.2 User-Centered Design

Donald Norman re-contextualized user testing into a methodology aimed at understanding the needs and interests of the user (Norman, 1988, p. 188). Drawing from his research in cognitive science, Norman addresses design issues through the user's perspective and coined the term 'user-centered design'. He argues in his book, *The Design of Everyday Things*, (originally published in 1988 under the title *The Psychology of Everyday Things*), that all design should be based on a simple conceptual model that is "Appropriate for the user" (Norman, 2002, p. 189). Central to his argument is the belief that "Much of our everyday knowledge resides in the world, not in the head" (Norman, 2002, p. 189). Norman humanized the more socio-technically focused participatory design methods to favor user needs and control. Additionally, he aimed to deliberately "Make things visible" (Norman, 2002, p. 206) to enable users to discover errors and take action towards resolving them (Norman, 2002, p. 216). Placing the user at the center of the development process (Buur & Ylirisku, 2007, p. 6) was core to the user-centered design process. Norman's ideology of user-centered design opened up a new perspective that discovered the benefit of user experience over user testing. Focusing on user experience rather than just efficiency and functionality of an artifact (Holmlid, 2009, p. 2; 9) user-centered design was refined through methods borrowed from behavioral science disciplines (Sless, 1997).

User-centered design evolved on its humanistic approach to user testing to include users throughout the development of a product or system. In other disciplines, user-centered design moved from designing artifacts sympathetic to users needs (Johnson, Salvo & Zoetewey, 2007, p. 324) to resolving wider societal needs (Buur & Ylirisku, 2007,p.7). This developed ideas where innovation that could be discovered by elevating users from 'helpers' to 'co-developers' in broader social contexts (Buur & Ylirisku, 2007, p. 7).

2.1.3 Service Design

The attention on user experience helped shape an emerging design methodology and discipline titled service design. Lucy Kimbell explains that service design "Draws on several traditions including product, environment, experience and interaction design" (Kimbell, 2009, p. 250). This shift occurred when businesses began to consider their products and services 'in use' as opposed to traditionally closing the value chain once transactions had been established (Kimbell, 2010, p. 3). This process focuses on what the user does with a good or service, including their journey and experience. Kimbell adds that the distinction between a service and product becomes irrelevant, for everything is a type of service that plays a role in 'value creation' (Kimbell, 2010, p.3). This perspective evolves from user-centered design, which emphasised users needs and wants. The meaning of a service, that encompasses both product and system, opens up a new and holistic approach to design practice that focuses on resolving service problems (Kimbell, 2009; Kimbell, 2010). Kimbell outlines the fundamental differences between user-centered and service design in the table below:

User-centred design	**Designing for service**
Value-in-exchange	Value-in-use
Production and consumption	Enquiries into value
Value chains	Value constellations
Designing a toaster	Designing a toaster project
Desirability, usability, usefulness	Relationality, temporality and accountability

Fig.3 (Kimbell, 2010, p. 7)

Fabian Segelström's (2010) research thesis on service design traces the practice to the 1970s. As discussed by Kimbell, Segelström argues the divorce of goods from services marked the beginning of a new business attitude (Segelström, 2010, p. 6). Prior to this movement, services were thought to be inferior to goods (Segelström, 2010, p.6). The development of service design gained momentum in the 1990s, owing much of its recognition to service marketing and meta design developed by Ezio Manzini (Kimbell 2010, p. 2; Segelström, 2010, p. 15).

Similar to service design philosophy, Manzini's meta-design focuses on resolving service issues for sustainability. Manzini takes a holistic perspective on society, utilizing "people power" to create socially innovative solutions. His methods focus on designing for complex networks, using peer-to-peer and open-source platforms to allow localized communities take control in the creation of sustainable solutions (Manzini, 2006, p.1). As such, systems are created that are multidisciplinary and enable all actors to become designers. Traditionally, meta-design was defined as "The design of a set of tools, methodologies and ways of doing capable to support designers in a variety of design processes" (Manzini, 2006, p. 2). Today, Manzini has extended this definition to include all users and stakeholders as 'designers' of a service in order to enable participants to evolve with outcomes, echoing the practice and ideology of co-design.

It is unanimous throughout all accounts on service design that methods take a holistic approach. The service design process includes designers, users and stakeholders who all either manage, influence or are affected by a service outcome. Visual tools (Fig.4) also play a central role in service design practice, such as journey maps, scenarios, storyboarding, posters and cognitive walkthroughs (Diana, Pacent & Tassi, 2009). These visual methods are employed to gather insights on the interactive life cycle of a service from the user's perspective and to communicate user insights (Service Design Tools, 2010; Segelström, 2009). This practice departs from participatory methods that focus on a specific interaction between an artifact or technical system. The 'user' in service design practice can range from a financial stakeholder, employee or customer. A large proportion of service design methods have been developed or borrowed from anthropology (Kimbell, 2010, p. 9; Friess, 2009, p.41). The service design process shifted from tacit 'designerly ways of knowing' to utilizing ethnographic methods of inquiry in order to better understand humans and their experiences. As such, methodologies aim to generate a better understanding of all variables and personas involved with a service.

[IMAGE REMOVED]
Fig.4 Service Journey Map (Service Design Tools, 2010)

It is a holistic and visual perspective that is key to service design. The narrow view of participatory and user-centered design methodology blinkered insights for innovation. The service design approach includes stakeholders as part of the process and all other users interacting with the service throughout, rather than just the end user. The strength of adopting a broader perspective towards products and services increases understanding on the connections between stakeholders and users and allows for the collaboration and exchange of knowledge from all key participants to make better informed and innovative design outcomes (Holmlid, 2009, p.7). These developments lead towards a more humanized attitude towards design practice, which in turn, influenced the emergence of human-centered design.

2.1.4 Human-Centered Design

From the early 1990s, user-centered and human-centered were often interchangeable terms used for methods that integrated end users into the design process. In its early stages, much like with previous methodologies described, human-centered design began its rounds within technological and product systems circles (Friess, 2009, p.40-43). During this period, human-centered design was acknowledged as human-centered interaction (Gasson, 2003). The methodology started to evolve in the late 1990s (Sanders & Stappers, 2008, p. 10), changing context from a techno-driven process to one with a human(itarian) focus.

In an early book on the subject, *Design for Success: A Human-Centered Approach to Designing Successful Products and Systems*, William B. Rouse (1991) defines human-centered design beyond the idea of humans as 'cogs' and prescribes an alternative philosophy. Rouse (1991) argues human-centered design as a mindset that incorporates the "Roles of humans in complex systems, enhancing human abilities, aid to overcome human limitations and foster user acceptance" (pp.6-123). Similar to existing participatory and user-centered philosophies, Rouse describes the human-centered design process to include users such as stakeholders who are involved or affected. Rouse situates his book within the discourse of systems and product engineering, however, it highlights an important step towards broadening the narrow perspective of users previously discussed in user-centered design methodologies whilst also building on empathic design practice developed through early co-design approaches. Yet, the reliance on human-centered data for decision making and process innovation can erode authority in design practice. Design thinking runs the risk of not being guided by user data, but instead basing decisions on quantified user information (Friess, 2009, p. 40). Friess (2009) argues that the consequences of human-centered design is its empirical reliability, stripping designers of their 'rhetoric' and reducing designers to little more than a passive bystander (p.45). Ironically, the emphasis on empirical data may strip human-centered design of its humanistic ethos, where "Bracketing emotion and character for the sake of user data does not make a design process 'more' human-centered" (Friess, 2009, p.48). Taken to its extreme, the empathetic characteristic of a human-centered methodology may be lost beneath a detached process of collecting quantitative and qualitative data from participants with no responsibility given to designer intuition. Friess (2009) claims that human-centered design (and indirectly design thinking) lacks distinction from other methodologies:

> Although it appears on the surface that no two definitions of HCD are exactly the same, sometimes differentiation between two supposedly distinctive definitions of HCD is highly difficult. (p. 42).

It may be difficult to differentiate human-centered design from other user-centered and collaborative design practices. However, human-centered design changed direction when designers realized the wider impact design practice could have on societal problems. Service design allowed for human-centered design to redefine its meaning and develop into what is now understood as the foundation of design thinking.

2.1.5 Conclusion

The first and second generation of design theory enabled evaluations and improvements in the way designers think and work. This led to the development of new design methodologies, introducing emerging design disciplines that have now been accepted as part of the repertoire of design practice. The theories and methodologies identified in this brief history have contributed to the evolving practice of design and what is now known as design thinking. This brief history of design thinking has traced fundamental developments within the design field to illustrate that our contemporary design thinking practice is grounded in the design field and has a historical genealogy in both design academia and practice. Understanding the past has provided a foundation for synthesizing and clarifying definitions on design thinking that are presented to date.

3. Current Practice

Today, design thinking is fraught with confusion over its position and definition within design. Its increasing popularity over the past ten years has appeared as though sudden and without substance. The term 'design thinking' as opposed to 'design' appeared to be new and innovative, and as a result, sparked confusion over whether design thinking was a newly evolved design discipline distinct from other design practices. Thus, contemporary definitions of design thinking varied and sometimes appeared detached from the history that has been identified in this review. Hence, the aim of this section is to investigate and critically deconstruct dominant characteristics that constitute contemporary theories on design thinking. This section is required in order to identify if contemporary descriptions of design thinking reflect or differ from theoretical foundations outlined in this review. This clarification is constructed in light of current and historical perspectives and developments on design theory and methodology. This section will first identify what is the contemporary understanding of design thinking before presenting possible future directions for design thinking practice. This section will conclude with the research question, and in doing so, sew together key ideologies discussed throughout the literature review, proposing potential research gaps and future opportunities for design thinking research in complex environments.

3.1 What is Design Thinking?

Contemporary design thinking is described as both a mindset and a method. Design thinking owes much of its recent popularity to consultancy agency IDEO and the Stanford Design School. These institutions have inspired large businesses to adopt design thinking as a new method to tackle complex 'wicked' problems in the hope of creating innovative solutions (Carlgren, 2013; Brown, 2009). Current controversy on design thinking has increased confusion over its definition, fuelling skepticism over who is deemed a design thinker, if methodologies are unique and, most of all, if the process is creating innovative outcomes.

Design thinking methods are tangible representations of the design mindset. Holistic, human-centered methods of inquiry are fundamental to the process of design thinking. The most commonly known resource for design thinking methods comes from consultancy agency IDEO. Founded by Tim Brown in 1991, IDEO have developed toolkits tailored towards business innovation (Methods Cards, 2010), education (Toolkit for

Educators, 2011) and social innovation (Human-Centered Design Toolkit, 2010). All kits use methods that invite stakeholders and users to participate in the design-development process. Design thinking methods are often used as tangible representations of, and to enable, the mindset. As a methodology, current design thinking draws heavily from internal practices as well as external, such as research methods from anthropology and behavioural science (Shluzas, Steinert & Katila, 2014, p.136; Lockwood, 2010, p. xi). Fundamental to this trend is the adoption of a human-centered, multidisciplinary practice that re-contextualises problems in a more empathetic way in order to discover innovative possibilities.

The "mindset" camp of design thinking advocates believe a creative, non-linear and human-centered perspective is the driving force behind design thinking. Design thinkers possess intuitive and divergent thinking skills, using both creative and pragmatic thinking to create innovative yet practical solutions. On the surface, a human-centered philosophy is what sets a design thinking process apart from its methodological predecessors (Mootee 2011; Brown 2008; Leavy 2010; Davis 2010; Jahnke 2009). A human-centered approach is reviewed as one of the most important aspects of design thinking (Design Thinking and the Big Society 2011, p.07), with Stanford University's Design School focusing heavily on the human-centered design process for design thinking innovation. Norman and Verganti argue that human-centered design is not a precise set of methods but a philosophy (Norman & Verganti, 2012). It is more about storytelling and re-interpreting meaning through collaboration, empathy and understanding of the user and society, than using data on society (Design Thinking and the Big Society, 2011, p. 08). Tim Brown believes the innovative ideas that result from design thinking prove the movement to be a new and innovative process, justifying "The emphasis on fundamental human needs-as distinct from fleeting or artificially manipulated desires- is what drives design thinking to depart from the status quo" (Tim Brown urges designers to think big, 2009). Design thinking "Favors the perspective of the user and context" (Jahnke, 2009, p. 10). This focus is consistent across all types of projects that design thinking is applied to, from business to social innovation.

These characteristics do not represent the process but the attitude towards processing 'wicked' problems. Designers such as Mauro Porcini (2009) argue that the design thinking mindset is trained unconsciously as much as it is consciously during design school. He believes design thinkers are those that possess an attitude which "Surfs comfortably on the fine edge between the feasible and unfeasible- because that's the only geography where innovation likes to lie down and rest" (Porcini, 2009, p.13). However, describing the design mindset has opened up ground for debate, with some practitioners disputing that design thinking is not a talent unique to a designer, but a perspective exemplified by all visionaries who dare to break out of the boundaries (Norman, 2010).

Descriptions of design thinking can be attributed to non-designers, creating confusion over who should be privileged with the title of 'design thinker'. Porcini and Norman both discuss the idea that a design thinker is not necessarily a designer, and that not all designers are design thinkers (Porcini, 2009; Norman, 2010). Adding to the ideology that design thinking is representative of more a mindset and philosophy as it is a methodological process, Lawson (2006) points out in his book, *How Designers Think*, that this unique way of thinking is a learned skill "We are less ready to recognize that thinking might need similar attention. The book as a whole is devoted to developing the idea that design thinking is a skill" (p.15). Lawson argues that in today's society, the act of designing represents more of a mentality than a craft, proving a division between those who design and those who make (Lawson, 2006, p.21).

At a fundamental level, design is about process. Many contemporary theorists have made attempts at re-evaluating the design thinking process. Reinterpretations of design thinking emphasize abductive thinking, pragmatic theory and the interplay between problem-solution spaces also known as the "fuzzy front end" (Dorst, 2010, p.133; Gumienny et. al., 2010, p.245; Lundberg & Pitsis, 2010, p.281). Discussions surrounding divergent and convergent thinking remain popular, albeit not an entirely new concept "Design thinking aspires divergence instead of representativeness in order to develop a broad inspirational understanding about a situation" (Gumienny et. al., 2010, p.244). Richard Coyne (2005) argues that design thinking is an understanding between theory and practice, where the "Designer explores concrete integrations of knowledge that will combine theory with practice for new productive purpose" (p. 7). Wolfgang Jonas (2007) illustrates that the design process is embedded in the "Socio-cultural phenomenon" and follows "Evolutionary patterns with no final goals" (p. 1365). Tim Brown (2009) argues that the design thinking process is non linear and fundamentally exploratory.
Charles Owen (2006) outlines six primary characteristics of design thinking "Human-centered focus, environment centered concern, bias for adaptivity, predisposition toward multifunctionality, systemic vision and ability to work systematically with qualitative information" (pp. 23-25). Mauro Porcini (2009) sums up all individual assumptions stating "Different definitions, but most have similar processes defining what the inputs

and outputs will be for each phase" (p.10). Each designer will have his or her own process of design thinking but common ground can be found in the mindset and method of a design thinker. Contemporary scholars agree that there exists no current formal consensus over what defines design thinking. Yet, reviewing the literature, major themes emerge and remain consistent across contemporary definitions [See Table. 1].

Empathy	(Brown, 2008), (Clark & Smith, 2008), (Dunne & Martin, 2006), (Holloway, 2009), (Junginger, 2007), (Lockwood, 2009), (Lockwood, 2010), (Porcini, 2009), (Von Thienen et. al., 2014, p.101)
Abductive	(Brown, 2009), (Lockwood, 2009), (Fraser, 2009), (Martin, 2009, p.65), (Dew, 2007), (Jones 2008, p.219), (Dorst, 2010, p.136)
Prototyping	(Rittel 1987, p.1), (Benson & Dresdow 2013, p.7), (Lockwood, 2010, p. xi), (Rylander 2009, p.5), (Drews, 2009), (Fraser, 2007, 2009), (Holloway 2009), (Bevan et al., 2007, p.140), (Kimbell, 2011, p.287), (Seidel & Fixson, 2013, P.1), (Liedtka, 2013), (Von Thienen et. al., 2014, p.102), (Lindberg, Noweski & Meinel, 2010, p. 33), (Brown & Wyatt, 2010, p.32), (Shluzas, Steinert & Katila, 2014, p.136)
Problem – solution framing	(Farrell & Hooker, 2013, p.689), (Bevan et al., 2007, p.143), (Friedland & Yamauchi, 2011, p.70), (Lindberg, Noweski & Meinel, 2010, p. 33), (English, 2006, p.5), (Dorst, 2010, p.136)
Optimistic	(Rittel 1987, p.8), (Owen 2005, p.13), (Gloppen, 2009), (Owen, 2006, p.24), (Leinonen & Durall, 2014, p.108), (Brown & Wyatt, 2010, p.32)
Fuzzy front end	(Porcini, 2009), (Löwgre & Stolterman 1999, p.17), (Ranjan 2012, p.31), (Drews 2009, p.41), (Le Masson et al., 2011, p.219), (Young 2010, p. 15), (Blyth & Kimbell 2011, p.12), (Jahnke 2013) in (Carlgen 2013, p.22), (Smulders & Subrahmanian, 2013, p.362)
Wicked problems	(Benson & Dresdow 2013, p.6), (Gharajedagi 2010, p.108), (Bharathi 2013. p.83), (Farrell & Hooker, 2013, p.686), (Westcott et. al, 2013, p.4), (Dorst 2011, p.522)
Inventive and innovative	(Owen 2005, p.5), (Brown, 2009), (Gharajedagi 2010, p.108), (Bevan et al., 2007, p.140), (Kimbell, 2011, p.287), (Benson & Dresdow 2013, p.7), (Lockwood, 2010, p. xi), (Westcott et. al, 2013, p.3), (Plattner, Meinel & Leifer, 2011, xiii) in (Laakso & Hassi 2011, p.2), (Owen, 2006, p.24)
Human-centered	(Owen 2005, p.12), (Lockwood, 2010, p. xi), (Brown, 2008), (Porcini, 2009), (Ward et al., 2009), (Sato 2009), (Buchanan, 2001, p. 9), (Owen, 2006, p.24), (Kimbell, 2011, p.287), (Liedtka, 2013), (Leinonen & Durall, 2014, p.108), (Von Thienen et. al., 2014, p.101), (English, 2006, p.5), (Brown & Wyatt, 2010, p.32)
Visualisation	(Owen 2005, p.13), (Lockwood, 2010, p. xi), (Brown, 2009), (Carr et al., 2010), (Drews, 2009), (Lockwood, 2010), (Jones 2008, p.219), (Owen, 2006, p.24), (Kimbell, 2011, p.287), (Liedtka, 2013), (Von Thienen et. al., 2014, p.102)
collaborative	(Owen 2005, p.14), (Gloppen, 2009), (Dunne & Martin, 2006), (Boland & Collopy, 2004), (Jones 2008, p.226), (Herrmann & Goldschmidt, 2014, p.33), (Owen, 2006, p.24), (Liedtka, 2013)
multidisciplinary	(Owen 2005, p.14), (Brown, 2009), (Benson & Dresdow 2013, p.11), (Westcott et. al, 2013, p.2), (Clark & Smith, 2008), (Dunne & Martin, 2006), (Holloway, 2009), (Lockwood, 2010), (Sato et al., 2010), (Kimbell, 2011, p.287), (Von Thienen et. al., 2014, p.102), (Lindberg, Noweski & Meinel, 2010, p. 35)
Iterative	(Benson & Dresdow 2013, p.11), (Rylander 2009, p.7), (Herrmann & Goldschmidt, 2014, p.33), (Kimbell, 2011, p.287), (Von Thienen et. al., 2014, p.102), (Friedland & Yamauchi, 2011, p.68), (Lindberg, Noweski & Meinel, 2010, p. 33), (Shluzas, Steinert & Katila, 2014, p.136)
Intuitive	(Rylander 2009, p.5), (Porcini, 2009), (Jones 2008, p.219), (Lindberg, Noweski & Meinel, 2010, p. 33), (Brown & Wyatt, 2010, p.32)
Ethnographic	(Beckman & Barry, 2007), (Brown, 2008), (Carr et al., 2010), (Dunne & Martin, 2006),

	(Lockwood, 2010), (Owen 2005, p.14)
Systemic thinking	(Owen 2005, p.14), (Dunne & Martin, 2006), (Jones 2008, p.219), (Owen, 2006, p.24), (Brown & Wyatt, 2010, p.32)
Rapid	(Lockwood, 2010, p. xi), (Carr et al., 2010), (Holloway, 2009), (Lockwood, 2010), (Brown, 2009), (Herrmann & Goldschmidt, 2014, p.33), (Liedtka, 2013), (Brown & Wyatt, 2010, p.32)

Table 1. Commonly cited characteristics of design thinking

Design thinking is the accumulated history of design theory, process methods, mindsets and tools. Contemporary definitions of design thinking, whether conscious or not, have articulated characteristics that have been identified in the brief history outlined in this review. Thus, in light of the brief history outlined in this review, design thinking is not a new type of practice, but rather, a new perspective for fields outside of the design industry wanting to capitalize on its innovative potential (Dorst, 2010, p. 131). It may be proposed that design thinking is simply a broad term used by professionals outside of the design industry to describe the activity involved in design practice. In this sense, design thinking may be synonymous with the term “design” but places emphasis on the mindset behind design practice.

This brief history outlined in this literature review focused on the theory and methodologies from within the design industry, in order to establish that the contemporary confusion over design thinking is rooted in a history that has evolved from design practice. Recent discussions over the trend and applications of design thinking have provided literature on the impressions of design practice and design thinking from authors and professionals external to the design field. Analysing literature from authors external to design is beyond the scope of this review, but major authors outside of design have been recognized for their aid, adoption, development and expansion of design thinking (See Liedtka 2000, 2011; Martin, 2009; Lundberg & Pitsis, 2010).

3.2 A Likely Future for Design Thinking

To those external to design, design thinking is a term for communicating how designers work. This has in turn reinvigorated discussions within the design industry that challenge the very nature of what it is to design and be a designer. Of interest to this research are the new sub-disciplines of design practice that have evolved through the investigation of design practice and design thinking. Contemporary scholars and practitioners have recognised the transformation taking place in design practice through re-interpretations and applications of design thinking. This transformation is seeing design evolve from traditional craft to a new type of practice (Lundberg & Pitsis 2010, p.278). The design of intangible artifacts signifies this turning point "The key shift is from the design of tangibles to the 'design' of intangibles" (Jones 2010, p.219). The design field can be seen to have grown and evolved through the inherent multidisciplinary practice that is found in user-centered design as well as the recent adoption of design thinking from industries outside of the design field. A stratification of design visualises this evolution [See Fig .5].

Economic and environmental pressures also played a force in the evolution of design practice, pushing industries to reconsider traditional product-centric business models to people and service-centric models. The rise of people-powered social media meant industries required new approaches that focused on meaning, people and loyalty (Kimbell in Engine, 2012). Contemporary design thinking evolved from "traditional" artifact-based practice, indicated through the brief history of design thinking outlined in this literature review. The evolution of the design industry combined with the appreciation of design thinking from non-design professionals helped expand what is considered to be design practice. This development has seen design evolve to more complex environments.

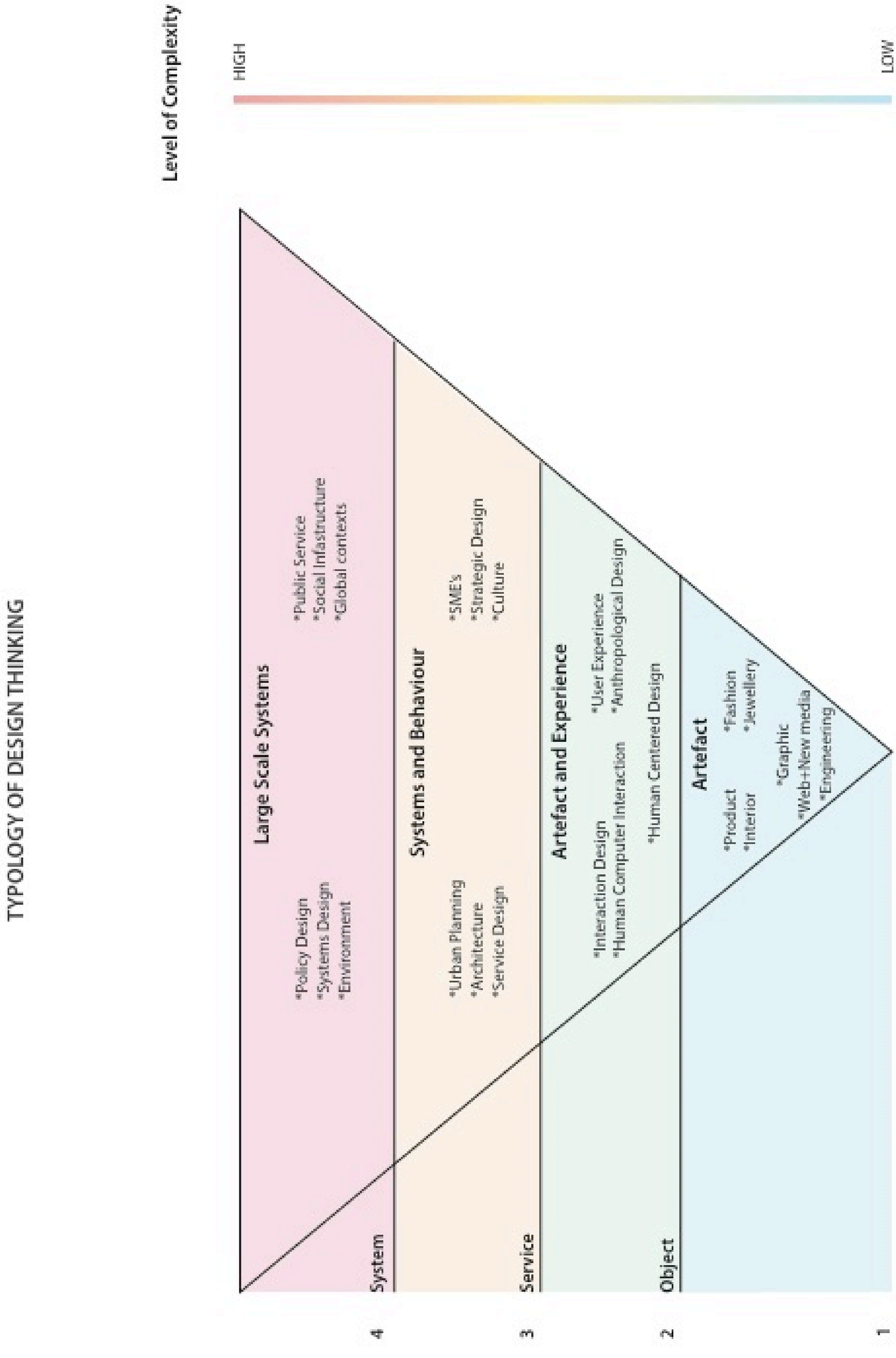

Fig.5 Typology of Design Thinking

Current descriptions and applications of design thinking reflect a peak in the maturation of the design industry. Buchanan (1992) was the first to make an attempt towards defining the different areas, known as 'orders', of design thinking practice. Using Buchanan's dissection of design as a framework, contemporary design thinking can be analysed according to levels of complexity and tangibility. The current consensus of design thinking, favoring human-centered, intangible and complex problems, reflects the 'fourth order' of design described by Buchanan (Buchanan 1992, p.9) [see Fig.5]. Similarly, Rittel & Webber's articulation of wicked problems reflects the complexity that is understood to be inherent in contemporary definitions of design thinking practice. Yet, third and fourth orders of design practice were not widely recognized as conventional to design until the emergence and trend of design thinking. A typology of design thinking highlights current sub-disciplines of design practice operating on different levels of complexity [see Fig 5.].

Yet, design thinking does not have definitive traits or relate to specific sub-disciplines of design expertise. Instead, descriptions of design thinking, both contemporary and historical outlined in this review, depict foundational characteristics; methods, processes and mindsets that have been acknowledged as fundamental to a design approach. This has been documented in Table.1, where the most common contemporary characteristics of design thinking have been identified in design academia and practice. In addition, the historical developments of design outlined in this literature review have provided evidence that design thinking is not a brand new field or sub-discipline of design, but instead, is seen as a new approach for fields outside of design practice. In addition, the history presented has shown that design is an adaptive field and one that is continually expanding and evolving:

> Design thinking process [...] struggle twofold: firstly, they must depict context-sensitivity and situational adaptability of workflows without losing 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. (Gumienny et al. 2010, p.246)

As such, design thinking has crossed many boundaries and industries, spreading the fundamentals of a designerly approach to areas unfamiliar to traditional design practice (Gumienny et al 2010, p.243). As a result, design thinking is not foundational to any one field, but rather, underpins the art of design, shaping and guiding multidisciplinary fields of practice.

3.3 Conclusion

In review, many contemporary descriptions and definitions of design thinking have been proposed. Amidst these discussions persist complaints over a lack of consensus as to what exactly defines design thinking. The adaptive nature of design thinking and its applicability in new disciplines and contexts contributes towards confusion over where and how to classify design thinking "No stable consensus about the term has emerged yet. This ambiguity is (in part) the consequence of using 'design thinking' for an emerging discipline and for traditional design" (Jones, 2010, p. 219). Lawson highlights this problem that has plagued design theory for decades "If knowledge is about the known and designers can't explain the known, then what do they know?" (Lawson, 2006, p. 43). Confusion still surrounds whether to define design thinking as a mindset and an attitude, a process methodology and method or a new field of design practice. It appears that the popular global spokesman for design thinking, Tim Brown, cannot decide whether design thinking is a mindset or a method. In his 2010 book*, Change by Design*, Brown uses broad and ambiguous keywords such as 'foggy spaces' and 'attitudes of experimentation' before continuing his definition to describe tangible methods of design thinking that lie in the power of brainstorming and prototyping (Brown, 2010, p. 68).

Ironically, when attempting to describe the designerly approach, the definition of design thinking becomes a wicked problem in itself, where answers seeking to describe the process, mindset and practice can only 'satisfy' rather than definitively resolve:

> 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 (Gumienny et al 2010, p.243).

Yet, it has been presented in this review that a consensus over common characteristics that underpin design thinking can be found from descriptions proposed by practitioners and academics [See Table.17]. The issue of definition has persisted since the first generation of design theory, where attempting to definitively establish a design thinking definition may be counter-intuitive to the very nature of design thinking. Instead, building knowledge on the behavior, application and adoption of design thinking in new and emerging contexts will result in a greater understanding of the phenomenon of design thinking.

3.4 Complexity

Wicked, complex problems have become a part of the identity of design thinking. Complexity has remained a fundamental aspect of design practice as exemplified throughout the brief history in this review. In particular, the impact Rittel and Webber's paper had on the design research community has shaped contemporary definitions of design thinking, with current definitions drawing examples from higher orders of design practice. It is higher orders of design that the thinking and practice is most conceptual, intangible, strategic and complex, and where the design thinking term has most value (Jones, 2010, p. 219; Gumienny et al, 2010, p.245). It has been suggested in this review that complexity and 'wickedness' is inherent in design practice, but complexity varies depending on the design discipline and order. Complex environments have been defined in this thesis as 3rd and 4th order domains where projects involve and affect a systemic network of individuals and where formative phases of design development focus on intangible ideas rather than physical artefacts.

Due to the association with complexity influenced by Rittel and Webber, design thinking as a way to resolve highly complex problems has filtered into areas such as business management, organizational and policy design practice. Scholars and practitioners are turning to design thinking for innovation advantage for resolving 'wicked' problems in complex environments such as service and policy design (Gero, 2010). Additionally, sustainable (environmental) issues are pressuring professionals in all fields to create innovative, financially viable yet environmentally sustainable solutions using a design approach (Kimbell in Engine, 2012, p.21).

In 2012, the European Commission commissioned a report titled, *Design for Growth and Prosperity: Report and Recommendations of the European Design Leadership Board*, that comprised of 26 key proposals for introducing, enabling and sustaining a designerly approach across the European Union. This report highlights a significant advancement in design thinking and practice, proving its worth and value in tackling large scale societal problems:

> And for complex societal problems, design offers people-centered approaches that can achieve better solutions. A number of European studies and reports written during the past three years have explored and communicated design's power to make a difference
> (Design for Growth and Prosperity, 2012, p.19)

In a similar fashion, the Australian Government commissioned a report titled, *APS Innovation Action Plan*, in 2010. Having applied design thinking in the Australian Taxation Department (as well as establishing a design lab for taxation policy), the Australian Government has extended its interest in design thinking through the development of a new innovation initiative (the *Innovation Action Plan*) that includes a newly developed design center. Like the European Union, the Australian Government is realising the value and potential of design thinking in tackling complex problems:

> It could help practitioners to adopt new perspectives in thinking about a problem. Such an approach would facilitate cross-agency interaction involving public servants, academics, citizens and businesses to create solutions for societal problems (APS Innovation Action Plan, 2010, p.22)

Design thinking and complexity have also made waves for sustainability and social innovation. At the forefront of design driven sustainable innovation, Ezio Manzini has championed the designerly approach for complex social and sustainable innovation. Operating under the practice of meta-design, Manzini has for over a decade extended his research on the designerly approach for the resolution of social and sustainable problems. Manzini boasts an array of social initiatives such as *Changing the Change, Sustainable Everyday Project* and *Sustainable Consumption Research Exchanges (SCORE)*, (Manzini, 2009). Manzini has proven the worth of applying a design methodology for the creation of innovative projects that address complex social and sustainable needs:

> 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.
> (Smulders & Subrahmanian, 2010, p.365).

The initiatives exemplified by the European Union, Australian Government and Ezio Manzini emphasise the value of the designerly approach for innovation in complex environments ranging from service to policy and sustainability issues. These initiatives signify the evolution of design practice. With roots in traditional craft based practice, design thinking has moved forward from the aesthetic 'styling' practice with which it was traditionally associated, to applying its methodology as a strategy for larger and more systemic complex problems.

With the concept of complex problems and complexity only sketched out in design theory and practice, further clarification is needed over what constitutes complexity in design; both as an object of research and context of practice. Highlighted above, complex problems have been referred to as issues situated within large scale, open and adaptive systems that require multidisciplinary collaboration for their resolution. As such, complex environments have been defined in this thesis as the large scale, systemic and ambiguous contexts for which design problems lie. As design tackles broader and more systemic problems, design theory requires a more structured definition of complexity in order to identify complex environments for research and practice.

This dissertation has addressed the topic of complexity by supporting theories on complex design problems which have been sketched throughout design history, with systems theory. Systems can be perceived as complex from both a structural (organisational) or cognitive (social) perspective where a high degree of variables are present, "Systems can be described as emergent or designed networks of interconnected functions that achieve an intended outcome" (Jones, 2014). Yet, in discussing systems, it must be noted that this thesis aims to remain focused on design theory and acknowledges, but does not include, a deep examination of the divergent positions and theories outside of design field discussing design, such as organizational (institutional), complexity and design management theory.

The subject of complexity has been historically tackled through three main perspectives: chaos theory, adaptive systems and social behavior (Warfield, 1996, p.48). However, design practice should not need to rely on or reinterpret itself as a science in order to effectively address complexity. A definition of complexity in design requires a balance between preserving the tacit ambiguity of design thinking with formalized approaches to complexity. Rather, an appreciation is required from design to acknowledge the formal contributions made towards clarifying complexity in fields external to design theory.

Warfield & Staley (1996) discuss complexity, stating that "Illustrative examples from the practice of interactive management (a system of management that supports the development and interpretation of structural models of complex situations, and design of improved systems) show the significance of structural thinking as the primary intellectual mode required to manage or cope with complexity" (p.47). For Warfield and Staley, complexity resides in semiotics which is processed, and limited by, social understanding and interpretations on what may be classified as complex. Echoing this sentiment towards systems, Peter Jones (2014) states:

> Today we must conceive of all systems as social systems, or at least socially implicated systems of systems. Researchers have accepted a consensus (Stockholm Memorandum, 2011) that human intervention has intervened in all aspects of the planetary ecology, rendering even natural and ecological systems socially influenced (p.3)

In another perspective, organised systems and complexity can be viewed from a more objective approach. John Flach (2011) discusses the fuzzy concept that is complexity in his paper, *Complexity: learning to muddle through*. Flach (2011) acknowledges that "the term "complexity" is "notoriously difficult to define"" and that there is an "explicit connection between complexity and uncertainty" (p.188) further supporting the propositions made by design theorists who state that "wicked" problems are a sign of complex design practice.

In proposing a structured model for identifying complexity [Fig.6], Flach describes the dimensionality of the problem space. Dimensionality is a reflection of the "number variables, parameters, degrees of freedom, or states that contribute to shaping the field of possibilities" (Flach, 2011, p.189). In design theory, this is what would be described as problem framing or the "fuzzy front end" but this process undergoes a more tacit and intuitive effort at imposing order and constraint.

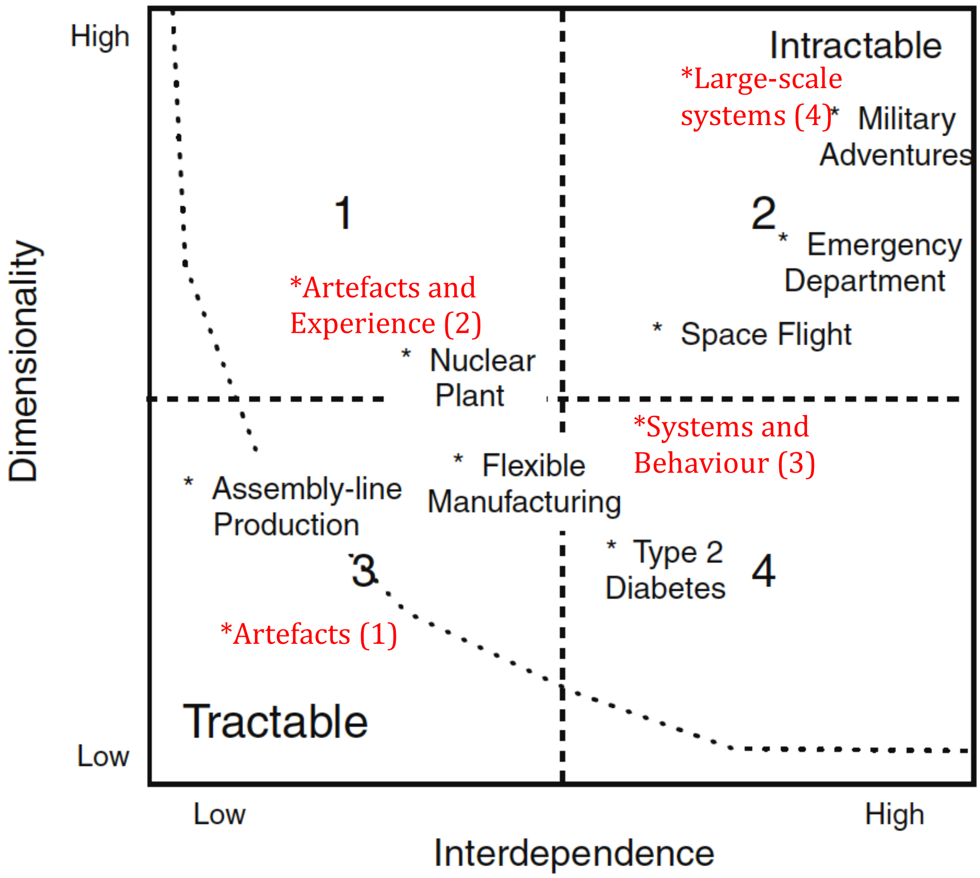

Fig. 6 Flach (2011) model of complexity in problem spaces.
(Design domains added in red)

Flach explains that as interdependence between dimension increase, so too does uncertainty and thus complexity, "When the interdependence is high, progress through the state space will depend on interactions among the dimensions, such that the behavior of any specific variable might change as a function of the behavior or state of other variables (Flach, 2011, p.189). We can use Flach's model as a basis for which to determine complex environments in design practice. Combining Flach's model with Buchanan's four orders of design practice (adapted in Fig.6) we can see how complexity increases in higher orders of design practice, and make this assessment using Flach's theory of dimensionality and interdependence.

In line with a critical realist perspective used in this thesis, a definition of complexity in design must acknowledge socially constructed complexity as well as structure and scale of complexity. Complex environments have been defined at the intersection of systems and design theory, to accommodate both cognitive and structural variables that constitute a complex environment:

> We require a broad crossover of principles between systems and design theory for the purposes of expanding design practice to higher levels of complexity (Design 3.0 and 4.0). (Jones, 2014)

This definition respects the social construction behind the concept of complexity outlined by Warfield, with the attempt to objectively identify complex problem spaces through using Flach's model of dimensionality versus interdependence. These two authors support the groundwork proposed by design theorists on complex, wicked design practice.

Design thinking and its core characteristics; multidisciplinary, iterative, rapid prototyping, human-centered, collaborative, visual and divergent thinking, are now seen as suitable for working with problems where the future is tangled and uncertain. Similarly, services are beginning to understand the long-term impact that economic uncertainty can have on business (Kimbell in Engine 2012); significantly, the impact from environmental change. Design practitioners have taken steps towards applying their methodology to the issue of sustainability, utilising a human-centered and collaborative approach most evidently through meta-design practice. This holistic perspective introduced an understanding of the interdisciplinary connectedness of complex systems and artifacts. As professionals deal with larger and more complex problems, the concern for breaking down boundaries and increasing "The interaction of many participants from different disciplines" (Du, Jing & Liu 2011, p.111) calls for more research into design thinking in complex environments.

3.4 Innovation through design

A driver for the adoption of design thinking in new and complex contexts is the promise and demand for innovation. Innovation and design thinking have become inseparable concepts. Innovation has been attributed to the success of design thinking, with Stanford acknowledging the process as a source of innovation in their educational programs "We focus on the design process because we seek to equip our students with a methodology for producing reliably innovative results in any field" (Stanford Design School, 2010). In a report published by the European Commission (2012) titled *Design for Growth and Prosperity*, design is described as linking creativity and innovation and a driver of user-centered innovation. In discussing the defining characteristics of design thinking innovation, Brooke Davis (2010) states "A defining attribute of design thinkers is their ability to constantly make new connections. They are able to do this because they are well versed in a process that promotes this kind of activity" (p. 6535). How design inspires innovative thinking has been postulated by many professionals and academics. The most common speculations point towards a social focus, collaboration, problem re-framing and re-interpreting meaning.

What makes design thinking innovation different to other practices and processes for innovation? Dorst attempts to answer this question by stating that design goes beyond adopting conventional frameworks in order to 'break away' from current work ethic (Dorst, 2010, p.138). Dorst describes this phenomenon as re-framing and believes this habit, integral to design thinking and design process, is what distinguishes design thinking innovation from other strategies. Ironically, Dorst's justification is a 're-framing' of Schön's theory of problem setting. The process of reframing allows the designer and creative team to re-interpret meaning; another factor that leads to innovation. Brian Lawson and Kees Dorst (2009) have described design thinking innovation as "Actively imagine[ing] and create[ing] solutions to complex problems in an improvised and also co-created way". Lundberg & Pitsis (2010) claim that design thinking is a form of 'enhancing' innovation through methods of co-creation (Lundberg & Pitsis, 2010, p.284). Buchanan, Gupta & Simon (2011) echo others by concluding that design firms engaging with higher orders of design thinking operate differently, for higher conceptual levels of design thinking rely on models of:

> Radical collaboration by teams, knowledge sharing, wide reaching cross pollination and the habit of gaining early insights through tangible expressions of ideas in order to foster continual and rapid innovation (p.301).

Donald Norman and Roberto Verganti (2012) published a paper on innovation titled, *Incremental and Radical Innovation: Design Research Versus Technology and Meaning Change*. Norman and Verganti discuss the differences between incremental and radical innovation, arguing that radical innovation is a process that relies on technological and meaning driven change. Alternatively, incremental innovation is a slow 'hill climbing' process involving human-centered methods:

> Under this view, human-centered design methods are a form of hill climbing, extremely well suited for continuous incremental improvements but incapable of radical innovation. Radical innovation requires finding a different hill, and this comes about only through meaning or technology change.
> (Norman & Verganti, 2012, p.2).

Norman and Verganti observe that the design community is generally more interested in radical innovation over incremental, and as such, design thinking has been characterised as a form of radical innovation (Norman & Verganti, 2012, p.6). However, Norman points out that no radical innovations have been created through human-centered processes and thus design thinking is not a process for radical innovation (Norman & Verganti, 2012, p. 6). Norman explains that this is largely due to the fact that human-centered design is a form of 'hill climbing'. This is not necessarily a negative contention as "Successful radical innovation occurs infrequently within any particular area, perhaps once every 5 – 10 years" (Norman & Verganti, 2012, p. 6). This implies that design thinking is a useful process for constant, incremental innovation in industry (The Open Book of Social Innovation, 2010, p.108). Norman adds that the value of incremental innovation is "Necessary to transform the radical idea into a form that is acceptable to those beyond early adopters" (Norman & Verganti, 2012, p.6). Incremental innovation is especially important for adaptivity, continual improvement and practical implementation of a product or service.

Design thinking invites stakeholders to participate in the creation of innovative solutions. Collaborative creativity is one factor that connects design thinking to innovation. Lundberg & Pitsis (2010) describe that it is the "Collaborative creating together which should be seen as crucial both to innovative processes and to process innovation." Co-creation as innovation is now understood across business, academia and government, with the European Commission adding "Collaborate in open networks that drive innovation into Europe's whole industrial ecosystem" (Design for Growth and Prosperity, 2012, p.8). Hence, it makes sense that in order to increase innovation in complex practice, a process is required that is social, collaborative and multidisciplinary. Design thinking and its emphasis on human, empathetic and collaborative creativity provides a fertile process for innovation in complex environments.

Sabine Junginger (2006) has investigated the topic of human-centered design innovation in large organisations in her PhD dissertation, *Change in the Making*. Following her doctoral research was a focus on the position of design thinking development in relation to the project organization. Junginger has presented a new perspective on innovation and design thinking by introducing the concept of how the position of design thinking impacts an organization.

Junginger refers to the Danish Design Council's Design Ladder as a way of assessing the position and impact of design within an organization, including the way design is used as a management tool. In her critique of the Design Ladder, Junginger (2009) notes that the model does not "accommodate general organizational problems that might be addressed by design thinking and design methods. These organizational problems often fall into the category of "wicked problems"" and discusses how design is being explored in a wider organizational context, or "third" and "fourth" order problems. The Danish Design Council's Design Ladder, although a model to assess design capability within organisations, mirrors the different orders of design practice that has been modeled in Fig.5.

Building upon this research, Junginger (2009) explored the locations that design thinking may "take place" in relation to an organisation [Fig.7].

Fig.7. Junginger's position of design thinking practice relative to an organisation

Junginger (2009) describes design as an external resource that is an "add on: a resource that can be called upon or dismissed". Often the design expertise called upon relate to artefacts, graphic and product design, and where the design work conducted is treated "like a contract" (Junginger, 2009). Design as part of the organization describes departments within an organization that may house designers or a designerly process. In this context, design is usually limited to marketing, product and service departments. Design at the core of an organization has the ability to affect change in its operations, whereas design integral to an organization is formed and shaped by a design approach, where organizing and managing is part of the design process and not distinct from it (Junginer. 2009). Junginger (2009) argues for further research investigation into a series of key questions:

> One may ask if an external design location is always less influential and less likely to instill, generate and implement change within the organization? It might well be that there are cases in which design "on the fringe" enjoys more freedom to explore, envision and invent that within a stubborn organizational construct. (p.10)

Junginger refers to an institutional organization, but this thesis has chosen to use the term 'organisation' to denote an organized system, which may or may not be represented as an institution. Nevertheless, the questions proposed by Junginger have provided framework and inspiration which guides both research and analysis in this dissertation into the exploration of the behavior of design thinking in complex environments, which is outlined in more detail in *Chapter 3. Research Framework*.

4. Research direction

One of the fundamental weaknesses in the publicity that surrounds design thinking today is the lack of evidence supporting claims of its effectiveness. Nigel Cross flagged awareness of the need of empirical research into design methodology since the mid 90s "We suggest that these observations are relevant to the analysis of design activity, and important to the design methodology of teamwork" (Cross N & Cross A, 1995, p.170). Norman (2010) adds to the design thinking critique suggesting "This [design thinking] myth is nonsense, but like all myths, it has a certain ring of plausibility although lacking any evidence." Design thinking is only a good as its implementation, and can only be measured by its outcomes and applications. Lundberg & Pitsis (2010) echo the transparency of design thinking, stating "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" (p.278). Research is lacking in the analysis and critique of current design thinking applications and outcomes, with contemporary professionals demanding proof from the process "The practical implications of an instrumental meeting or merging of epistemologies have rarely been studied empirically" (Jahnke, 2009, p. 6). This is a significant obstacle in the evolution and adoption of design thinking. If process methods and subsequent outcomes are not documented and critically analysed, skepticism will fuel negative, ill-informed critiques that will ultimately damage the design discourse. It has become clear that design thinking is still in need of empirical evidence to justify self-proclaimed innovation, particularly from design practice in complex environments.

Concurrent with support for the designerly approach, many researchers and practitioners argue for more efficient answers to complex challenges. The justification for design thinking is partly in response to the need for adaptable and innovative solutions to new and emerging complex environments. As discussed in this review, design thinking is now recognised by society as a force for "breaking down silos" in order to "work across disciplines and change our perspectives" (Blizzard & Klotz, 2012, p.457). Many professionals are turning to design thinking despite its fuzzy and ill-defined nature.

Kimbell (2012) suggests an alternative solution for filling this problem-gap. By focusing on the "Material and discursive practices in which designers of particular kinds do, know, and say" (Kimbell, 2012, p.130) we may begin to establish elements that combine to define design thinking. In a similar stance, Dorst (2010) argues that some activities in design are universal but have been combined to create a unique discipline that is worthy of study (Dorst, 2010, p.133). Much to Dorst's dismay, research is reinterpreting design thinking; focusing on design thinking as a form of collective activity instead of phenomena associated with the designer (Kimbell, 2012, p.141). Attempting to provide a definitive definition of design thinking may be counter intuitive, but adding knowledge to the rich repertoire of design thinking will deepen our understanding on what design thinking is. Thus, the aim of this thesis is not to establish a finite description of design thinking, but to observe and understand its behavior as it moves through different disciplines and contexts.

A description of the fundamental characteristics behind design thinking has been established in this review. This is used as a point of reference and consistency when observing the application of design thinking in emerging practices, specifically in complex environments. It has been established in this review that design thinking is gaining momentum in complex third and fourth order environments. Providing much needed knowledge on the behavior of design thinking in this emerging context will help professionals better understand, manage and apply design thinking in similar contexts. In addition, it will add depth to our understanding and theory of what design thinking is, how it works and what kind of impact it has in practice.

4.1 The research question

What is the behavior of design thinking in complex environments?

As the adoption of a designerly approach increases in complex environments, so too does the responsibility of design thinking. Disturbingly, even though design thinking is defined as tackling ‘wicked’ problems, not enough research has been performed on exactly how design thinkers are able to design for highly complex problems. Current design practice is still developing competency in handling the complexity of large, multidisciplinary and integrated environments, as Kimbell points out “There hasn’t been much work on how you design complex service systems” (Kimbell in Engine, 2012, p.24). Junginger (2009) also adds, “While more and more organizations are picking up on the possibilities of design’s broader role within an organization, there are still few tools for managers and designers to develop, assess and appropriate design thinking and design methods to organizational problems” (Junginger, 2009). This thesis seeks to answer this need with critical observations on how design thinking is adopted for the design of complex environments. In doing so, evidence will be provided that will enable practitioners and researchers to deepen their understanding of design thinking and design thinking in complex environments.

4.1.1 *Does location affect the design process in complex environments?*

In order to better understand the behavior and effect of design thinking in complex environments, the position of design thinking will be a focus for consideration and analysis. Positioning relates to the relationship between design activity and the problem or organizational system context. This question seeks to build upon the concept of positioning design practice introduced by Sabine Junginger (2009). Acknowledging the position of design thinking activity provides a richer understanding of the behaviour of a designerly approach in complex environments. This understanding will be further enriched through a causal analysis of the underlying mechanisms that enable designerly behaviours to emerge in complex environments.

4.1.2 *What are the underlying mechanisms that enable or disable designerly behaviors to emerge in complex environments?*

This sub question aims to deepen analysis on the behavior of design thinking by understanding how and why certain behaviours emerge when design is applied in complex environments. Analysis on emergent behaviours will be guided by a critical realist perspective. The purpose of this question is to identify and postulate causal mechanisms that will provide not only descriptions of design thinking, but explanations driving the behavior of design thinking in complex environments. These explanations serve to act as seeds towards the development of a theoretical foundation on the behaviour of design thinking in complex environments.

4.2 Conclusion

Contemporary research and practice have focused heavily on the design thinking process; identifying methods and attitudes that drive innovation. However, limited attention has been paid to understanding the behavior of design thinking specific to complex environments. Additionally, with an increasing demand for design thinking in complex environments, designers and researchers will benefit from knowledge generated on how best to manage the application of design thinking in this new context. By providing knowledge in response to the research question outlined in this review, descriptions and explanations will be presented that aim to advance both design thinking theory and practice. The knowledge presented in this thesis aims to offer a richer understanding of design thinking so that practitioners and researchers may improve upon their practice specific to third and fourth order (complex) environments. The longevity of design thinking depends on the critical analysis of empirical research. This is required not only to increase credibility but to improve and evolve design thinking into new and emerging contexts.

3.

Research Framework

The thesis has been designed to investigate the question, *what is the behavior of design thinking in complex environments?* First, a foundation of knowledge has been established through a literature review on current and historical research on design thinking. From this review, a research gap emerged; there is limited empirical research on innovation through design thinking particular to emerging practice in complex environments. The primary focus of this dissertation is to collect empirical case study evidence on design thinking applied in complex environments and to investigate causal phenomena that support or inhibit emergent design behaviours and outcomes. Knowledge generated in this thesis will be directed through a critical realist ontological and epistemological perspective, using grounded theory as a primary vehicle for methodological inquiry.

Critical realism bridges the methodological gap between qualitative and quantitative research. This approach attempts to break down limitations from traditional research paradigms that explore phenomena in isolation, falsely creating closed systems (Dickens, 2003, p.100). Research into complex design environments can be explored in a more holistic and critical manner using a grounded theory methodology positioned within a critical realist framework (Bergene, 2007, p.8). Grounded theory provides a methodological foundation for analysing complex, multidisciplinary environments. As the research direction is exploratory, grounded theory provides methodological freedom to adapt research methods as categories unfold. Additionally, critical realist grounded theory aims to unify both internal and external validity. This aim aids in the analysis of interactions between both internal design processes (social) and external (systemic) outcomes. The ontological position of a critical realist framework allows for a range of qualitative and quantitative data collection methods and perspectives.

This chapter will proceed as follows: first, a brief introduction to current design research practice is reviewed before proposing the adoption of critical realism as a theoretical framework for research into complex design practices. Second, the critical realist ontology and epistemology is presented and discussed in light of the research focus. Third, a discussion of the methodology that will guide the research design is presented before concluding with an outline of the research design and analytical framework.

3.1 Research into design practice

Knowledge generated in this thesis has been constructed using a critical realist perspective. Academic research into design practice has relied heavily on subjective epistemological and ontological theories borrowed from the social sciences, most common of which are constructivism and pragmatism (Scheer, Noweski & Meinel, 2011; Lande, 2012, p.22; Jones, 2010, p.71; Oxman, 1999, p.111; Dalsgaard, 2014; Bousbaci, 2008, p.44; Feast & Melles, 2010). However, these theories may not be most appropriate to accommodate the scope of complexity that is inherent in third and fourth order design practice. The research objective of this thesis tackles the issue of complexity in design practice and as such, proposes an alternative theoretical framework. This thesis argues that design research is in need of a new epistemological and ontological position that is more suitable for investigating new and expanding varieties of complex, interdisciplinary environments faced by design practitioners today.

Epistemologies employed in design research generally sit at one end of two extremes: subjective interpretation and objective (positivist) analysis. The theoretical gap between subjective (postmodern) and positivist theory is not only evident in social science but reflects a fundamental power struggle between qualitative and quantitative research. This dichotomy does not accommodate research that requires the construction of knowledge using a collection of data from both ends of the epistemological spectrum. Design research that investigates complex, multidisciplinary problems may not adequately provide holistic examinations within the current divide. Furthermore, fundamental flaws arise when justifying the use of subjective or objective theories; especially in research on design thinking for complex environments such as the focus of this thesis. A brief analysis highlights why conventional epistemological approaches applied in design research are unsuitable for research into complex design practice.

A designerly approach is no longer limited to traditional craft-based practice. Today, design thinking interacts with and shapes social, technological and environmental systems. Friedman (2003) considers the shift in design practice, stating "Design now plays a role in the general evolution of the environment, and the design process takes on new meaning" (p.509). A positivist approach to design research may reject tacit knowledge that is inherent in practice; that is the designerly way of knowing (Cross, 1999) understood to be design thinking. Alternatively, a positivist approach applied in human-centered contexts may miss fundamental ethnographic insights that could aid in the development of strategic outcomes. Furthermore, a purely objective framework alienates inter-subjective cultural and social cues "Reducing society to nothing more than a group or loose aggregate of individuals" (Sayer, 2010, p.16). Research in design cannot quantify judgment, emotion and intent; the heart of the design process (Archer, 2007, p.3). Furthermore, a positivist approach strips research into design of its creativity, resulting in formulas that are void of intuition, purpose and ultimately, design.

However, analysing design problems with a subjectivist approach excludes a wealth of knowledge that exists externally to the researcher's interpretive position. A purely subjectivist perspective in design research is a precarious methodology particularly in the face of economic and climate instability. Subjectivist research generates theory through social judgment, construction and interpretation. The epistemological position of the subjectivist approach is often ontologically conflicting with research on naturally occuring (objective) phenomena. This may exclude a rich world of research such as environmental science and behavioural economics "Interpretivists deny the possibility of knowing what is real and reject the possibility of discerning causality. They can only provide their own interpretation. What is not clear in the interpretivist approach is by what standards one interpretation is judged to be better than another" (Easton, 2010, p.118). Subjectivist research places tight boundaries on knowledge creation, inhibiting objective investigations into wider complex systems. Proposed theories of how to develop and improve upon complex social systems cannot be created solely using a subjectivist approach. Furthermore, measurement and replication of subjectivist theories is near impossible as there are no variables by which other investigators can test or verify (Crouch & Pearce, 2012, p.59). All knowledge can be said to be social as its realisation depends on the mind, however, what is lacking in mind-dependent epistemologies is space for causal analysis on and between social and naturally occurring phenomena. Discerning causality is key to improving research on complex design practice.

Design practice is goal orientated. Herbert Simon (1996) eloquently described design as "concerned with how things ought to be", with Bruce Archer (2007) describing design as "The third great defining characteristic of humankind" (p.2). This third knowledge combines practices from both art and science into a discipline that "Meets particular needs, producing a practicable result and embodying a set of technological, economic, marketing, aesthetic, ecological, cultural and ethical values determined by its functional, commercial and social context" (Archer, 2007, p.3). As such, design research requires a methodology and epistemology that unifies this knowledge to create a 'third' theory of knowledge generation. As the research aims to investigate the complex design thinking practice, it requires a new approach to design research that argues away from traditional research models and towards adopting a new approach that explores trans-disciplinary research through a critical realist perspective.

3.1.1 An alternative theoretical perspective

> Designers are endlessly confronted with design problems that emerge from ideas situated on this continuum from the objective to the subjective (Crouch & Pearce, 2012, p. 34)

In response to the epistemological dichotomies, developments in the social sciences have begun to favor a critical realist approach. Critical realism is appropriate for academic research in design, as it argues for "A unitary, but non-positivist conception of scientific knowledge" (Baehr, 1990, p.766). As highlighted in the introduction to this chapter, design research that aims to construct pro-active models for social change require an epistemology that respects cultural context whilst allowing for the inclusion of objective, quantifiable data and causal analysis. Design is an inter-subjective, collaborative and trans-disciplinary field, which relies as much on social and cultural construction as it does on naturally occurring, factual phenomena including causalities from mechanical (technological) systems.

Furthermore, design is evaluated on its usefulness of results (Archer, 2007, p. 4). As described through the literature review, over the history of research investigations into design practice, little empirical research has been conducted on many facets of design thinking, particularly the impact that complex environments exhibit on the shape, evolution and innovation of design thinking. Bruce Archer (2007) distinguishes design from the sciences and humanities, proposing:

> Design is described as productive to distinguish it both from Science, which, as we have seen, is explanatory, and from Humanities, which are reflective, and to place Design in the world of action. (p. 3)

A causal framework is needed to account for the scope and complexity of information when analysing design thinking in complex environments. Critical realism has been proposed as a solution to this dilemma.

3.2 Critical realism

> Contrary to traditional realism, critical realism is based on an ontology that is deep, differentiated and stratified. And contrary to empiricism, critical realism is based on an assumption of natural necessity.
> (Bergene, 2007, p.12)

Critical realism presents an ontology that respects both socially constructed and naturally occurring realities. Critical realism has been proposed as a way of "coordinating the disciplines" (Dickens, 2003, p. 95) of art and science. Critical realism describes a world that exists external to our consciousness, but at the same time, in a dimension that relies on a socially constructed knowledge of reality (Danermark & Ekström, 2001, p.5, Mingers, Mutch & Willcocks, 2013). Phenomena observed, whether natural or social, factually exist prior to our conception and prescription of meaning and reality; it is this unique ontological position behind critical realism that allows for an objective reality to exist and be integrated within social design research (Sayer, 2010, p. 33). Social objects are both socially defined but also a part of an objective reality, as Danermark and Ekström (2001) describe:

> Natural science 'facts', just like social science 'facts' are thus theoretically and ideologically conditioned. The important difference is that whereas the objects of natural science are indeed socially defined but still naturally produced, the objects of social science are both socially defined and socially produced but they are nevertheless just as real (p. 22)

This perspective understands that abstractions from social data are just as real as data from natural sciences, for both abstractions are an extract from reality (Danermark & Ekström, 2001, p. 48). Roy Bhaskar (1979), the creator of critical realist ontology, previously described this theory as transcendental realism. Bhaskar penned the theory in the 1970's in response to extreme positivist and post-modern ontologies. Bhaskar writes that socially constructed reality is 'transitive'; that is, socially produced methods and theories used to describe real structures. Material (real and/or natural) processes are 'intransitive' (Baehr, 1990, p. 767).

A key contemporary critical realist, Andrew Sayer (2010), describes critical realism as utilising pragmatic, constructivist and positivist epistemologies but explanations are fundamentally constructivist. He attempts to explain Bhasker's theory through hermeneutic deconstruction. Sayer explains that the study of real subjects, or natural objects, only involves a 'single' hermeneutic; that is, there can only be prescribed one direction of meaning as naturally occurring phenomena do not interact or construct a relationship of meaning with the observer (Sayer, 2010, p.21). Subjects that are culturally dependent, such as ideologies and concepts conceived via social construction, require a 'double' hermeneutic as engagement with meaning is two-way and depends on the relationship of knowledge construction between people (Sayer, 2010, p. 24). Most importantly in critical realism is the understanding that the single hermeneutic (natural phenomena) does not embody concepts or cultural meanings; they exist whether or not we prescribe ideas or labels to them and are thus not socially produced (Sayer, 2010, p.18). For a critical realist researcher, it is thus imperative that he or she is critically rigorous in his or her acknowledgement of concepts that are prescribed to the social but particularly to the natural world (Sayer, 2010, p. 26).

In his seminal book, *Society and Nature*, Peter Dickens criticizes contemporary research. He argues that both the arts and sciences are guilty of epistemological 'imperialism' and depart from common sense (Dickens, 2004, p.19). His criticisms reflect the problems faced by design researchers and advocates for an alternative approach to understanding society-nature relations (Dickens, 2004, p.19). Peter Dickens (2004) outlines the key elements of critical realism:

> 1. Knowledge is a product of society, but knowledge is not only a product of society. It can refer to real processes and mechanisms in the world.
> 2. Science is about establishing the causes underlying phenomena of interest. Real, relatively enduring structures and causal mechanisms in the physical, biological and social worlds underlie what we observe and experience. They do so in combination with one another and often in combination with contingent circumstance. 'Closed systems' are created artificially to develop understandings of causal mechanisms, but these are rare in society and nature.
> 3. The world is envisaged as hierarchically stratified. At the most general level are physical mechanisms (e.g. Gravity). At 'higher' level are chemical structures and mechanisms. Higher still are biological mechanisms (e.g those generating an organisms growth). Finally, there are psychological and social mechanisms. Mechanisms at each level of reality are rooted in- but not reducible to- those operating at lower levels.

> 4. The nature of these structures and mechanisms is subject to constant critique and scientific development. This critique and development can also stem from practical, everyday experience (p.20)

The elements outlined by Dickens argue for a new hybrid of knowledge that allows for strategic theories that are open and built from both social experiences *and* scientific knowledge. Dickens (2003) justifies this approach by returning to basic evolutionary ideas; we are part of nature and "Subject to many of the same mechanisms of growth, development, illness and death as other species" (p.95). For Dickens, the current climate crisis is forcing a re-connection with our natural environment. This is in turn abolishing prevailing philosophies of nature and the natural sciences as the *other*, which we have become ideologically estranged from for too long (Dickens, 2003, p.98). It is Dickens' opinion that critical realism offers a balanced recognition of both social and external (natural) realities (Dickens, 2004, p.20) that is needed for design to deepen its understand on the increasing complexity between environment, society and design.

3.2.1 Critical realism and complex environments

Critical realism offers an epistemological framework for research and evaluation into complex design processes. For the purpose of this thesis, critical realism provides a sound epistemological foundation appropriate for the research question: *what is the behaviour of design thinking in complex environments*? As investigations and analysis will surround complex 'wicked' problems, critical realism provides a guiding ontology and epistemology towards sense-making through its theory on causal relationships within and between complex (wicked) environments:

> Epistemologically, the aim of Critical Realism is to explain the relationship between experiences, events and mechanisms. The perspective emphasises questions of 'how and why' a particular phenomenon came into being, got its specific character and so on. The emphasis is on the explanation of the constitution of empirical phenomenon and not to give predictions (Jeppsen, 2005, p.5)

As described in the previous chapter, complex environments are defined as open systems that are complex from both a cognitive and structural perspective. An open system may include an organisation of individuals whether they be represented through business institutions or as a self-organised aggregate of individuals. This definition of complexity in design allows for analysis on contexts beyond business management and organizational (institutional) design, to integrating a holistic ecosystem of contexts or emerging patterns of organized behavior, such as open source innovation. Critical realism supports analysis on complex environments because it aims not for 'thick descriptions' of data but conceptual theories that dig deeper into causal relations and explanations behind complex systems. This is achieved through analysis of causal mechanisms in transitive and intransitive domains using the vehicle of retroduction.

Retroduction is the process which transforms critical realism from an ontology into an epistemology. Retroductive reasoning is the first step in the critical realist process of logic and knowledge production. Retroduction is described as "A mode of inference in which events are explained by postulating (and identifying) mechanisms which are capable of producing them" (Oliver, 2011, P.380). Retroduction is a process of logic that operates in reverse, using both abductive reasoning and inductive logic to postulate causal mechanisms. It identifies causes that are then substantiated through evidence (Bhaskar, 1986). The relevance and usefulness of the retroduction technique is explained in more detail in section 3.5.

3.2.1 Open and closed systems

Pivotal to the critical realist construction of knowledge and analysis is the distinction between closed and open systems. Complex systems in both the natural and social worlds share similarities and are distinguished as having intrinsic or extrinsic conditions, existing in intransitive and transitive domains (Baehr, 1990, p.767). All complex systems exist in an intransitive realm. The intransitive realm is the objective reality that does not depend on social constructions (Barrett et. al., 2010, p.6). It is not until we attempt to comprehend complexity and prescribe theories to complex systems and structures that they exist in the transitive realm; the realm of socially constructed knowledge (Baehr, 1990, p.768). Reality, for both transitive and intransitive realms, operates through causality:

> For critical realists the scientific project is to understand and explain phenomena. Reality is seen as a result of causal powers. Some powers are transitive (for example language and ideas) and others intransitive (like gravity)
> (Kempster & Parry, 2011, p.107)

Bhaskar describes open systems as having extrinsic properties, with closed systems holding intrinsic conditions. The distinction between intrinsic (closed) and extrinsic (open) systems echo's Simon's description of 'tame' and Rittel and Webber's writings on wicked problems. Sayer (2010) elaborates on social systems, stating that they "Can only be quasi-closed, producing regularities that are only approximate and spatially and temporally restricted" (p. 84). This means that predictions cannot be made on social systems as can be done for natural systems as they have extrinsic (open) properties, but conceptual theories based on emergence and causality of social structures can be produced to enable change.

Social systems, like natural ones, can be analysed through their causality and emergent properties. However, social mechanisms have the power and agency to change their structure (Easton, 2004, p.121). A key tenet behind critical realist theory is discovering the emerging causalities embedded within systems in order to enable new and improved theories and outcomes. This emancipation is not achieved without digging through layers of reality, a process also known as stratification.

Stratification outlines the layers of reality from the empirical (observable) to the unobservable. Stratification provides foundation for critical realist analysis into structure, agency and emergence, and is the framework for retroductive analysis. Bhaskar explains that social or natural realities can be stratified into three levels:

> **Empirical**: observable by human beings
> **Events**: existing in time and space
> **Real or Deep**: powers that are often unobserved yet causally efficacious
> (Bhaskar, 1979 in Kempster & Parry 2011, p.110)

Layers of reality	Positivist/ empiricist approach	Interpretive constructivist approach	Critical realist approach
1	Empirically observed characteristics	Symbolically expressed meanings	The empirical (experiences)
2			The actual (events)
3			The real (mechanisms)

Fig.8 Stratification of Reality (Wuisman, 2005, p.368)

Causal powers exist in both the social and natural world. Critical realism provides a view of reality that is stratified, with causal mechanisms affecting all levels of reality, from the physical, biological to social levels that combine to create the world that we experience (Dickens, 2003, p. 95). This theory of causality can be applied to investigate the causal mechanisms of social systems alone or combined with the natural world in order to understand our relationship and effect on our natural environment. This understanding is achieved through investigations into structure, agents and causal mechanisms operating in complex systems.

The aim of focusing on causal mechanisms is to understand how they work, all the while with the question in mind "What makes this possible?" (Oliver, 2011, p.380). This analysis takes into account both internal and external web of interacting forces (Oliver, 2011, p. 374) that may have influenced change in a system. This process breaks down phenomena observed into more basic stratified layers (Oliver, 2011, p.374). Furthermore, the tenet of causal investigation is to understand and uncover the existence of unobservable mechanisms that may casually interact with and influence observable events (Barrett et. al., 2010, p.6).

The research design of this thesis devotes much attention to the structure and agency of design thinking in socially constructed environments. A primary vehicle for interpreting causality in social systems is through analysing agents of change. An agent of change is a conceptual differentiator from natural systems. Social systems comprise of people (agents) who interact in and are influenced by the system yet have the ability to influence and change the structure of that system. Due to the individualistic and complicated nature of agents, social structures are inherently open. However, there are some systems that can be described as 'quasi-closed' (Barrett et. al., 2010, p.9). A quasi-closed system can be identified through the nature of habit. Habit restricts a system from evolving; it disables agents (people) within and thus inhibits changing the nature of the system.

Kempster & Parry (2011) explain the importance of structures and agents. Structures are "A nexus of embedded meanings, practices and relationships that pre-exist agents," while agents are individuals who "Sustain and elaborate meanings, practices and relationships" within the structure of a system (p.111). This knowledge aids in the complex understanding between agents (people) and structured systems; that is structures and agents interact, affect, and in turn can change their agency or structure. Furthermore, when a system is identified as 'quasi-closed' this signals a need for actionable change to improve and evolve its social structure for the benefit of both the agents within and across the system as a whole. Thus, this perspective provides an analytical framework for understanding the relationship between design agents to discern the unobservable causal mechanisms that influence or inhibit design processes, innovations and outcomes. A causal analysis of design agency may also provide a broader understanding of the position of designers in the wider network of inter connected complex systems.

Causality is not an interpretive exercise. It seeks to understand why events happen rather than subjectively describe what has happened. It is a pragmatic practice into theory conception, by using causal language and retroductive logic to describe and explain complex systems. Easton (2004) notes:

> However there is no way that such an assumption can ever be proved or disproved, as social constructivists, pragmatists and even positivists are ready to argue. But this assumption is surely performative. In other words we behave as if it was true, as if the world was real. In general this supposition works, especially for the physical world. (p.119)

Critical realist ontology is a pragmatic approximation of real world events that aims to provide a practical research methodology for emancipating social structures governed by causal mechanisms, in order to enable change and also new theory development. This provides a working methodology for research in this thesis for it guides critical analysis into the nature of complex structures and mechanisms operating in the organic and social worlds, whilst questioning the relationships and process governing them (Dickens, 2003, p. 99). This theoretical model provided by critical realism is appropriate for supporting research and analysis into a complex design practice such as design thinking.

A critical realist framework presupposes the complexity of open and adaptive social systems. Its ontological position allows for a more informed and holistic evaluation into complex process, structure and environments. The primary purpose of investigating causal categories behind complex systems is to emancipate society and enable change (Barrett et. al., 2010, p. 6; Oliver, 2011, p.375). It is crucial for critical realist researchers to constantly question why events occur and what causal mechanisms create and influence particular outcomes. Easton, along with many other contemporary critical realists, argue that causal investigations must be carried out in real time generating grounded theories that evolve with data (Easton, 2004, p.127). It is for this reason that contemporary critical realism has embraced grounded theory methodology.

3.3 Methodology

3.3.1 Grounded theory

Grounded theory is a common methodology adopted in social science research. It is a framework that aims to develop theory simultaneously with data collection, thus grounding theory in the data described (Strauss & Corbin, 1994, p. 273). Grounded theory is a rigorous and critical exercise in data collection and analysis, as it requires researchers to consistently reflect and compare hypotheses that develop against the opinions of individuals, in order to validate the reality of the theory in development (Strauss & Corbin, 1994, p. 280).

Grounded theory was created by two sociologists, Barney Glaser and Anselm Strauss. Glaser and Strauss developed grounded theory in reaction to criticism against social science research methods. Previous to this technique, social science methodologies were often regarded as 'journalistic' and lacking the "Rigor of good scientific research" (Silverman, 2001, p.26). In their seminal book titled, *The Discovery of Grounded Theory: Strategies for Qualitative Research*, Glaser & Strauss assert that current methodologies in social science have been preoccupied with verifying theory rather than creating it (Glaser & Strauss, 1967, p.1).

Traditionally, qualitative research was seen as inferior to quantitative data and served merely to 'set up' theories for formal quantitative research. Glaser & Strauss re-conceptualised this approach, asserting that there is no hierarchy between qualitative and quantitative methods of data collection for both offer valid approaches for grounding theory (Glaser & Strauss, 1967, p.18). The fundamental characteristic of grounded theory is the method of comparative analysis. Comparative analysis functions to develop and validate hypotheses as they evolve through data analysis. Glaser & Strauss firmly believe that adequacy of a theory "Cannot be divorced from the process by which it is generated" (Glaser & Strauss, 1967, p.5). Comparative analysis may be conducted across different data collection methods and theory strengthened when qualitative and quantitative methods are applied.

Akin to testing hypotheses in science, comparative analysis performs as replication for validating facts (Glaser & Strauss, 1967, p.23). Validation does not equal accuracy, as grounded theories aim to create general concepts that depict general phenomena. Verification is assumed through the comparative process, as evidence from the data is used to illustrate the theory developed (Glaser & Strauss, 1967, p.28).

A focal point during comparative analysis is discerning emergence. Emergence is the concept that "Structures or behaviors can be found in a system that were not intentionally put there, i.e., they emerged" (Gero, 2010, p. 178). Diversity between categories of emergence is fundamental in developing a well grounded theory. The process of 'digging deeper' into underlying emergent categories reflects the critical realist approach of causal conceptualisation through stratification.

Grounded theory methodology is open and iterative. It requires researchers to re-evaluate assumptions and conduct analysis as data progresses; evolving theory in conjunction with the changing structure of social phenomena observed. Its process methodology allows analysis and synthesis of data from a wide range of qualitative and quantitative methods required for the investigation of the research question. This methodology reflects the inherent focus behind critical realism; to conceptualise observed and unobservable causal mechanisms. This makes the grounded theory approach an appropriate framework to guide methodology under a critical realist perspective when so little is available on how to apply critical realism in research (Carlsson, 2003, p.6).

3.3.2 A critical realist grounded theory

Grounded theory functions harmoniously within a critical realist framework. The usefulness of a grounded theory methodology in critical realism has been promoted heavily amongst contemporary researchers (Rennie, 2000; Parry, 1998; Bergene, 2007; Porter, 1997; Downward & Finch, 2002; Kempster & Parry, 2011; Easton, 2010), but none of whom have conducted critical realist grounded theory research in the design discipline. Two writers who have had the most significant impact on the development of contemporary critical realist methodology are Carolyn Oliver and Ken Parry.

Oliver (2011) has adopted a critical realist grounded theory approach in her social work research and has published a paper on the topic titled, *Critical Realist Grounded Theory: A new Approach for social work research*. In this paper, Oliver (2011) acknowledges the popularity of grounded theory methodology in the social sciences but highlights the inclusion of critical realist theory to "Marry the positivists search for evidence of a reality external to human consciousness with the insistence that all meaning to be made of that reality is socially constructed" (p.371). Oliver describes the compatibility of grounded theory and critical realism through hermeneutical inquiry, pursuing emancipatory conceptualisation through emergence and generative mechanisms; ambitions that are inherent in both critical realist and grounded theory process. Echoing Glaser & Strauss' original methodology, Oliver's approach to critical realist grounded theory focuses on mixed methods. Oliver advocates utilising both qualitative and quantitative data in triangulation, a process she understands was once contradictory within traditional paradigms but under a critical realist perspective has become coherent (Oliver, 2011, p.379).

For Oliver, grounded theory under a critical realist ontology and epistemology ties research more firmly to practice (Oliver, 2011, p.373). This position strengthens relationships between design thinking research with practice, producing theories that are pragmatic and relevant to professionals. Critical realist grounded theory emancipates not just social phenomena under study, but the research conducted in academia. A critical realist grounded theory methodology produces knowledge that is relevant and practical to practitioners by "Grounding findings in the experiences of those it seeks to inform" (Oliver, 2011, p.384). As such, research and theory on the relationship between design thinking and complex environments will emphasise practicality, and as a result, strengthen academic research with professional practice. Most importantly for Oliver, and for this thesis, critical realist grounded methodology offers an opportunity to engage and build relationships with practitioners. This aim is to strengthen the connection between academic research and design practice (Oliver, 2011, p.384). This methodology fulfills a central goal of this thesis: to expand on and contribute original knowledge on design thinking in complex environments that is useful and applicable in practice.

In his 1998 paper, *Grounded Theory and Social Process: A New Direction for Leadership Research*, Ken Parry argues for a grounded theory methodology in response to quantitative methodologies that have dominated research on leadership practice. In contrast to sentiments described by Glaser & Strauss, Parry explains that using qualitative methodology is too subjective as it aims to merely describe phenomena rather than interpret and generate theory (Parry, 1988, p. 88). For Parry, critical realist grounded theory fills an empirical gap between qualitative and quantitative research for theory generation.

In his most recent paper on the subject, Parry extends his argument on grounded theory to critical realism. In a paper co-authored with Stephen Kempster, *Grounded Theory and Leadership Research: A Critical Realist Perspective*, Parry and Kempster justify a critical realist approach to grounded theory, stating "Grounded theory adopts a contextual examination of social processes in organizations and such a focus will be argued to be in close accord with the underlying philosophy of critical realism" (Kempster & Parry, 2011, p.109). Central to Parry's advocation of critical realist grounded theory is the ability to research non-observable phenomena (Kempster & Parry, 2011, p.107). Understanding non-observable phenomena is central to comprehending the complexity of both design process and multidisciplinary project practices. For Parry, the qualities and characteristics of leadership are manifested in intangible conditions, resulting in research that requires investigation into abstraction and analysis of underlying causal mechanisms. Design thinking serves to produce tangible solutions to complex problems, whilst also operating in an intangible and cognitive realm. Akin to descriptions of leadership practice, research into design thinking also needs abstraction and analysis of underlying causal mechanisms. For Parry, and this thesis, grounded theory provides a methodological way forward (Kempster & Parry, 2011, p.109) for research into new practices in design.

3.3.3 Methodological limitations

The objective of the research question is to investigate design thinking in complex environments. This investigation requires multiple case studies to compare findings across diverse and complex design thinking project contexts. Grounded theory methodology situated within a critical realist perspective has been chosen as the framework for conducting comparative analysis across case studies. This research strategy requires collecting qualitative research from complex design projects, whilst remaining open to the use of quantitative methods and data to support grounded theories of the phenomena under study (Danermark & Ekstrom, 2001, p.153). Results of this research will then be used to create general causal conclusions on the behaviour of design thinking in complex environments.

Adopting a new theoretical perspective for the research design introduces both opportunities and limitations. A primary limitation of using a critical realist theoretical framework is that evidence of its usefulness and application in research practice is limited (Wuisman, 2005, p.367). Research conducted using critical realist grounded theory is sparse, and as such, few examples can be drawn from existing research to guide the research design (Carlsson, 2003, p.6), with scholars arguing that the critical realist perspective needs refinement (Jeppsen, 2004, p. 7). Critical realist grounded theory is under published in the context of design research. This less than established approach leaves rogue researchers open to criticism as research designs vary according to interpretations and applications of the theory. This proves difficult for the novice and experienced researcher alike to apply a critical realist framework for research methodology, particularly for design research. This thesis maintains transparency towards the limitations of this position.

Critical realism's ambiguous process of deriving causality is open for debate. Downward et al. (2002) describe the insecurities that arise when adopting a critical realist approach "How will I know whether the characteristics I have identified are 'essential'? How will I be able to tell when I have successfully identified a cause? How can I be sure that the process description is 'thick enough' to permit causal explanation?" (p.491). These writers assert the importance of answering such limitations so that researchers gain confidence in the reliability of their results. Perhaps the greatest difficulty of being a critical realist researcher is balancing context with generalizability (Bergene, 2007, p.6).

Arguments have erupted against adopting a critical realist grounded theory methodology to extract causality and infer generalisations from a single case. Rebuttals claim that critical realism cannot seek to describe generalisations beyond the case at hand because no two contexts are the same (Kempster & Parry, 2011, p.117). Following this perspective, it can be argued that case studies are a poor method of generalisation due to the unique history that affects each case. This drives researchers to adopt a multi-case study, to increase potential for deriving general propositions. Stake (2005, p.12) argues that a multi-case study is for illustrating diverse contexts rather than commonalities, concluding that a few cases are not sufficient for generalisations. Bergene (2007) also recognises this limitation, proposing an extreme solution, that "Every relevant case be studied," (p.10) in order to arrive at causal explanations. This problem of discerning general causal validity is prevalent in social systems, where agents (people) have the ability to constantly adapt and re-structure their environment. However, this problem is not unique to critical realism but all social sciences that attempt to imply general (and causal) theories on a social phenomenon.

In response to this limitation, a causal analysis on social structures can become less problematic when habits are identified. Habitual practice creates quasi-closed systems that share common characteristics across differing contexts. Selecting cases that are contextually diverse yet habitually similar may alleviate the dilemma of contextual causality and provide contextual similarities shared across all cases. The contextual limitations of using case study research can be addressed using a clear 'quintain' (Stake, 2005), that is used as criterion for selecting relevant yet diverse cases.
However, what is considered a strength in case study research (deep contextual analysis) is branded as a limitation in grounded theory research. Grounded theory is often criticised for being fixated on micro phenomena (Carlsson, 2003, p. 2). Critics suggest that researchers using the grounded theory method will overlook unobservable influences (Kempster & Parry, 2011, p.117), focusing on interpersonal relationships and individual actions, while missing broader, structural and systemic powers (Carlsson, 2003, p. 2). Yet, positioned within a critical realist perspective, grounded theory critical realists retort that the aim in a critical realist framework is not to seek grand theoretical generalisations, but to examine regularities across cases to gain deeper knowledge and analysis of causal influences (Bergene, 2007, p.14; Stake, 1995, p. 8).

In response to the collective consensus that critical realism has not been adequately defined for research practice, this thesis has modeled both analysis and design from the recent scholars whom have adopted a grounded theory critical realist approach in their research. Many scholars have acknowledged the need to move forward from critical realist ontology and prove its epistemological usefulness in research practice (Downward et al, 2002, p. 491; Carlsson, 2003, p.6; Wuisman, 2005, p. 376). The limitations of critical realist grounded theory offer an opportunity; researchers have creative freedom to design their research plan and build upon existing literature on the subject. This opportunity continues the tradition of Glaser & Strauss, whose principal aim was to "Stimulate other theorists to codify and publish their own methods for generating theory" (Glaser & Strauss, 1967, p.8).

A critical realist grounded theory methodology has been chosen for the research question, *What is the behavior of design thinking in complex environments?* as it provides a framework for exploration into an under researched field of design practice. Furthermore, this methodology allows the researcher to contribute depth to existing literature on the topic of complex design practices, by adding an analysis of underlying causal mechanisms driving design behaviours in complex environments.

3.4 Methods

Grounded theory's iterative methodology allows for theory to unfold as research is collected, following an explorative manner. As such, case studies have been designed with an explorative purpose whilst being open to evolving explanatory analysis. In any new research field such as design thinking, an explorative research approach is favored (Jeppsen, 2005, p.2).

A critical realist methodology for theory generation requires both an internal and external understanding of the phenomena under study. Investigations in a new field of study adopt an intrinsic approach, one that aims for a 'deep' analysis over 'thick' descriptions of a case or phenomena. A critical realist epistemology seeks to understand causal relationships at play within observed phenomena, thus allowing for intrinsic and extrinsic knowledge generation (Wuisman, 2005, p.393). This implies that qualitative and quantitative data and methods are often used together in order to conduct causal study.

A critical realist researcher often takes full advantage of both qualitative and quantitative methods and data. The epistemological position of critical realism advocates the use of mixed methods in order to validate and strengthen casual analysis (Danermark & Ekstrom, 2001, p.153). Contemporary critical realists have rallied for the adoption of mixed methods research in order to break down traditional paradigms (Teddlie & Tashakkori, 2012, p.779). Under a critical realist ontology, qualitative and quantitative information are used together to support the generation of new theory.

Also dubbed a multi-strategic approach, mixed methods offers strength in validation, triangulation and the freedom to explore a wider variety of methods for the research question and direction. This is supported in critical realist research practice, as epistemological and ontological dualisms are broken down to allow different methods appropriate for different situations (Bergene, 2007, p.6). Traditionally, qualitative methods were applied purely to 'set up' data for proper analysis using quantitative methods. Today it has been acknowledged that both methods have merits, that when used in conjunction, offer strengthened validity and theory development (Danermark & Ekstrom, 2001, p.153).

Critical realist grounded theory methodology allows the use of qualitative and quantitative methods and data for theory generation; particularly to validate hypotheses inferred from data. As the research design involves predominantly qualitative methods, it reserves the option of including quantitative research and data through archival documentation to support findings and theory development. The following section covers methods that are fundamental to the research design.

3.4.1 Case study

Case study research is a fundamental method adopted for data collection in qualitative research. Yin (2009) advises that the "Distinctive need for case studies arises out of the desire to understand complex social phenomena" (p.4). Yin also advocates the case study method for its usefulness in 'how' and 'why' research objectives; that is explanatory and exploratory research (Yin, 2009, p.2). Exploring complexity in design thinking practice is the focus of this thesis, thus, case study has been chosen as an appropriate data collection method.

Eisenhart (1989) extends on the benefit of case study research, arguing that it is a useful method for theory generation. Similar to the grounded theory approach, Eisenhart (1989) explains that building theories from case studies is "Highly iterative and tightly linked to data" (p.535). Echoing Yin, Eisenhart adds that it is particularly appropriate for new areas of research (Eisenhart, 1989, p.532). Eisenhart's paper, *Building Theories From Case Study Research*, supports the methodological approach of grounded theory. It is for this reason that this research design has used the case study method with a grounded theory methodology.

Stake (2005) explores the topic of multiple case study research in his book, *Multiple Case Study Analysis*. Of fundamental importance for Stake is defining the quintain. Stake describes the quintain as the umbrella for case study research (Stake, 2005, p.6) belonging to a particular group of cases (Stake, 2005, p.4). The quintain is the wider boundary in which the study is situated and selected. Stake places more emphasis on the importance of understanding context in case study research, but allows for generalisations to be made through cause and effect- reflecting the position of critical realist theory (Stake, 2005, p.12). In contrast to Yin's opinion that multiple cases should be of similar context and outcome, Stake (2005) argues:

> An important reason for doing multi-case study is to examine how the program or phenomenon performs in different environments. This often means that cases in both typical and atypical settings should be selected (p. 23).

The research design of this thesis condones the selection of variable cases unified beneath the boundary of an allocated quintain, and as such, has chosen three diverse case studies for analysis. The quintain is defined in the following section, 3.6. *Research Design.*

This approach is also supported by Cecil Bergene (2007) "The chief merit of comparative case studies is often said to be that it allows for an examination of patterns of similarities and differences across a moderate number of cases, thus combining depth with a more extensive approach" (p.8). In order to adequately comprehend the under-theorised practice of design thinking in complex environments, an explorative, multiple case study design that exhibits a variety of contexts and outcomes is essential.

Geoff Easton advocates the appropriateness of case study research for critical realist theory. However, for rigorous critical realist investigations, Easton (2004) advises that one study is more beneficial than many. Explanations are thus more thorough, credible and "Incorporate a number of different emergent levels (individual, group and organisation) and a number of different entities" (p.127). Easton concludes that thoughtful critical realist analysis is more deep than broad. As the research design incorporates multiple case studies, application of a coherent and rigorous critical and causal analysis is not implemented until after grounded theory analysis surfaces core categories. Critical realist grounded theory has been utilised as a framework for theory generation filling a methodological gap in grounded theory; the transformation of categories into theory.

3.4.2 Participant observation

Participant observation is a method of field research that aims to immerse the researcher in direct observation of the phenomena under study. There are varying degrees of observation that may be conducted, from non-participant to complete participation (Emerson et. al., 2001, p.101). This research design adopts a passive participant perspective, allowing phenomena to remain unobstructed by the researcher to preserve objectivity. Stake (2005) praises the use of direct observation stating "The most meaningful data gathering methods are often observational — both direct observation and learning from the observations of others" (p.4). Limitations of this approach often surround the inability to interrupt participants as information unfolds (clarifying concepts, asking questions) and the restricted research experience due to inability to interact within the case context. However, these limitations also serve to counteract more inclusive participant observational methods and their limitations, such as issues of researcher bias and influence over the phenomena when the researcher is participating in the case. This research design has chosen to adopt a passive and non-participant approach to data collection, to ensure complete objectivity and reduce the risk of personal bias that would cloud data analysis. Non-participant observation allows the researcher to detect both spoken and unspoken action through body language, intonation and tacit inferences between workers.

3.4.3 Semi structured interviews

Interviews are one of the most common and insightful methods used in qualitative research. Seidman (2006) articulates that the goal of interviews is to "Encourage participants to have the time and opportunity to reconstruct their own experiences and reality in their own words" (pp. 15-19). Interviews are particularly useful when relying on archival data in case study research. Stake (1995) adds "The purpose for the most part is not to get simple yes and no answers but description of an episode, a linkage, an explanation"(p. 65). Interviews commonly follow ethnographic aims; to understand social meaning and culture (Warren, 2001, p.85). For this thesis, the semi-structured interview method offers the researcher freedom to focus on the primary research subject (design thinking practice in complex environments) whilst remaining open to investigating causal factors that may be cultural and symbolic. The research design has favored a semi-structured interview approach to aim for more fluid and flexible data collection under an explorative context. An additional benefit of using this method is the ability to perform interviews with individuals that are not geographically accessible to the researcher. This allows researchers to collect case studies that are otherwise unavailable due to geographical constraints. The advancement in tele-conferencing technology such as Google Hangout and Skype allow for primary interviews using both video and audio be conducted; strengthening data analysis and most importantly, allowing the researcher to conduct interviews with participants across diverse geographical locations.

Interviews are often conducted after project completion. This situation presents an issue surrounding selective memory and hindsight bias. Respondents may not consciously be able to reiterate aspects of the project, especially finer details of conversational meetings amongst members or specific actions undertaken during the design process. Re-collected accounts are usually broad and often generalised. This limitation can be reduced through intensive analysis of archival documents, to remind interviewees of specific circumstances in the project or process. Furthermore, cross-checking project perspectives individually with other participants according to the comparative method, serves to validate accounts from a group of participants.

3.4.4 Field notes and recordings

In both observation and interviews, the process of data recording needs to be addressed. Field notes can take many forms, from hand written notes to video recordings. This research design has chosen to take advantage of new technology, the Echo smart pen. This instrument has been the primary medium for taking field notes as it provides the ability to audio record simultaneously as information is scribed. For ethical reasons video recordings have not been utilised, but mobile technology has been used to record images of research phenomena to support data collected. For field notes, recordings and photos obtained during observation, participants signed consent and were informed prior to performing any recorded action. Reflexive thoughts and opinions were noted as data is documented during observation, without referring to theoretical analysis. This process has been chosen to keep a clean "theoretical slate" (Strauss & Corbin, 1998) as instructed by grounded theorists. The limitations of recording field notes is researcher dependent. Not being able to write fast enough or collect the correct information are limitations of this method. Stake (1995, p. 66) suggests that a field researcher should listen and take only a few notes rather than write detailed accounts. Depending on the objective of the research, understanding the meaning behind the data is more important than collecting descriptions of phenomena observed. These limitations require practice and experience from the researcher to overcome. Furthermore data collected using physical documents such as journals, instruments and cameras have potential to go missing. Rigorous back ups using hard drives and physical filing cabinets ensure that immediately after each observation and interview, data is stored securely.

3.4.5 Archival evidence

In conjunction with observation and interviews, archival evidence plays an important role in the research and collection of cases in this dissertation. Archival data has been chosen for conducting extensive comparative studies across diverse geographical locations. Participant observation methods are time intensive and difficult to achieve for many factors, primarily location. For the purpose of this study, archival evidence has also been adopted for it reduces time required for data collection, allowing more time to be devoted to analysis and conducting follow up interviews.

Archival evidence has the benefit of reducing researcher reflexivity and bias (Yin, 2010, p. 149). However, limitations around organisational motives and bias must be challenged throughout archival analysis (Yin, 2010, p. 149). Archival evidence is often sent to the researcher in the form of images, video, audio recordings and digital documents via the internet.

3.4.7 Conclusion

An initial and intensive observational study was conducted for the purpose of strengthening literature outlined on the topic of design thinking, whilst instrumentally providing a foundation and direction for the following case studies. Justified in more detail under 3.6. *Research Design*, cases after the first instrumental case study had been collected using archival evidence on pre-existing projects, delivered to the researcher from various design and institutional agencies.

The use of quantitative methods in the research design of this thesis is tentative. As the exploration and evaluation of the designerly approach for innovation in complex environments is highly tacit, empathetic and iterative, qualitative research will dominate the methods employed in data gathering. However, a critical realist approach has been adopted not just for its ontological stance on causation and objective reality, but for the inclusion of quantitative as well as qualitative methods for the research design. This freedom allows the research plan to explore the most appropriate methods of data gathering as themes and insights evolve using the grounded theory approach. Quantitative data will be collected when required for analysis and theory generation.
An increasing number of contemporary researchers are advocating for an eclectic mix of methods in research (Teddlie & Tashakkori 2012, p.778). This signifies the rejection of epistemological dualism, as more researchers investigate frameworks for mixed method investigation. This approach has been chosen for its rigor and thoroughness that is required when investigating complex phenomena.

3.5 Analysis

The data collection and analysis of the research question is an exploratory adventure. Since the methods movement of the 1960s, design research published across academia and in practice has focused intensely on the unique process and methods of design and design thinking. It became apparent through collating material for the literature review that minimal empirical research has been conducted towards collecting evidence on how design and design thinkers innovate and how designerly behaviours emerge in complex environments. Furthermore, how this design process shifts and influences highly complex and multidisciplinary design environments is in need of more empirical analysis.

A critical realist grounded methodology has been chosen as the framework for data collection and analysis (see fig.7). A fundamental objective of critical realist analysis is to 'dig' through superficial details to uncover underlying processes (Downward et al., 2002, p.491). The analysis of underlying processes is conducted in an open and reflective framework, using the flexibility of grounded theory to evolve insights with theoretical frameworks, and to guide analysis on underlying causal mechanisms. Critical realists understand that empirical data is just 'the tip of the iceberg' and exploring underlying causal relations is key to emancipating complex social structures bound by habit (Bergene, 2007, p.12). As the analysis of this research is exploratory, findings will focus on generating the foundations for a theory that seeks to analyse and explain the underlying causalities that may be influencing the phenomena studied.

The researcher's position in this thesis takes on many roles. The primary objective is to be investigative and exploratory, developing new knowledge through a research design that utilises qualitative methods and quantitative data if required. The primary purpose of the researcher under the critical realist perspective is to maintain transparency. Throughout investigation and analysis, the researchers position and perspectives on the context of the case is reflected on. As a result, the research journey and exploration of data is documented, highlighting insights that direct new avenues for interpretation (Crouch & Pearce, 2012, p.65). A critical realist researcher is often referred to as a 'disruptive investigator' as analysis aims to deconstruct existing ideologies (Crouch & Pearce, 2012, p.142) whilst re-interpreting how individuals relate to larger, changing, social contexts. In this instance, how designers and multidisciplinary teams relate to complex social contexts through design thinking. The critical realist lens provides a theoretical framework that forces researchers to acknowledge their position and influence throughout investigation and analysis, thus reducing bias through their transparency.

The analysis of data collected in this thesis follows a semi-structured framework. The framework for analysis follows three broad phases: developing codes and memos, constant comparison method and theory generation [Fig.9].

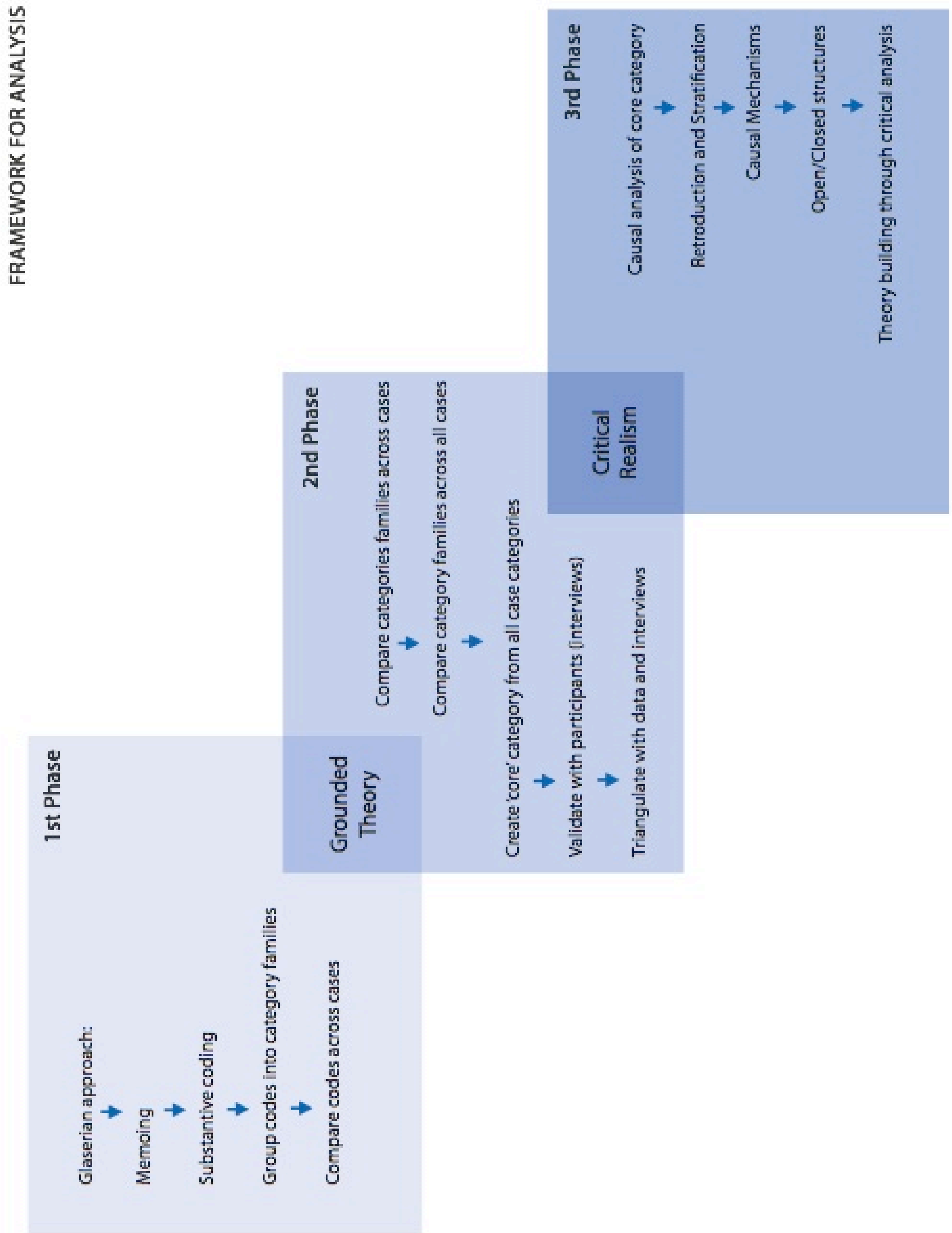

Fig.9 Framework for Analysis

3.5.1 1st phase: developing codes and memos

The first phase of analysis is dedicated to developing codes and memos as case data is collected and transcribed. As field notes and interview audio are collected, data from the case is transferred to software Excel; audio transcriptions, field notes and images taken are all recorded in the same document. References to archival documents relevant to sections of audio are also included. This ensures a clear, chronological spreadsheet outlining the process behind the case study. The chronological documentation of data (as opposed to themes) has been chosen to provide maximum clarity for causal analysis [See Appendix. 1].

This phase begins by memoing initial insights and impressions from the data whilst transcribing and collating audio, documents and notes. A second iteration of analysis is then conducted in qualitative analysis software, Nvivo, this time producing categories and codes (also referred to as 'tags') from memos and insights recorded in Excel during initial round of analysis [See Appendix. A]. This process follows the Glaserian approach to grounded theory analysis. The Glaserian approach favors substantive coding (basic observations) of data that are then grouped under 'coding families' (tag themes) (Kelle, 2007, p.192). This grouping is conducted in qualitative synthesis software, Mural.ly; codes conducted in Nvivo are exported (including direct data from which the code relates) [See Appendix. B] and then clustered in a Mural.ly "board". Each case study has its own board to cluster the codes that were established in Nvivo, using an affinity diagramming technique [See Appendix. C]. From these basic coding families do theoretical codes develop, marking the beginning of developing theory. It is at substantive coding where analysis may influence theoretical sampling and direct the focus of follow up interviews and data analysis for theory development. This process is replicated for all other cases collected.

3.5.2 2nd phase: constant comparison method

Once initial memos and codes are established, the second phase of analysis begins. This phase introduces the constant comparison method. Initial codes and category families from the first phase are compared across cases. Patterns and coding similarities are analysed and established until a core category emerges. Establishing a core category (through cross-case comparison of categories created in all cases) strengthens the reliability of the core category becoming a valid basis for theory development. This also implies that the category is nearing saturation; where no more cross (and individual) case analysis yields fundamentally new insights (Dey, 2007, p.167).

The process of cross comparative analysis during this phase involves two stages: internal and external validation of the core category. Titled the comparative method in grounded theory, this process aims to strengthen and validate concepts by pattern-matching (Yin, 2009, p.139). The comparative method is used to confirm insights present across a number of cases (Glaser & Strauss, 1967, p. 23). This 'replication' of facts and concepts is one of the strongest methods for developing reliable theory in qualitative research [See Chapter 8. Cross-comparative analysis]. Empirical evidence from the case is used to illustrate theoretical concepts; that is used to strengthen theoretical generalisations (Glaser & Strauss, 1967, p.24).

Internal validity is achieved through in depth (contextual) analysis of the phenomena in each case, using grounded theory to guide theoretical categories before triangulating findings across cases. This process is carried out through all cases, exploring concepts unique to each project whilst keeping an eye open for causal patterns signifying 'quasi closed' systems and relationships (Downward et. al., 2002, p.485). Bergene (2007) articulates the objective of this phase stating "Researchers need to conduct an internal analysis of each case. Instead of standardising for, or factoring out, factors common to all cases, internal analysis might reveal how the common factors manifest themselves differently in different contexts" (p.19). Understanding how causal categories manifest in different cases adds insight and knowledge to the developing theory.

Triangulation of categorical insights is a critical component in this phase as categories developed within each individual case are compared with participants for verification and validity (Yin, 2009, p.42). Triangulation is a robust and repetitious addition to internal and cross case study analysis. It serves to confirm whether observations are manifested in different contexts (Stake ,1995, p. 113). It is fundamentally exercised to compare views amongst different sources of data and agents to achieve consistency and reliability of theory developed from data (Stake, 2005, p. 77).

External validity is critically analysed after categories and patterns become evident through cross-case, comparative analysis. Bergene (2007) emphasises the importance of conducting both internal and external analysis of cases for theory generation under a grounded theory critical realist framework, arguing that both internal and external analysis needs to be conducted on each case (p.21). This process ensures that the core category described is contextual yet applicable to a broader understanding of the research question. This method also ensures that the category uncovered has enough internal and external validity to proceed to the next and final phase of analysis.

As stated earlier, theory generation in grounded theory does not aim to provide a perfect or predictable account of phenomena; accuracy is not imperative, either. For analysis and theory development in this thesis, importance is placed on explanatory power. The aim of grounded theory and of this research design is to explore and explain causal relationships between the design thinking process in complex and multidisciplinary environments, in order to deduce generalisable insights that can be used as the foundations for a pragmatic theory for complex design practice.

3.5.3 3rd phase: theory generation

The third and final phase of analysis is the construction of theory. Critical realism is emphasised in this phase for its role in transforming grounded categories into foundations for the formulation of theory. The purpose of applying critical realist analysis during this phase is to bridge a gap in grounded theory methodology (Hood, 2007, p.162). Mentioned in *3.4.5 Methodological limitations*, grounded theory is heavily criticised for its methodological ambiguity during theory creation (Scott, 2004, p.113). The process of conducting memos and creating core categories has been refined by both Glaser and Strauss, however, both authors share little insight on how to develop theory from categories.

In response to this limitation, a causal analytic framework has been adopted during the final phase of data analysis, bridging coding categories to theory generation using critical realism. In this framework, analysis and theory generation is guided by conceptual principles from critical realist theory [See Chapter 8. Cross-comparative analysis]. The most important principle is exhibited through the question "What caused those events to happen?" (Easton, 2004, p.121). In explorative analysis, the aim is to explain why events occurred and what caused the events to occur, or more pragmatically, why certain decisions lead to certain outcomes (Easton, 2004, p.127).

The second conceptual framework for critical realist analysis is the notion of open systems. The idea that social systems are open and contain agents of change requires the researcher to pay mindful attention to the idea that societies and social groups transform their structures and as such can never approach closure (Dickens, 2003, p.97). The implications on analysis and theory generation is that grand generalisations or predictions cannot be made on social systems. The aim of this thesis is not to submit grand generalisations, but to explore conceptual theoretical foundations that may present themselves under similar 'quasi-closed' conditions (Baehr, 1990, p.768). Quasi-closed conditions are present within bounded systems where agents perform repeated, habitual tasks in daily practice, for example, through the adoption of a design process framework. Constructing a research boundary (otherwise referred to as the quintain) is necessary for research design and analysis in explorative contexts as it provides manageability for the researcher to investigate large and complex 'quasi-closed' social practices.

Collecting cases studies that fulfill core criteria required to answer the research question allows the researcher to investigate habits or patterns across cases that are diverse and thus explore conditions of quasi-closure that may affect design process, innovation and outcomes in differing contexts. Friedman (2003) states that a theory "Describes dynamic flows with contours that trace relatively closed loops as well as relatively open links" (p.515). As causal explorations are also interpretive, they do not attempt to depict actual processes closely (Sayer, 2010, p.90). Rather, through a grounded theory approach, processes can be conceptually general as causes are evident across cases for they all share the same core category and categorical patterns. Conceptual cues from critical realism guide the researcher to reflect holistically during causal analysis, triggering greater insights into the core category; broadly, the behavior of design thinking in complex environments.

Once a category has been compared across cases and is established as a core category, critical realist analysis deconstructs the category and investigates causal mechanisms that affect that category of investigation. This process is guided by the method of retroduction. This method guides deep, stratified analysis of causal mechanisms that underlie the core category and that operate on all levels of reality: the empirical, events and unobservable mechanisms.

Retroduction is a form of abductive reasoning. Retroduction is a logical process towards discovering answers to insights obtained from data during analysis. It allows logical movement beyond the surface phenomenon using abductive inference to identify underlying structures from empirical data (Bergene, 2007, p.15). The depth and complexity of analysis into underlying mechanisms of the phenomena under study is subject to theoretical insights that emerge during data collection and analysis. On a superficial level, critical realism offers conceptual frameworks to trigger data analysis in new theoretical directions that may not be directly observed empirically.

The critical realist framework allows the researcher to adopt a more thorough and holistic analysis of case study phenomena, particularly for the analysis of complex environments and systems. The critical realist method of analysis used in this phase is not detached from grounded theory methodology, as it echoes the Strausserian approach for knowledge generation. The Strausserian grounded theory approach dictates that a core category be analysed for causation (Dey, 2007, p.178). This process is a rigorous causal analysis of the core category in relation to both the context of the case and across cases. The result aims for a holistic, yet grounded theory, that addresses the complexity of design thinking in new and complex environments. This process of analysis works within the methodology of grounded theory and is one of the reasons why grounded theory is the favored methodology for critical realist research. Grounded theory methodology is prescribed when the formulation of new empirical knowledge is required in under-theorised topics such as design thinking. Thus, it provides an appropriate methodology not just within a critical realist ontology and epistemology but for explorative studies such as the research objective of this thesis.

3.5.4 Criteria

Research designed to investigate the question*, What is the behaviour of design thinking in complex environments?* follows an iterative and exploratory process. Using critical realist grounded theory as a methodology allows the researcher to explore causal themes and evolve research directions as data unfolds. Analysing multidisciplinary design practice in complex environments calls for a critical and intensive case study analysis, for critical realism favours intensive research designs (Bergene, 2007, p.16). Intensive case study research is designed under an explanatory umbrella. For emerging fields such as design thinking, explanatory research is an appropriate framework for multiple case study analysis:

> An explanatory research project can be conducted in a new field, if the study is well defined, and focused on selected aspects of a phenomenon etc. Such project(s) can be complemented by other projects that further expand knowledge on the subject; deepen the complexity of our understanding and the dynamics involved, and add to knowledge creation (Jeppsen, 2005, p.2).

As such, a strict plan was not developed for case collection and analysis, but instead, a framework has been created to guide case exploration and data analysis. This framework includes structures for analysis and the development of criteria to guide case study selection for the research design.

Cases selected for the research design fulfill broad categories of criteria to ensure appropriate data has been collected to investigate the research question. Criteria has been constructed for defining and establishing boundaries (the quintain) on the research design whilst remaining general to ensure diversity of contexts. This provides the research design with focus yet freedom to explore diverse contexts of applied design thinking in complex environments. The criteria for case study selection has been devised as follows:

Process and Approach: Design Thinking
Context: complex environments (classified as 'Third' and 'fourth order' design practice) and situated in the second and fourth quadrant in the Flach (2011) [Fig.6] model of complexity in problem spaces.
Outcome and direction: a focus on systems and intangible designs (the process is not product-centric)

Process and Approach

The methodology of the project process must reflect a designerly approach. The characteristics that define design thinking have been critically atomized throughout the literature review. In each case study selected, the project must be holistically directed by and through a design process and/or methodology.

Context

Cases collected for research have been chosen from the context of complex environments. A complex environment has been classified as projects that involve multiple stakeholders throughout the process, whose outcome affects a large number of individuals (both internal and external to the project/client) and where results never resolve but can only satisfy current conditions (Simon, 1996, p.27). A complex (wicked) environment is constantly evolving; it is an open system that can change from individual agents operating within the system and whose system can change the operation of agents within it (Baehr, 1990, p.768). As such, results and solutions are never final and reflect an ongoing process between agency and structure. Designed solutions can only 'satisfy' current conditions, whilst remaining open and flexible to future iteration and evolution.

Returning to the typology of the design thinking, complexity differs at each level of design practice (Fig 5.) As portrayed in the literature review, the diagram shows many variables that operate within different stratified layers of design thinking practice. Design thinking for complex environments is reflected in the upper levels of design thinking (3^{rd} and 4^{th} orders) and are found in the context of medium to large enterprises, local, state or federal government, or deal with uncontrollable externalities such as environmental and social innovation and systems. Furthermore, a complex environment has also been defined using Flach's (2011) [Fig.6] model of complexity; projects that have high interdependence and/or high dimensionality are considered complex. In defining design thinking in this way, the research design is able to set clear criteria for case study selection.

Outcome

Cases collected for analysis focus on project problems that exist on a 'high level' of design complexity, where tangible (product orientated) solutions are not the sole focus of formative design developments. This means that whilst a product can be a part of a larger solution (such as a service) it is not the emphasis behind the initial project design. Cases are socially orientated and conceptual solutions such as services, strategies, policies, plans and initiatives, events or collaborative ideas may be designed for an actionable outcome. Intangible ideas may be manifested through material methods but the process revolves around an ongoing purpose or intent than a finite product. These results often reflect wicked environments that require adaptable and evolving solutions and signify a higher and more conceptual level of design thinking.

3.6 Research design

Investigation into the research question, *What is the behaviour of design thinking in complex environments*? requires a multiple case study research design. The aim is to conduct exploratory investigations on complex design innovation; to provide empirical evidence for if, how and why design thinking is a useful and valuable platform for complex environments and its problems.

Three project case studies have been selected that fulfill criteria for the research design. Criteria consists of three categories: the application of a designerly process and approach, in complex environments involving multiple interdependence and dimensionality (Flach, 2011) (3rd and 4th order design practice) and driven by intangible concepts and not product-centered outcomes. Case studies that adhere to this criteria will provide rich data on whether the designerly approach is a valuable platform for design innovation dealing with wicked problems in complex environments.

The research plan designed for this thesis utilises multiple case studies. Stake (2005) offers advice on selecting cases that are adequate for the research design:

> As a general rule, there are three main criteria for
> selecting cases:
> 1. Is the case relevant to the quintain?
> 2. Do the cases provide diversity across contexts?
> 3. Do the cases provide good opportunities to learn about complexity and contexts? (p. 23)

The questions outlined by Stake are appropriate for the research direction and question in this dissertation, as complex environments is a primary focus of investigation. Answering the questions proposed by Stake aid the design of research.

3.6.1 Is the case relevant to the quintain?

The quintain (conceptual research boundary) is directed by the research question but also refined through the construction of criteria for case study selection. Case studies in the research design have been chosen for fulfilling a criterion for analysis, explained in *3.5.4 Criteria*.

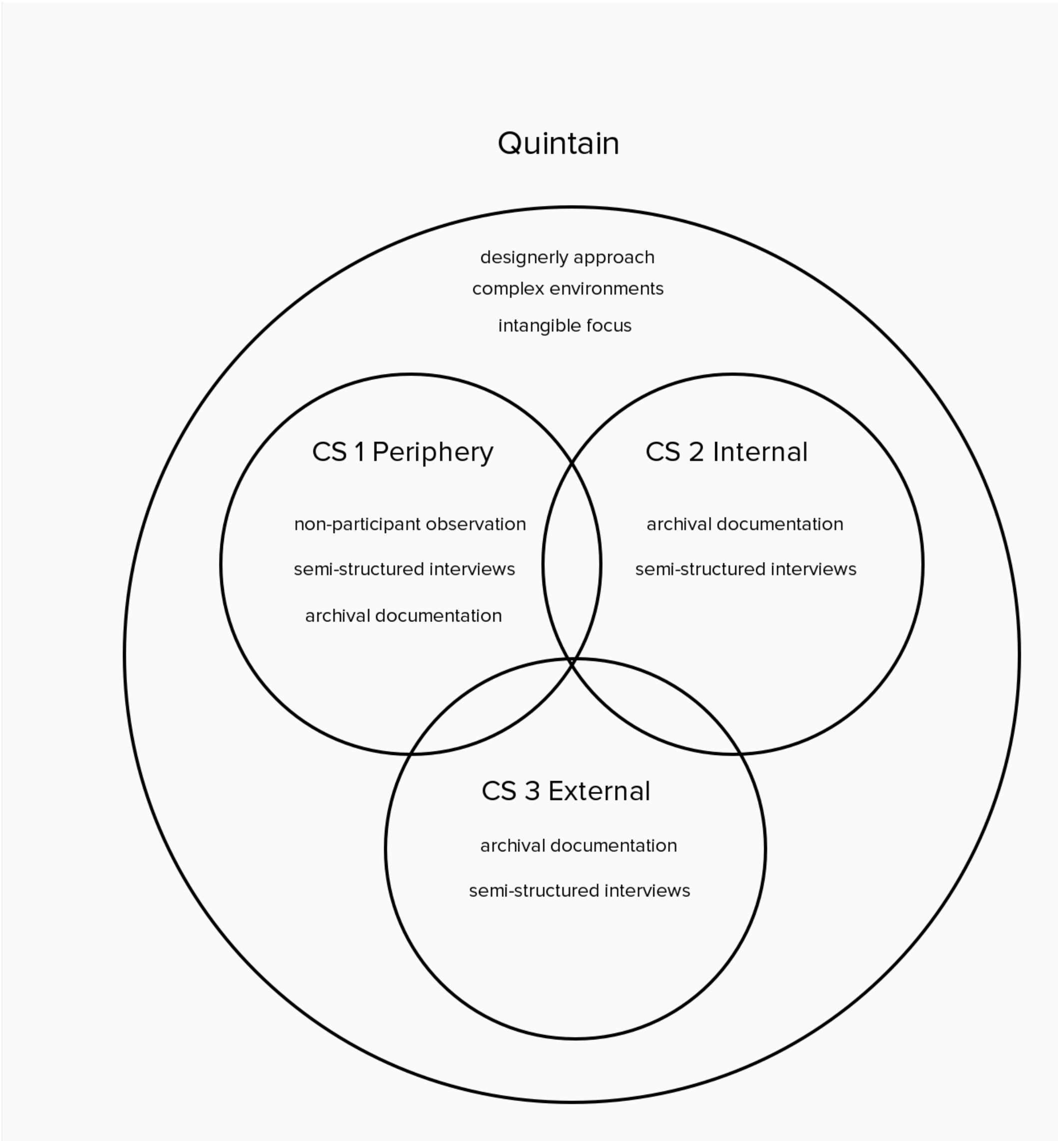

Fig.10 Research Design quintain

3.6.2 Do the cases provide diversity across contexts?

The case studies in this thesis each satisfy the selection criteria outlined above. However, an additional layer of consideration has been taken into account when deciding between possible cases; to ensure that each case portrays varying positions of design activity relative to the organizational system, inspired by Sabine Junginer's (2009) analysis.

The research design has deliberately considered three professional contexts that fulfill the case study criteria whilst offering project diversity. One case study from service, public policy and social innovation, all provide fundamentally diverse project environments yet depict complex, third and fourth order design thinking. Furthermore, each case study offers diverse positions of design thinking activity relative to the project context following Junginger's (2009) theory on the position of design thinking relative to an organizational system. These positions include: design thinking situated on the periphery to an institutional organizational system, design situated internal to an organizational system and design situated in an external, open and unstructured system.

3.6.3 Do the cases provide good opportunities to learn about complex contexts?

Each case represents major design practices currently tackling problems in complex environments. Service, policy and social innovation are three fields that have major impact in the way we shape and transform complex systems. In addition, each case study has been selected based on complexity in relation to size; projects that include or affect a large number of individuals. The inherent complexity in practice, coupled with different disciplinary contexts driven by design thinking, are what makes the research design a satisfactory framework for investigating the research question.

3.6.4 Conclusion

In order to investigate the question, *What is the behavior of design thinking in complex environments?* critical realist grounded theory has been chosen as the most effective research framework and perspective. Critical realism affords the opportunity to analyse causal mechanisms to provide a deeper analysis of the research question beyond descriptions of data conventionally tackled to date. Furthermore, critical realist grounded theory enables data analysis to frame new theory generation on the subject.

4.

Case Study 1

A service design agency was selected as the first case study for this dissertation. Based in Australia, the agency addresses client briefs with a design thinking mindset, collaboratively resolving problems with the aim of co-creating solutions. Established in 2000, the agency's priority has remained unchanged; to conduct meaningful work that has a positive effect on society. As such, the agency has a pro-bono program to give back to the community, applying service and design thinking for social and sustainable solutions.

The case available from this agency presented itself as an opportunity to conduct in depth observation on a complex project with a large media communications client. Using Junginger's (2009) guide on the position of design thinking, this case was selected as it represents design as a resource external to an institutionalized organizational system. The study allowed for intensive and thorough data collection with the opportunity to document a project holistically from brief through to implementation. The flexibility of the design agency allowed for regular and consistent visits for data collection. Research on this case consisted of 14 days of non-participant observations over a three-month period. Observational visits to the agency were recorded using audio equipment, resulting in a total of approximately 32 hours of recorded data observation. Observational research conducted at this agency provided the research design with a thorough foundation for initiating data analysis that would later be supported through follow up interviews.

4.1 Data collection

Observational research commenced in September 2011 and ceased in early December of the same year. The focus of this case study was to observe and collect empirical evidence on the process and behaviour of design thinking applied as a peripheral resource to resolve a problem situated in an organised complex system. Direct, non-participant observation was chosen as the primary method for data collection for this case. This allows the researcher to reflect with objectivity on the process; on the position of each designer and the relationships between team members. Non-participant observation ensures that the researcher's reflective bias is minimised as the researcher has no personal involvement or motive in the project (Bernard, 2006, p.342). Data was documented using recordings and field notes captured on a Livescribe Echo pen and booklet. Images of design methods were captured using a mobile (iPhone) camera. No additional data was collected other than through the mediums described. Audio was recorded simultaneously with written field notes.

This case study acted as an instrumental investigation on design thinking in complex project environments. In conjunction with direct observational data collection, semi-structured interviews were performed during initial rounds of analysis, including a follow up interview with a project lead to triangulate insights and strengthen the validity of analysis and accounts of evidence collected. The comparative method was used to construct robust validations on hypotheses proposed from initial interpretations from evidence (Eisenhardt, 1989, p.545) as outlined in detail in the previous chapter, 3. *Research Framework*.

4.1.1 Analysis

Preliminary data analysis began with creating memos of ideas and impressions on conversations as data was transcribed. This 'first round' analysis captured initial impressions from the data in line with the grounded theory method, outlined in 3.5, *Research Design*. Codes were later assigned to the memos documented and the audio transcribed [See Appendix A]. Rounds of iterative coding continued until a level of saturation was achieved. Codes were then grouped under themes in preparation for cross-case comparative analysis [See Appendix C]. Saturation was established when iterative analysis of the data did not yield new coding insights. 384 codes were created on the project case. The codes and their references were exported in preparation for contextual mapping using the affinity diagramming technique. Using an online mapping software, Mural.ly, the codes were mapped according to relationship and context between each code's reference and meaning [Appendix C]. This contextual mapping phase, coupled with memos noted during rounds of coding analysis, provided the foundation for emerging theoretical themes and relationships described in this chapter.

Consistent with the boundary of the literature presented in the literature review, references presented within these findings are selected from design literature and have been chosen for their impact, discussion or relationship to design thinking theory. The purpose of the references presented within the findings is to contextualize the findings discussed on design thinking in this case study. The references are used as a point of contrast and triangulation.

4.1.2 Project Background

In August 2011, the design agency was commissioned by a large telecommunications client to design a solution for a new service to be rolled out in the following year. The project had two components: the client required both a service delivery focusing on customer experience and an internal organisational re-design to support the service solution. Thus, the project was split in two; with one design team working on customer research specific to the product-service, and another team working on developing the internal organisational capability to ensure the new service would be a success. The project and teams are henceforth referred to as phases, with phase 1 depicting research and design for the service delivery and phase 2 following work established by the team in phase 1 in developing organizational capability.

4.1.2 Phase 1

The project began with investigating the nature of the service to be designed. The design agency assigned four primary investigators for this task, including a design intern to assist. Central to the case was the issue of designing around the unknown. The project assigned by the client involved developing a product-service Australia-wide that did not currently exist. In essence, the product on offer to the public by the client was brand new - in that no other product or service of this kind had been established in Australia. This added an additional level of uncertainty for both the client and designers; the designers found little relatable information and the client could not clearly describe in full detail the nature of the brief or the product-service offering:

> Central to this case was design for the unknown, which you describe then as a brand new service offering which it is and was. It's very true, that particular thing [the service], but that happens in every single thing we do. The fuzzy front end, the fuzzyness piece is always around not knowing what the problem is. That's why the emerging piece in the beginning, the exploration piece, is vital. But yes because this was a brand new service offering there was nothing to start off, there was no baseline. (Interview, Phase 2 Designer, 2014).

The design team explored secondary research on existing services and products from competitors that seemed similar, whilst reviewing user-research reports previously conducted by the client. During this preliminary phase, the designers collected documents and reports about the new product-service from the client to help clarify what they needed to design. The design team spent roughly 2 weeks on secondary research. Following this initial research phase, the design team chose to conduct their own foundational user research to help clarify what service scenarios they will need to design for. The designers contracted a future forecasting agency to develop workshops with users on future states related to product and technology from the client. The design team collaborated with a team from the future forecasting agency and volunteered 'users' to co-create ideal future states around the product-service. These workshops ran over a three-week period.

The purpose of conducting future forecasting workshops with users was for the designers to propose hypothetical scenarios as a result of this new product-service introduced by the client. Using hypothetical scenarios, the design team collected information on preferred states from users. These workshops helped the design team contextualise what future states they may be dealing with, and what scenarios are preferred by the general public. Once the workshops had concluded, the design team wrote their insights on post it notes and began rounds of analysis, sensemaking and synthesis. This knowledge provided a foundation for the design team to formulate a preferred state (service scenario) from which to conduct user journey research.

The next step involved the design team developing tentative hypothetical service journeys around the product-service to prototype on users. User testing ran "over 2-3 days with 25 sessions in total" (Interview, Phase 2 Designer, 2014). The testing took place at the client's user research facility, and was based on a role-playing method. The design team consciously decided to have 'breather days' in between the days of user testing, in order to reflect on the findings gathered thus far and iterate ideas. Iteration focused on refining details, fixing common misunderstandings and adding or subtracting steps in the user journey scenario.

At the end of user testing, the design team initiated a phase of synthesis. The insights gained from user testing were loosely structured beneath a rough user journey outline that was developed and refined as user scenarios were refined. From this point on, the group focused on sensemaking, interpreting insights and refining the ideal customer journey for this new product-service.

The outcome of this process resulted in an ideal customer journey and service delivery for the client's product-service. The knowledge and findings generated by the design team was detailed in a report format. Two documents were submitted to the client; one that contained significant insights from their user research and another that described in depth the service journey and steps required to make the journey a success. The recommendations in this document and the findings from this research phase were then passed on to another design team who then focused on developing the organisational capability for this ideal service delivery.

4.1.3 Phase 2

Nearing the completion of phase 1, the design agency assigned a second group of designers to work on the organisational capability for this product-service. This team consisted of four designers; three new designers and one designer from the previous team in phase 1. The three new designers became the primary investigators and were briefed on the work conducted by the previous design team. The fourth team member, involved in both phase 1 and 2, was the design intern. His role was to again assist with props and tasks. Phase 2 commenced in September 2011 and ran through to November 2011 when the entire project was completed:

> Theirs [phase 1 team] was very specific because they did all this research about finding out what it could be before hand. They had scripts and they had [...] prototypes of pages and mobile app pages and stuff like that almost to the point they would call it UX design. That was the intention- of finding out how the experience would play out from a physical standpoint, and you describe it as customer journey but it's a customer journey in action. Whereas the purpose of the enactments we [phase 2 team] ran was to illustrate to the stakeholders "is

> this is the ideal experience that customers want to have? How are you set up to deliver this? How are you going to work together to make sure this is going to happen" (Interview, Phase 2 Designer, 2014).

Focusing on organisational capability, phase 2 of the project was much more complex and holistic. Central to this phase was brainstorming, which took up much of the design process. The design team began by looking at the ideal customer journey from phase 1 and figuring out what organisational departments were critical to the success of the journey. This phase was much more client inclusive, as the design team relied heavily on information about what client departments did, what departments would be affected by the journey and how departments currently communicate with each other.

Time constraint was a central issue in this phase and to the project as a whole. The design team in phase 2 were limited in depth, scope and complexity as they did not have enough time to holistically investigate the organisational ecosystem in detail "the timing it was really tight, and one of the tightest projects we ever had to date at that point" (Interview, Phase 2 Designer, 2014). Due to this time constraint, the client chose only two main service features out of the report submitted in phase 1 to be implemented. The design team in this phase had just four weeks to design an organizational strategy that focused on the selected two areas of the service delivery.

In contrast to phase 1, primary user research was not conducted but instead, user personas were created from the research collected in phase 1. These personas guided the design team through the creation of an ideal service journey that would later become the basis of an enactment workshop. The personas were used as a vehicle to portray the ideal user journey service scenario researched in phase 1. An enactment was chosen as the primary method of delivering the ideal service journey. The emphasis on the enactment workshop was to empower the client towards co-creating organizational capability:

> It was never meant to be a very detailed piece of work. It was supposed to remain at high level and kind of just give people an insight into what a customer experience is and what it could be, and so now that you know what that is you have the expertise to talk amongst yourselves to work it out
> (Interview, Phase 2 Designer, 2014).

The design team in this phase chose to create a workshop in order to trigger and transform the client's mode of thinking to embed a design perspective in the organisation's culture. Four main departments were chosen to participate in the enactment workshop, which ran over one full day in November, 2011.

This overview of the design process is to provide contextual details on this case study. This description is intended to emphasize transparency of findings and analysis. A detailed account of the case study processes and events allows for a more transparent and objective reading of the findings presented.

4.2 Findings

Analysis of empirical observations presented in this instrumental case study has revealed insights about the nature of design thinking in complex environments. The analysis focuses on the emergent patterns, impact and behavior of a designerly approach operating as a pheripheral resource to the project organization and ecosystem (Junginger, 2009).

4.2.1 Navigating uncertainty and the unknown

Uncertainty and ambiguity were dominant drivers behind process development in this case. Feelings of uncertainty recurred in both project phases and throughout the project process. The nature of the design problem described in 4.1.2 *Phase 1*, portrays a highly ambiguous brief. As such, the complexity and uncertainty embedded in the project was significant. Comments by the designers encapsulate this issue:

> It's really hard for us to nail it because they [the client] haven't decided it [the problem] themselves so its you know we can design something but when they change the whole thing…
> (Observation, Phase 1, 2011)

> A lot of stuff we came to [the client] with the questions they didn't know the answers yet because they are still figuring it out themselves
> (Observation, Phase 1, 2011)

Both design teams had to navigate their way through complex and ambiguous terrain, working towards an outcome for a brief that is subject to change. A key indicator of the sense of uncertainty experienced throughout the project was observed in the language used between designers during sensemaking, synthesis and brainstorming sessions. The language expressed amongst the design team was often undeveloped and rarely definitive. Repetitive comments such as "might be this" and "I don't know" reflected the uncertainty both design teams felt throughout the process of the project:

> Yeah and all those that might not be that, I don't know…
> (Observation, Phase 1, 2011)

> I don't know, I think that this is how it is working?
> (Observation, Phase 2, 2011)

The development of a design outcome in response to an unknown and ill-determined future state amplified modes of thinking such as: envisioning, anticipation, abduction and holistic reasoning. The uncertainty and complex ambiguity of the project problem led both teams to envisage ideal future scenarios. Attempts to frame a problem solution early in the process could not adequately account for all of the necessary number of variables that would impact the project. Envisioning future states was observed as a fundamental driver in the development of insights and ideas in this case study.

Envisioning future states in this case study had two primary functions; to predict the ideal service delivery from user research and provide a way of navigating and taming the complex ambiguity presented in the brief. To develop this vision, co-creation with users, user workshops, background research and intuition became invaluable drivers.
Thus, an intuitive and qualitative approach dominated research for development of preferred future states:

> We refer to it as an experience vision. It wasn't to the detail of physical customer journey steps, it's like the high-level strategic vision for how people would engage with the service.
> (Interview, Phase 2 Designer, 2014)

Enabling a vision for a future state required the design team to release control and constraint over the complex environment that they were dealing with. The uncertainty in the brief enabled the design teams to relinquish control whilst envisaging ideal states and holistic frameworks; keeping the project open and adaptable. This holistic perspective served to restrict both design teams from converging on ideas early on in the process, allowing the designers to work organically and evolve with emerging insights. Surrendering to the unknown amidst uncertainty was an attitude both design teams expressed. Designers working in the first phase of the project reflected on the open and adaptive process that they took:

> 9 out of 10 people all said something. So towards the end [of the user enactments] we had emails that were obvious were not needed, so cutting it out. So it's kind of like…an iterative and evolving kind of thing
> (Observation, Phase 1, 2011)

The uncertainty of the design brief created an attitude towards managing the process that focused on forfeiting control. Resigning control also affected discussions around the outcome of the project. Attitudes over the outcome are expressed in an open, adaptive and also indefinite way:

> If they [emerging insights] kind of align they will be aligned. We don't know yet
> (Observation, Phase 1, 2011)

> I'll design it maybe this way or this way depending…
> (Observation, Phase 1, 2011)

The complex ambiguity of the brief created an adaptive attitude towards the design problem that increased detachment to early ideas in the design process. Restraint played a significant factor in the designers' management of the complex, rapidly evolving and uncertain project brief. In reaction to this uncertainty, both teams envisioned future scenarios that facilitated the establishment of a vision framework.

4.2.2 Vision Framing

The development of an overarching intent was observed in this case. Intent centered on an ideal state preferred by the customer. Thus, the overarching vision and goal for the project did not emerge until preliminary user research was conducted. To maintain a holistic approach, the team focused on core 'higher level' insights from user research to create an overarching vision which later became a framework that guided project development. The vision frame was not a solution and did not aim to address an identified problem, but instead, identify an ideal goal. It is focused on achieving an *experience* over a tangible outcome. Driven by empathy, a vision is not necessarily an definitive objective, but the intent towards creating an ideal emotive experience:

> So the ideal customer journey is like the backbone of what we are creating and then we are providing kind of information around that.
> (Observation, Phase 1, 2011)

This vision framing process appears to be a symptomatic reaction towards grasping uncertainty. Problem framing too early in the design process may narrow perspectives. It was observed that a vision frame enabled the designers to work towards a goal, whilst alleviating themselves from infinite variables hidden in the complexity of identifying problems in order to reach an end solution.

Observed in this case, complex scenarios change the way design teams process and frame information. An overarching vision framework facilitated an open and adaptive response to dealing with the uncertain and complex scenarios in this case, which in turn, enabled a more organic design process. However, vision framing in this case presented a limitation; a holistic "vision" framework established in the formative stages of the design process answered to the goals and intent behind the project, but provided little direction towards practical solutions. As a result of this, it was observed in both phases that the design teams explored solutions much later in the process.

Both design teams expressed that the ambiguous brief was problematic. This did not imply that this was a problem that the teams needed to resolve and reframe in order to complete the brief. In the formative stages of the project, the design team did not refer to an established issue to be realized as a problem for re-framing, but rather, stepped beyond problematic details to conceptualise and focus design development on an ideal, overarching future state. The vision was not created in direct response to a problem identified in context of the solution, but rather, the problem of designing in a broad and ambiguous environment.

> So even though they [the client] came to us with the landscape strategy and work out the best way to provide services within this changing landscape, we still want to connect with why are we going to be working together in the first place and to achieve what higher outcome?
> (Interview, Design Manager, 2014)

The observation of framing in this case conflicts with practice commonly observed by design researchers. Commenting on research conducted in his 1997 thesis, Kees Dorst (2007) explains "empirical studies have shown that designers spend quite some time at the beginning of a design assignment to consider what kind of problem they had to deal with" (p.6). The empirical studies conducted by Dorst focused on observational research on industrial design engineering practice. The nature of the research task presented in Dorst's thesis concerned designers creating an artifact in response to a prescribed design brief (the development of a new litter system). The problem to be re-framed was identifiable and tangible (an artifact). Compared with the application of design thinking in this case study (a complex service delivery) it can be argued that the nature of both problem and framing departs from conventional practice. Thus, it is observed in this case study that design framing in higher orders of intangibly-focused complex practice may favor a vision framework prior to problem and solution identification.

4.2.3 The fuzzy end-to-end

Conventionally, uncertainty in the design process is associated with formative stages of project development. Dubbed, the "fuzzy front end", this phase is often depicted as ambiguous, uncertain and an interaction between the strategic problem and solution space (Blyth & Kimbell, 2011, p.12; Drews, 2009, p.41; Le Masson et al., 2011, p.219; Löwgre & Stolterman, 1999, p.17; Porcini, 2009; Ranjan, 2012, p.31; Smulders & Subrahmanian, 2013, p.362; Young, 2010, p.15). Compared with literature available on the design process and design thinking, few authors make reference to the fuzzy front end. The dance between framing problems and formulating solutions as a result of uncertain future states and project objectives was observed to exist throughout the design process, and in this case, was not isolated to the front end. Both design teams experienced uncertainty over the outcome of the project. This uncertainty occurred in both phases and persisted through to the final stages of project development. The uncertainty observed over both the design problem and solution throughout project development in this case indicated that the fuzzy front end was not isolated to the 'front' end of the design process. This observation portrays the fuzzy front end as a consistent feedback loop; where the design process unfolds through many fuzzy iterations. In a complex project which requires a high degree of assumptions over future states, such as this case, the fuzzy front end is observed as a fuzzy end-to-end process:

> That is kind of the hardest part of our project. We don't know
> what the end result will be
> (Observation, Phase 1, 2011)

> It's actually one thing I was thinking about, especially in the beginning.
> There were a lot of questions- we didn't know and how it was going to work
> (Observation, Phase 1, 2011)

> I don't know…I think that this is how it is working. And then the other service
> elements will expand on these other ones…I don't know?
> (Observation, Phase 2, 2011)

The uncertainty observed over the outcome and the problem-solution space throughout the project case provided evidence for a fuzzy end-to-end process. The nature of such an ambiguous and complex brief forced the design team to focus on and remain in a divergent and holistic mindset. The practicality of remaining in a divergent space allowed the team to adapt and evolve solutions rapidly as detailed user insights emerged. A change in focus and perspective on the design solution (often due to problem-framing informed by user insights) would then restart the 'fuzzy' phase as the designers re-iterated on the outcome.

As a way of managing complex and uncertain future states, anticipation over complexity was also observed. Anticipation became another coping mechanism for both design teams when faced with complex and ambiguous information. Assuming and anticipating future states is defined in this analysis as performing different cognitive processing functions to vision framing. In contrast to vision framing, which focuses on positive and ideal future scenarios, anticipating future states was observed as a thought-method to mentally prepare the team for practical and feasible solutions. These scenarios may be positive or negative:

> The knowledge is like this at the moment and we are trying to structure it a bit more because we know we have three deliverables and they are kind of like this, but they could be more like this, and we don't know the complexity yet as well (Observation, Phase 1, 2011)

> They don't have it [the solution] yet, but it's a tool that they [the client] would make to help them [the customer] determine and recommend the ideals (Observation, Phase 2, 2011)

In contrast to the fuzzy front end, with its focus on problem and solution framing, anticipating future states did not seek to identify a single problem to resolve, but rather, a variety of potential states that may affect the vision framework. This thought-method was used as an aid in designing around unknowns in the complex and ambiguous brief. Thus, this abductive form of reasoning was also used to substitute for gaps in knowledge and concrete information; a hurdle in both phases of project development. This phenomenon may indicate that methods used to facilitate design thinking may not always be tangible. Rather than tangible methods, thought experiments may be just as practical for managing and designing around complex problems.

4.2.4 Design feeling not thinking

Emerging from complex uncertainty was an increase in intuition. Both design teams 'felt' their way through unknown and conflicting terrain. Knowledge gaps and unknown future states proved to increase the level of intuitive language in both design teams, influencing the designers to abductively "guesstimate" future scenarios and ideal user outcomes. Envisioning preferred future states manifested through the process of abductive reasoning, and requires hypothetical thinking and imagination to create scenarios that are both ideal and realistic. An increase in abductive reasoning is observed in this context, as designers guesstimate, hypothesize and anticipate the future state of the project brief:

> It is kind of conflicting- how it was going to really work.
> That's why we eventually had to go with what is our idea of the ideal
> (Observation, Phase 1, 2011)

Abductive reasoning is central to design practice (Brown, 2009; Fraser, 2009; Lockwood, 2009; Martin, 2009, p.65). Abductive reasoning is defined as a logical process that utilizes a hypothesis in place of observable data. As John Kolko (2010) writes, abduction is "the hypothesis that makes the most sense given observed phenomenon or data and based on prior experience. Abduction is a logical way of considering inference or 'best guess' leaps" (p. 20). Abductive reasoning proved to be a major force behind the navigation around complex and ambiguous project briefs such as this case. Rationalization through anecdotal experiences was observed as secondary to the reliance on intuition and abductive reasoning. Where there was a crossroad between relying on user feedback or intuition to fill in for gaps in knowledge, the design teams often chose to trust their own ideas and instincts. Designers 'filled in' for missing information using intuition and gut instinct:

> [It was from] our personal insight, but also from talking to [the client].
> You know there were people there [at the client] that had mapped out things
> as well. So some of it was from talking to them, some of it was from our instinct
> (Observation, Phase 1, 2011)

> I think that might happen as a result, because you probably say, you know, go to this link or... (Observation, Phase 2, 2011)

The uncertainty and complexity of the project brief amplified design intuition. Another key indicator of intuition observed in both design teams was the use of sensory language. Phrases such as "I feel" dominated discussions, showing that instinctive reactions to uncertainty dominated the design process:

> I feel like it needs to be like that
> (Observation, Phase 2, 2011)

> I feel like the theme that is popping out here is this
> (Observation, Phase 2, 2011)

The complex, ambiguous project brief significantly influenced the attitude, mindset and approach that both design teams took towards the design process. Intuitive and abductive reasoning was observed as a fundamental driver for both design teams when faced with complex and ambiguous environments.

4.2.5 Balancing opposing states

Balancing opposing states emerged as a dominant pattern in both phases of the project and throughout the design process. It was observed that designers in this case study operated on a cognitive continuum that fluctuated between often conflicting cognitive extremes.

This tension was observed predominantly as an internal state that manifested through five main areas: balancing holistic and detailed perspectives, balancing initial insights and emerging information, balancing between broad knowledge and sharp focus, balancing intuition and needs and balancing between clarity and complexity. Balancing opposing states also includes divergent or convergent thinking.

Convergent and divergent thinking was most evident during phases of synthesis. Concurrent with the design thinking literature, this polarity assisted in the development of refining the problem solution space (Brown, 2008, p.68; Pauwels et al., 2013, p.45) as insights emerged. Most importantly, convergent and divergent thinking assisted in the development of high-level insights that overarched and enabled direction towards the overall project focus:

> We should look at the big ideas first before getting sucked into the details because we might miss something, if you go into the details too quickly
> (Observation, Phase 1, 2011)

The tension between diving into detailed analysis and preserving a holistic perspective portrayed a fine tightrope that both design teams had to balance. The ambiguity and complexity of the project brief amplified this tension; pushing for a need to rapidly converge and diverge thought throughout all developmental phases in order to grapple with the uncertainty and variable information that persisted in this context:

> I guess that we started off quite high level and then kind of went in deep
> but not consistently. I think it's just, the level of deepness is more like this,
> …sometimes something needs to be well developed
> (Observation, Phase 1, 2011)

The tension between detailed and holistic thinking affected the unfolding design process. The fluctuation between open and adaptive iteration (holistic thinking) and focus for implementation (problem framing) added evidence to the persistence of 'fuzzy' end-to-end phases.

Another detail observed was the balance between the amount of knowledge required on the complex task at hand and the ability to move forward and focus on an emerging theme. This directly affected the decision making process during design development. Deciding how much information is needed in order to move forward with an insight forced the team to critically analyse how much holistic and detailed user data they required in order to move forward:

> And yesterday we went our separate ways and thought "Ok. What is the level of detail we can go into and how much knowledge do we have"
> (Observation, Phase 1, 2011)

> Sometimes we might have one or two little “oh that’s a good idea” but it’s kind of, wait until it comes to a theme. Don’t just focus on one person. We had 5 different [user] profiles so you want to really make sure what you’re changing is what most people are saying and not just one [person]
> (Observation, Phase 1, 2011)

Balance between conflicting states was also observed to exist in project management. Deciding whether to structure a plan for user research and development, or release control and allow for a more organic and adaptable process, proved to be a source of confliction for both design teams. However, ultimately, both teams preferred organic and adaptable processes:

> See you can try and bring it down and use it according to systems, but in the end it just came out- we had to just play it as the customer did as well
> (Observation, Phase 1, 2011)

During synthesis, balancing also occurred between clarity and complexity. Both design teams grappled with presenting and clarifying the inherent complexity in the problem whilst not over simplifying or complicating the project:

> This is part of what I’m asking. if you are looking at that [the diagram] without knowing, would you understand that? Or is it making it more complicated?
> (Observation, Phase 2, 2011)

Similarly, the design team were constantly fighting to balance customer and organisational needs. During customer research, the design team faced the task of balancing insights between what the customer says versus what the customer does:

> Before the enactment, after the first workshops, the idea of the customer journey that was built, we were like “of course this idea! Why don’t we test it?” and then it changed. It’s the same thing in the customer workshops, they say something they think they’d do but they don’t actually do in the workshops
> (Observation, Phase 1, 2011)

Concurrent with this issue was the task of balancing client desires versus what the design team intuitively felt should be done. Tossing between the ideal and preferred state flung designers across realms of idealism and feasibility:

> We wanted to get into the ideal, where we are like "what's the ideal?" but not of falling into the trap of "but we can't do this. This isn't good"- the realities and stuff (Observation, Phase 1, 2011)

The uncertainty around the brief over how the client's product service will unfold added to the amplification of design intuition. When at a crossroad between ideal and real states, the designers most often chose to be directed by their gut feeling. Design intuition appeared to be amplified in complex environments such as this project case. Intuition proved to be a fundamental driver and tool, not just for direction in complex ambiguity, but as a facilitator for managing conflicting information.

This predisposition for balancing two extremes allowed the designers to maintain their open, adaptive and iterative process whilst keeping a sense of detail and direction when required. The process and habit of operating on a pendulum between opposing states kept the project and process adaptive. This flux restricts the process and thinking from getting 'caught' on one extreme, and thus a linear perspective.

4.2.6 Sensemaking and synthesis

Sensemaking and synthesis consumed a significant portion of the design process in this case. Sensemaking and synthesis is defined according to John Kolko's description "Essentially, sensemaking is an internal, personal process, while synthesis can be a collaborative, external process" (Kolko, 2010, p.18).

As sensemaking is an internal process, it is observed as a manifestation through the use of both visual and verbal language. Echoing Kolko's descriptions, synthesis in this thesis depicts the collaboration of sensemade insights; the arrangement of individual findings that are assembled together as a group to create new knowledge and meaning (Kolko 2010, p.13).

Sensemaking dominated project development in phase 1. Sensemaking in phase 1 focused on grappling with the future state of the product service to be implemented, including the future users of this service. Data collection in this phase focused on developing insights from user feedback on a future scenario. Sensemaking was less about trying to resolve a defined problem or testing a problem-solution space, as it was about creating a realistic understanding of ideal future scenarios of the product service system.

Sensemaking efforts centered on a thematic grouping of insights. This method reflects the technique known in academia as the KJ technique (Scupin, 1997), otherwise also known as affinity diagramming. Low fi tools, such as post it notes and butchers paper, was all that was needed to enable rapid thematic sensemaking of information using the affinity diagramming method.

The affinity diagramming method resulted in groups that the designers felt represented 'higher level' themes. This method once again depicts and enables a holistic focus, which in turn, dictates an open and adaptive design process. The thematic grouping of insights during the sensemaking and synthesis phase allowed both design teams to see broader relationships; alleviating themselves from the weight in the details of what users said. The objective with the affinity diagramming method was to find 'higher' relationships from user insights that could apply to both the service journey and the redesign of the organizational system. This sensemaking method facilitated a holistic and systemic perspective; one that is necessary for managing ideal states of the whole product service system.

Hierarchy assisted in the thematic sensemaking of user data. Designers in both phases made reference to 'high level' themes and insights that emerged from user data and which could not fit directly within detailed development of the service system. Specific to phase 1, residual insights left over from affinity diagramming were interpreted by the design team as higher conceptual themes which may apply to the overall project intent:

> So like we kind of found that there were some high-level
> themes of how a lot of our findings are breaking down
> (Observation, Phase 1, 2011)

> When I was writing the insights that I had, and observations, some of them were high level- they were less specific. There were more high-level insights (Observation, Phase 1, 2011)

Synthesis involved a triangulation of data sources; user workshops, enactments, client reports and secondary case study research. Synthesis and sensemaking stages in the design process is often depicted as a phase or step that is equal to other phases in the process. Whilst the order of phases in this study remained in tune with common convention of the design process, it would portray a fairer picture to distinguish the time devoted to different phases in different orders, or cases, of design practice. For design thinking in complex environments such as this case study, sensemaking and synthesis contributed to well over half of the design process timeline.

4.2.7 Visualisation

Visualisation is an integral part of the design process at any scale and order of design practice. Visualisation is defined in this thesis as any method or technique that transfers internal cognitive information into the tangible realm through formats that rely on organic spatial orientation. Transferring knowledge into words in a linear spreadsheet would not be classified as a visualisation technique, but positioning words in fluid spatial context to depict relationships (for example, mind mapping) would classify as an example of visualisation. Thus, fluidity of spatial positioning is regarded as key for identifying examples of visualisation in this dissertation. In addition, visualisation is also acknowledged as an internal action. When in the absence of observable and tangible visual methods, it is coded through descriptive language cues.

A range of visualisation techniques have been exemplified in this case. Each method and manifestation of visualisation has a unique facilitatory role that affects the design process and design thinking. It is observed in this case that visualisation operates as a core facilitator and enabler of emergent phenomena in design practice, and one that has consequential effects throughout project development.

4.2.7.1 Visualisation as facilitator for co-operation and collaboration

Visual methods used in the project case included sketching, prototyping and mapping. Prototyping was employed early on in project development, as a method for obtaining insights for iteration. Prototyping took the form of user journeys and scenarios carried through a role playing approach. The purpose of service journey prototypes was to gain knowledge and insights on user reactions to potential service scenarios. This method of knowledge inspiration and stimulation has been acknowledged in literature (Seidel & Fixson, 2013; Keil, 2014).

Prototyping in this project took on two meanings: for the design team in the first phase it was a method not for testing final designs, but a vehicle for gaining knowledge and inspiration from users on what the final design should look like. For the design team in the second phase, service prototyping was employed as a method of enabling organizational collaboration and focused on how best to transfer knowledge obtained in phase 1 through user scenarios to client teams.

Using role-playing as a medium for prototyping service scenarios invited users and clients to step into the designers' 'imagination space'. Storytelling was used to facilitate imaginative user scenarios and journeys to enhance visualisation of the scenario described via narration. Both design teams had an inclusive attitude towards creative visualisation and utilised visual methods to support the synchronization of perspectives between themselves and the stakeholders. Roleplaying, sketches and user journeys were employed to help sync viewpoints between client, user and designer for the purpose of sharing the vision of intent.

An observed characteristic of the design process was the impact that playful, 'primitive' techniques had on facilitating imagination and collaborative brainstorming. Both design teams harnessed raw, low-fidelity techniques using basic materials such as butchers paper, post-it notes and cardboard mock ups [Fig.11]. These raw materials encouraged unrefined expressions of thought that inspired fluid and uninhibited collaboration and ideation. Messy, raw materials allowed collaborative teams to 'play' and touch on a raw learning experience; interactive experiences that are basic and second to nature:

> I had a little desk and props set up. So sometimes we'd have the customer decide "ok I'm going to go to the store", you actually need to get up and come visit the store, and its like "No, no, you need to get up and be the customer like you've just walked into the store" and when you do that they really get it and are like "ooh ok yeah, yeah" and they see you take it very seriously which helps
> (Observation, Phase 1, 2011)

Fig.11 Example of low-fi materials

Externalizing ideas through prototypes and sketches has impact beyond just flushing out ideas for rapid ideation (Brown, 2009, p.87; Gero et al, 2001, p.274; Liedtka, 2011, p.17). In collaborative visual activity, as with sketching, low-fi prototypes enable playful emotive reactions within the team, sparking excitement, interaction and playful imagination. Playfulness through design has been investigated by Vaajakallio and Mattelmäki, via a discussion on design games. These authors argue that a "play framework" exists through design games such as role playing and aim to elicit empathetic understanding, collaboration and idea generation (Vaajakallio & Mattelmäki, 2014).

On the subject of role-playing, Tim Brown (2009) provides a brief justification, stating "Research suggests that this form of play is not only fun but also helps establish internal scripts by which we navigate as adults" (p. 96). This argument is supported by Tvesky (2010, p.500) who suggests that visual communication extends to prehistory; preceding written language and one of the earliest signs of culture:

> There is a stage and we're creating the sets for it [the service enactment]. The sets are actually just going to kind of be all set up so you know, there's the outside, the garden. So there's actually movement and there is the real physical journey on the stage and they can actually see that
> (Observation, Phase 2, 2011).

The raw characteristic of the visual tools used in collaborative activity break down internal barriers for ideation. A primitive approach to visualisation— using rough sketches, low fi materials and unrefined tools— breaks down expectation and pressure to provide 'good' ideas or refined solutions. As a result of utilising raw, amateur methods, collaborative visual activity in this case became more playful, open and non-judgmental. Additionally, for the design team in phase 1, low fi prototypes provided a playful environment for user role-playing. The playfulness of role playing, coupled with the raw, low fi material prototypes used, combined to create an environment that fostered unintimidating interaction enabling communication and imagination between the design team and the user. Similarly, in phase 2, user scenarios were raw and rough; using hand drawn images on butchers paper as 'backdrops' for scenes in the service scenario [See Fig.11]. In addition, client teams in phase 2 were provided with post-it notes, butchers paper and thick textas to express their ideas on the journey performed before them

4.2.7.2 Design thinking calibration

Sketching and mapping was found to be fundamental in the development of processing, communicating, and transferring complex information; both for collaborative and individual sensemaking. Sketching was observed to be vital not just for communicating information and insights, but as a mediator for language and efficiency for decision making (Lindberg et al. 2008, p.249). Supporting existing research on the topic (Carlgren et al., 2013, p.6; Drews, 2009; Tvesky, 2010, p.500), sketching was also observed to resolve confusion between participants and externalise internal visions and ideas into a tangible and communal space. Kees Dorst explains that visual representations of problems and solutions "allows the designer to develop their ideas in conversation with these representations" (Dorst, 2011). Similar descriptions have been made on visual artefacts, exemplified as a form of thinking with your hands, as well as a way of engaging in conversations with the drawing (Schön in Rylander, 2009, p.5).

Extending on Dorst and others, it was observed that engaging with visual artefacts develops ideas in a collaborative and communal conversation amongst team members, and not just as a private consultation with the artifact and its maker (Schön, 1983). In co-creating a holistic user journey (phase 1) and organisational capability (phase2), the design team calibrated their understanding using various visual cues such as sketching and mapping. The simultaneous act of cognitive sensemaking through visualisation in a collaborative group setting provided the fabric for collective thought. This action enables cognitive calibration; an emergent collective consciousness of the design team engaging with and building upon the sense makers reflective process through visual language. A brainstorming session between design members typified this action; with one member thinking through sketching, and inviting other members into his cognitive process:

> You know what I'm actually going to do, at the same time,
> I'm going to draw everything out
> (Observation, Phase 2, 2011)

> I'm just sketching away here,…each of these live on that scale,
> but not necessarily be parts of it…
> (Observation, Phase 2, 2011)

Sketching was observed as a tool to invite team members to 'sync' with an individual's perspective. A synchronised conversation emerged from interactions within the visual realm. The visual artifact provides a central and common focus for facilitating the 'building upon' group members thoughts and ideas (Vaajakallio & Mattelmäki, 2014). This method facilitates a collective design mind:

> No worries! Draw everywhere! So it looks like you've got these two things like that and then you've got these things like this, which, do that…maybe?
> (Observation, Phase 2, 2011)

> Oh, OK. That's interesting! [laughs]…this looks like planets to me!
> (Observation, Phase 2, 2011)

The synchronization of understanding mediated and enabled through visual cues such as sketching and mapping increased speed of cognitive processing amongst the team. Visual methods enable freedom to join in and 'surf' another members' wave, building on ideas presented in a rapid and iterative way. This 'building' upon ideas was an emergent phenomenon observed when designers collaborate around a central visual cue. The basic, raw materials used for visualisation together are crucial for facilitating open and unashamed collaboration. When words and their definitions can confuse and alienate participants, visualisation served as a language all participants can understand without risk of alienation.

4.2.7.3 Visualisation for complex practice

Designing for a complex and ambiguous project brief as presented in this case, required specific visual methods for sensemaking and synthesis. Sensemaking complexity was observed to exist as a co-creative process between unfolding visualisations and the design team. Sketching and mapping were primary methods used to 'co-visualise' and co-create sensemaking and synthesis for the clarification of complex ideas. Visualising complex information aims to transfer dense information at a glance. During both phases of design development, mapping was a central visual artifact that enhanced not just the creation of new ideas, but clarifying and evolving complex trains of thought:

> Let me print out a couple and put it up so everyone can use this,
> in a really visual kind of graphical map
> (Observation, Phase 1, 2011)

We had a week or two weeks of planning the enactment which was putting posters on the wall, pieces of paper, seeing…
(Observation, Phase 1, 2011)

I think another next step is tightening up the blueprints, from the value in [the service] because there are gaps in that first layer of the organisational journey...but I think...having all of this makes that easier
(Observation, Phase 2, 2011)

Both design teams visualised a system to keep the focus holistic and clear. Blueprinting and sketching were methods used for managing and directing the design process. In both teams, blueprinting (mapping) offered a holistic perspective without becoming bogged down in detail, a structure for direction without focusing on linear problems, and a framework broad enough to maneuver and maintain an open and adaptive process. Mapping was a formidable visual tool that encouraged holistic thinking for cognitive processing of complex information.

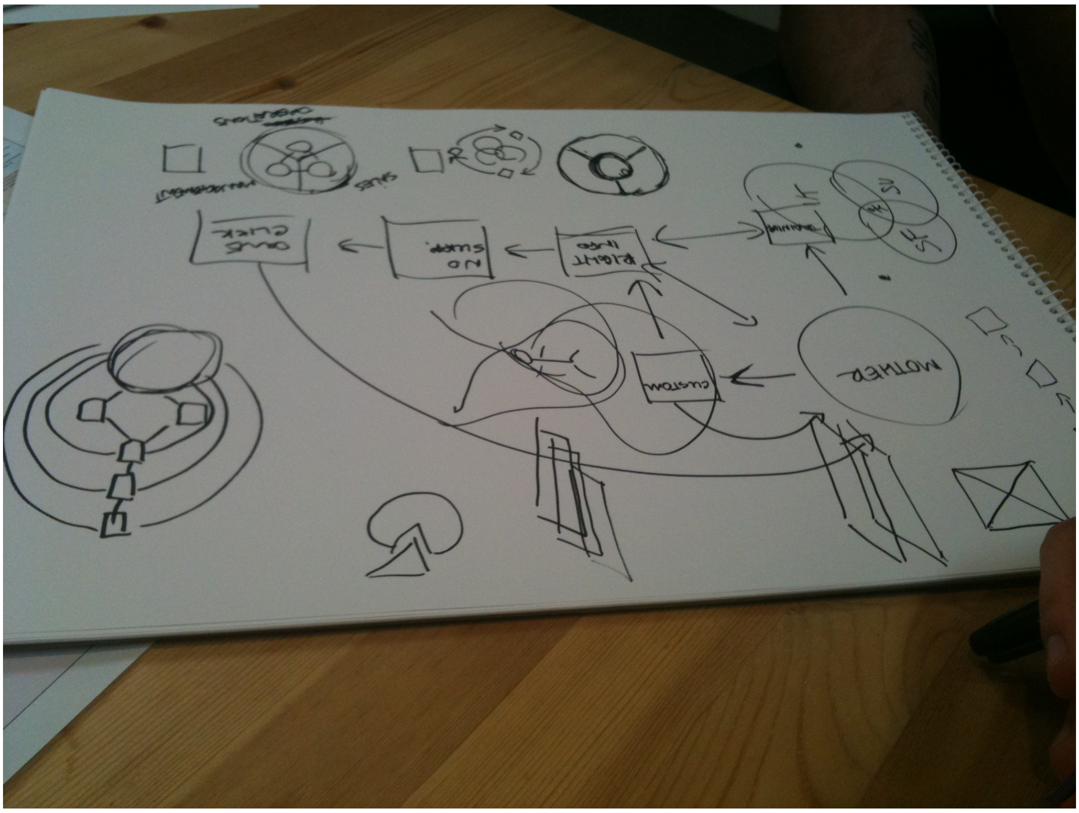

Fig.12. Design team in Phase 2 sketching the organisational ecosystem

Often referred to as a method utilized in the formative phases of the design process (Blomkvist & Holmlid, 2010, p.3; Kimbell, 2009, p.251; Ranjan, 2012, p.52) sketching was observed in the final stages of project development. Needing to synthesize the organizational ecosystem, the design team in phase 2 used rapid sketching to visualize their understanding of how the organizational ecosystem was going to work:

> Just to visualize, you know, it's not one area you can fix, you have to keep it consistent throughout the whole journey (Observation, Phase 1, 2011)

Mapping and sketching used as a tool for managing complexity also influenced holistic and systemic thinking. Through utilising mapping for clarification of complexity, the method enhanced overarching perspectives of the designers as well as maintaining a systemic and holistic design process. Mapping as a method exists in harmony with the overarching vision framework, strengthening higher cognitive perspectives on the project. Furthermore, mapping user pathways through to sketching blueprints of the organisational system was conducted to provide a framework for managing and accounting for future complex problems.

4.2.7.4 Visualisation for imagination and analogical reasoning

Imagination is described as the "genesis of ideation" (Wylant, 2008, p.7). Thus it can be proposed that imagination is an underlying driver for the visualisation of tacit knowledge in this case study. Imagination is what enables design teams to transfer complex ideas into visual form. The ambiguous nature of the design problem increased reliance on visual imagery and thus, imagination, as both design teams were forced to imagine future states and to visualize complex information:

> Yeah think about it like…a link to video…
> (Observation, Phase 2, 2011)

> Bigger the better because the visual that I've got in my head is…
> (Observation, Phase 1, 2011)

During complex sensemaking activity, a high degree of analogical reasoning was performed. The effect of this form of reasoning in this case was two fold: used as a vehicle for translating ideas to group members and as a source for collective ideation. In response to Fig.9, one designer exclaimed, "that's interesting! This looks like planets to me!?" (Observation, Phase 2, 2011), then elaborated:

> [Focusing on Fig.9] What I'm wondering with those things, are they part of the loop or do they exist off the orbit of one of those things…so it's like this, and then maybe…this whole little thing like that…so you've got this thing orbiting and then this little bit hanging off there…is that how its works?
> (Observation, Phase 2, 2011)

The use of conceptual metaphors appeared to occur when the designers were in a position to synthesise complex insights for solution ideation. Analogical reasoning was observed in the second phase of the project case where much of the cognitive sensemaking was focused on synthesizing insights.

4.2.8 Co-creation, collaboration and facilitation

Accounts observed in this project case aim to explore how designers facilitate; what methods and tools they choose to enable collaboration, the different facilitator roles that exist, and finally, the impact that both roles and methods have on the design process.

4.2.8.1 Facilitating perspectives

The facilitative process in this case focused on changing perspectives and shifting existing mindsets. Facilitation in the second phase of the project was focused on 'framing' the client's perspective; to prep and empower the client with the ability to identify insights and issues for themselves. The design team aimed to facilitate a different way of thinking; to motivate the client towards a designerly frame of mind. Design literature emphasises problem framing as an activity central to design practice, yet perspective framing emerged as an equally important issue for design development in complex environments:

> But it was a completely different outcome to this. We knew was going to happen. But the client is now so thrilled, that there has been so much progression in the way people are thinking and it actually took place on the day. In the beginning, the org kept thinking about what they need to give the customer and what we were asking from them was to think about it from their perspective...not to say, "oh the customer needs this!" and we were saying "no! we're telling you, that this is what the customer wants, can you do it?" So during the day [service enactment], there was a gradual shift towards the end of the day where the organisation was actually thinking from within and not projecting what they think the customer needs. So that's a massive, massive, massive shift
> (Observation, Phase 2, 2011)

The facilitation around shifting perspectives fundamentally aimed to emancipate the client from engrained attitudes of operation. The effort towards 'freeing' the client from cognitive constraints was supported by design methods geared towards breaking up internal organizational structures. Thus, the design objective in this phase was equally that of redesigning mindsets as it was redesigning organizational and service operations. The team aimed to achieve this through the co-creation of service deliverables; using methods that aimed to mix up internal organizational channels:

> I think it's about consolidation and not questioning out. We've got enough information on it. And Tuesday [the service enactment] is about consolidating, It's about getting them to understand as a collective, as a team, how and what it is they need to do together to actually tell that
> (Observation, Phase 2, 2011)

Facilitating a different mode of thinking is centered around inspiring the client to generate positive thoughts towards organisational possibilities. This facilitation thus centered on eradicating linear mindsets and narrow, negative thinking. The design team hoped to spark open collaboration between internal departments in the organisation. The design team wanted to empower the client to see and identify problems for themselves in order to independently frame solutions. The ambition of the design team was not to preach service solutions but facilitate empowerment and motivation for the client organization to move forward with a designerly mindset:

> With these multi-stream teams there is force for collaboration between them. What [the design agency] will do is we will, there is three of us, and we will help facilitate these talks amongst these people. Then we will brainstorm sessions by asking them things like "what's the overlap? How can we work together? What gaps are there?
> (Observation, Phase 2, 2011)

This stage of the design process embodies a phase of knowledge transfer; the communication of insights obtained by the design team in phase 1. The organizational capability defined by the design team in phase 2 is about capability, learning and teaching. The method for transferring knowledge from phase 1 is more than cultivating a design culture. Teaching becomes a significant vehicle for facilitating and empowering organizational capability.

4.2.8.2 Co-creating empowerment

Choosing an appropriate method for client collaboration and co-creation carries significant pressure for the effect that the method has on both the client and on the design process. In phase 2, role-playing (service enactment) was an educational vehicle to communicate key findings from user research to the client. Rather than preach to the client what needed to be done, the design team aimed to facilitate teaching; prompting participants to independently analyse and understand the capabilities required to make the ideal enacted service journey a reality.

The purpose of this service enactment was to break down internal hierarchies by inviting departments within the organisation who have responsibility in enabling the ideal journey to happen. The design team chose to 'tear apart' the department teams participating in the workshop. Individuals belonging to different departments were put in mixed groups; forming interdisciplinary project teams. The design team wanted to disrupt existing 'silos' and force team members to interact between departments that would not normally communicate, as well as understand the responsibilities each department holds over the process:

> This time acting isn't a description. It's a vehicle for provoking thought with you guys [the client] to pull yourself out of your operational streams and interact and work together in what we're trying to demonstrate here. We're not speaking to detail were speaking to the intention to demonstrate things. Because that hazyness lets them figure out between themselves "would you do that? Would you do this? I think we frame it not as a compromise but as a design and useful way of doing things
> (Observation, Phase 2, 2011)

The aim of the service enactment was to allow the client to co-create ideas and solutions themselves, whilst aiming to realise the dependencies and communication that is needed to make the ideal journey happen. This method of (forced) collaboration aimed to enable and empower the organisation to see problems for themselves, in a more holistic and customer centered manner. This would also empower the client to take responsibility for their position and for the service outcome.

The design team emphasized their intent to break down hierarchies in order to empower all employees to participate in service development. This was realized through creating cross-departmental groups for collaboration during the service enactment workshop. Additionally, this approach aimed to destroy power hierarchies; relieving employees from the pressure of needing to 'perform' in front of their department manager, and fear from feeling unable to share ideas.

4.2.8.3 Mediation in co-creation

In addition to facilitating perspectives and empowering individual stakeholders, mediation played an important role in the design process. Mediation was observed predominantly in phase 1, where the design team acted as representatives of the customers they gained insights from. Methods carried out in phase 2 were driven by empathy obtained from user research collected in phase 1. The enactment method was used to transfer user knowledge to the client. As such, the designers saw themselves as the 'voice' of the user:

> So there is a lot of direction involved here to say you know, if you were Phil what would be your thing? So you're sitting on the couch, what is the natural thing? Then people start getting into their own roles, so in this enactment we need to achieve this
> (Observation, Phase 2, 2011)

> That's the thing because we are always talking on behalf of the customer. People see that as the customer thinking, the customer's voice.
> (Observation, Phase 1, 2011)

Co-creation focused on the user and the co-creation of ideal future scenarios. Client collaboration focused on inviting internal departments from the organization to participate in a service enactment that operated as a vehicle for knowledge transfer rather than co-creation of the organizational strategy.

4.2.9 Relationship with the client

Observation on client collaboration revealed insights into the different perspectives that the design team and the client hold. An emergent, yet fundamental, part of the project was for the design teams to 'teach' the client how to manage problems from a design perspective whilst shifting their modes of thinking. An interesting observation showing subtle differences between the client and design team is through language of expression. Language used by the design team was consciously inclusive:

> We are tailoring our message for our particular audience. This bit here is what we got together...so this is the [refers to report] so they [the client] know what they are reading is something they have contributed to creating.
> (Observation, Phase 1, 2011)

Using an inclusive dialogue did not eradicate client expectations. When synthesizing insights from the enactment workshop in phase 2, the client team expected the design team to take control over the final design solution. The designer's perspective was not in line with this expectation, as the aim for the team was to highlight the need for internal collaboration, and most importantly, shifting perspectives, modes of thinking and ideas around service and organizational delivery. In the end, the design team was pressured to create a solution from the insights obtained during the enactment, rather than co creating a solution with the client team as was planned:

> Client: Ok so we need to divvy up now. Do we need to talk more in terms of a group or need to build?
> Designer: We need to build
> Client: You need to build, yeah..
> Client: So is there something we [refers to partner] can be doing?
> (Observation, Phase 2, 2011)

The responsibilities over implementation were unclear in this project. What was clear was the perspective and expectations that the client had on implementation. The client emphasized the need for practical solutions that could be successfully implemented:

> We need to do it as a way that works, not just a service that arrives and falls
> (Observation, Phase 2, 2011)

The practical mindset of the client team conflicted with the emotive and idealized visions of the design team. This difference in perspective was also evident in the way the client and design team expressed themselves when collaborating. Identified in 1.4, the design team often expressed themselves in an emotive manner signified by statements emphasising how they felt about the problem at hand. In contrast, emotive language was not expressed from the client and logic appeared to dominate:

> Designer: I feel like the theme that is popping out here is…
> Client: I think it's just changing it to information management…
> (Observation, Phase 2, 2011)

In no recorded observation did the client express their thoughts in an emotive way. The subtle emphasis on expression is significant for identifying the differences between a predominantly linear and practical mindset held by the client versus the emotive and inclusive expression from the designers.

The different modes of thinking in relation to dealing with problems was a source of tension between the client and design team. This difference in communication further emphasizes the conflicting frames that the client and designer hold. Collaborative and inclusive language; through dialogue and visual artefacts, alleviated some of this tension, but still struggled to fully synthesise and harmonise perspectives.

4.2.10 Systems thinking

A holistic, strategic and systemic perspective were mindsets that persisted throughout the project. Additionally, these mindsets became a coping mechanism for dealing with complexity and ambiguity. In both phases, the design outcome was not clear. The second phase of project development most evidently depicted a holistic and systemic approach. Yet, systemic and strategic solutions did not evolve until final stages of development. Design in complex practice gravitates towards intangible solutions, but without strategy for implementation the solutions can lose practical focus. This reason could be attributed towards why the design team in phase 2 felt the need to visualize the design of the service system for the client:

> I feel as though I myself need to start building a wireframe for this model and um, just see how this all feeds into each other
> (Observation, Phase 2, 2011)

> From our findings today, how they [themes] all work together as an ecosystem
> (Observation, Phase 2, 2011)

Knowledge played a crucial role in determining whether the design team could shift into a systemic level of thinking. In particular, the ability to transform holistic insights into strategic outcomes. Knowledge was pivotal to moving forward:

> So the strategy is kind of the smaller part of the ideal journey. We can't say we are building the strategy because we haven't done the detailed research (Observation, Phase 1, 2011)

The question over how much knowledge to obtain in order to move forward into a strategic mindset proved to be an obstacle in design thinking practice in this case. This invites the question of whether a designerly approach is enough to adequately address issues on this level of complexity.

The design team in phase 2 became apprehensive over converging their focus prematurely. The design team made conscious efforts towards 'refraining' from diving into early insights and ideas. As a result of the methods and mindsets described, the designers prolonged the divergent phase until late in project development. Thus, shifting into a phase of transition where insights are translated into practical solutions (that requires convergent thought) was also delayed.

4.2.11 Conclusion

Observing the designerly approach for complex problems in this case revealed limitations in its approach. A fundamental problem for the design team in this case was translating insights from customer research into tangible opportunities for organizational change. Central to this limitation is the lack of strategic insight during ideation. Furthermore, time constraint restricted the depth for which the design team could translate insights into articulate solutions.

The findings in this case suggest that the nature of the design brief presented a complex problem that was ambiguous and ill defined. The complex uncertainty embedded in the brief influenced the design team to create a vision framework; an overarching ideal based on user research. This framework served to direct the team towards an (ill defined) outcome.

The outcome delivered by the design teams was based on two broad aspects: user research and organizational delivery. The design team in the first phase delivered a document detailing knowledge obtained from user research on an ideal service scenario. This information formed the basis of the deliverable in the second phase; an enactment workshop focusing on organizational capability to implement the service solution. The second phase is the stage in the design process where insights required a transition from holistic ideation to tangible and practical implementation. The step from transition into implementation requires strategic translation. Systemic thinking surfaced throughout this case through high-level insights and holistic perspectives on the design problem and outcome, yet little discussion was observed on how to strategically apply the knowledge created during design development. It can be argued that strategy was a missing component in the design process that could have enabled the transition from insight into implementation.

5.

Case Study 2

The second case study selected for this dissertation focuses on the Australian Taxation Office. The Australian Taxation Office has become a global leader in design thinking for public services and provides an example of how a designerly approach is applied in large and complex governmental organisations. The Australian Taxation Office has championed design thinking for nearly 20 years (York, Wicks-Green & Golsby-Smith, 2010). It is the longstanding commitment towards cultivating a design culture that makes the Australian Taxation Office (henceforth ATO) an appropriate case to examine. This case study fulfills all three criteria described in chapter, 3. *Research Framework*. This case showcases a design thinking approach, operates in a complex environment (pertaining to “third” and “fourth” order design) and emphasizes intangible outcomes rather than product-centered solutions. In addition, guided by Junginer’s (2009; 2012) descriptions on the position of design activity, design thinking activity operates internally to the ATO and thus organisational system.

The ATO is an exemplar of design thinking in complex environments due to the inherent wickedness involved in both designing taxation solutions for a nation and designing within and for a system that houses over 20 thousand employees (Australian Taxation Office, 2013, p. 5). Additionally, designing with a broad network of inter-disciplinary stakeholders from various backgrounds and departments provides a challenging and complex environment for design thinking practice.

Herbert Simon (1996) is most famously quoted for stating "everyone designs who devises courses of action aimed at changing existing situations into preferred ones" (p.111). This phrase is most commonly referred to as placeholder for a universal definition of design and design thinking. Simon continues from this iconic statement, providing an accurate description of where design thinking and design practice has evolved to today "The intellectual activity that produces material artifacts is no different fundamentally from the one that prescribes remedies for a sick patient or the one that devises a new sales plan for a company or a social welfare policy for a state." (Simon, 1996, p.111). The design industry has extended its practice to include the design of and for healthcare, large corporations and government policies. The ATO has become a global leader in applying design thinking in government practice and is an example of how capabilities can be created to enable a designerly approach in complex environments.

5.1 The development of design thinking in the ATO

Design thinking was introduced to the ATO in the mid 1990s when management realised the need to streamline services and increase tax compliance amongst Australians. Chief Commissioner Trevor Boucher initiated a turning point for the ATO in the late 1980s and established a vision that has since flourished into a global example for design thinking in complex, governmental organisations (York et. al, 2010). Armed with the aid from a senior design researcher, a leading Australian university and a consultancy practice, the ATO began implementing a design thinking culture within its organisation by the turn of the 90s (York et. al, 2010).

Three key themes defined the change in the ATO: facilitation of strategic conversations, design of the Australian income tax act and design thinking embedded within the entire taxation system (York et. al, 2010). Another major turning point for the implementation of design within the ATO arrived in 1999 with the Australian Review of Business Taxation (Junginger, 2006, p. 258; Review of Business Taxation, 1999). This review (also known as the Ralph Review) was the result of lengthy investigations into operations within the ATO, initiating developments that would see design practice and design thinking employed holistically throughout the organisation (Terrey, 2012, p.4). The Australian Review of Business Taxation inspired the creation of the Integrated Tax

Design project that aimed to formally acknowledge and implement design practices within the ATO. The Integrated Tax Design project outlined capabilities for tax policy, legislation and administrative processes, lead by John Body and directed by a high profile team including Tony Goldsby-Smith, Richard Buchanan and Jim Faris (Macdonald, 2005, p.8). The Integrated Tax Design project drew heavily on "insights provided by product design literature and was mentored by international design experts" (D'Ascenzo, 2004, p.2). The emphasis was on human-centered design and how this perspective could improve operations in the ATO (Junginger, 2006, p. 259).

The ATO turned to design thinking to remedy negative associations that Australians held towards the taxation system. The ATO realised that the Australian public viewed the taxation system as "bureaucratic and defensive" (Godfrey 1994 in York et. al, 2010). In response to this realisation, the ATO turned to design thinking to improve efficiency and compliance. The human-centered mindset underpinning design thinking introduced a fresh insight into designing for and empowering both users and employees of the ATO (Junginger, 2006, p. 261). The introduction of design thinking in the ATO required the organisation to undertake a "paradigm shift" (Terrey, 2012, p.5). This paradigm shift was lead by design expert, Richard Buchanan. Buchanan was one member of a team of design mentors who contributed to the development of creating design capability in the ATO.

Buchanan and the ATO team explored three broad categories fundamental to the function of the Australian tax office system: systems, processes and people (Junginger, 2006, p. 262). These categories are a constant consideration behind design efforts in the ATO today:

> By involving users in the planning, development and implementation of solutions, successful design ensures that new initiatives deliver on their intent, are user friendly and reduce compliance costs (Artefact 1, ATO Design Guide, 2008, p.1)

Buchanan had just released his theory on the "four orders" of design in the early 1990s when Trevor Boucher was sparking interest in utilising design thinking in the ATO. The four orders of design would provide a conceptual framework underpinning Buchanan's contribution in the ATO, but in particular, towards shifting rigid mindsets. The ATO staff quickly realized that they were now creating interactions for users, rather than determining laws and regulations (Terrey, 2012, p.5).

5.2 Research on the ATO

The ATO's long-term organisational implementation of design thinking provides an abundance of information on the nature, culture and implementation of design thinking in large scale, fourth order design practice. Because of this, the ATO have been the subject of interest for design researchers. Two researchers in particular have made an impact with their study on the ATO: Sabine Junginger and Nina Terrey. Junginger (2006) conducted case study research on the ATO as part of her doctoral thesis, *Change in the Making*. Terrey, a former ATO employee, completed her thesis on the ATO in 2012 titled, *Managing By Design*. Both researchers provide comments on gaps within design research, particular to fourth order design "The fourth order is a relatively unexplored area, as Buchanan expressed in a conference presentation, this 'could be part of a new practice of design'" (Terrey, 2012, p.31). Sabine Junginer analysed the impact and application of the human-centered design approach to enable internal design capability within the ATO "the design approach continuously moves the project forward and constantly produced tangible outcomes that could not have been determined up front" (Junginger, 2006, p.259). Similarly, Terrey focused her thesis on the implementation of design as a method of management practice in the ATO.

This case study builds on the work of Junginger and Terrey, but instead, focuses on the current manifestation, application and characteristics of design thinking in complex third and fourth order practice. The analysis on the ATO will emphasise the nature of fourth order design thinking and evaluate the current approach to complex problems faced by governmental institutions.

The results from analysis on this case study will be presented as follows: first, a brief overview on the process methodology currently employed in the ATO is introduced. This overview will outline key terms, design phases and personnel that will be referred throughout this case. Second, the results will then be presented under an analysis of themes discussed in light of the holistic process and methodology of design practice in the ATO.

Archival case data and semi-structured interviews were the main methods of data collection for this case. Archival documents were gathered on two projects related to improving access and information to superannuation accounts for individual taxpayers:

concessional contributions cap and the Supermatch superannuation portal. Along with documents provided on these two projects, information documents about the design process at the ATO were provided for analysis. Semi-structured interviews with key designers and project team members working on the projects supported analysis on archival documentation. Five core design team members were interviewed: a design lead, design facilitator, a business lead, project lead and a co-design lead. Analysis of information followed the same pattern as described in Case Study 1 and outlined in Chapter 3. *Research Framework* [See example of analysis from Appendix A, B and C].

The information provided on both of the superannuation projects was not without limitations; confidentiality restricted coherent end–to-end information to be collected on each project. This did not impede on analysis, as the focus of this case study was to obtain an understanding of holistic design operations in the ATO. Thus, detailed information on both the concessional and Supermatch projects was not necessary; a combination of documents provided on both design projects allowed a coherent view of the general nature of design processes adopted in the ATO. It is for this reason that the details behind these projects will not be discussed and the conversation will remain on the nature of design thinking applied in the ATO.

5.3 Design thinking practice in the ATO today

This case study focuses on analysing the current use and application of design thinking in fourth order design practice; understanding the transformation, effect and evolution of design thinking in a complex governmental institution, the ATO. In 2009, the Australian Government published the Henry Review. This review provided recommendations on achieving a vision for Australia's future tax system (Artefact 2, CC Blueprint, 2011; Australia's Future Tax System, 2010). In 2011, a review of the superannuation process sparked a superannuation reform program aimed at making a "stronger and more efficient tax system" (Artefact 2, CC blueprint, 2011; Australia's future tax system: final report, 2010). This super reform program hosted a number of minor programs aimed at holistically improving the superannuation system, from business through to individual taxpayers:

> The administration system would allow people to engage with the tax and transfer system through a single, individualised portal that draws on natural business systems to automate business interactions with government. Governance arrangements would support a more responsive system and ensure the benefits of reform are preserved and enhanced over time. (Australia's Future Tax System: final report, chapter 3).

Minor programs included the redesign of systems and processes for: data and e-commerce, tax file number and account consolidation, individual taxpayers and self managed super fund measures (Artefact 2, CC Blueprint, 2011). This case investigates the end-to-end design approach used to create solutions in response to the individual taxpayers component of the super reform project under the superannuation review.

5.3.1 The design process

Design in the ATO rests on design principles and a design process framework. Working within established design principles and process is mandatory. An internal document, *The Design Guide*, helps ATO staff navigate through this predetermined design process. In this guide, it states:

> Any proposed change that will have an impact on the community, the Government, taxpayers, and/or the Tax Office staff, must follow the design principles. It applies to policy-based changes as well as those that focus on improving aspects of Tax Office administration. (Artefact 1, ATO Design Guide, 2008, P.4)

The design principles are overarching philosophies and objectives articulating what design means in the ATO (Artefact 1, ATO Design Guide, 2008, p.12). The design principles are outlined as follows:

1. Build a shared understanding of intent
2. Take a user centered approach

3. Make the emerging design visible early
4. Work collaboratively in interdisciplinary teams
5. Follow a disciplined yet flexible process
6. Create a coherent blueprint for change
(Artefact 1, ATO Design Guide, 2008, p.13).

A design process framework is the tangible and a practical methodology that acts as a vehicle for manifesting these design principles. This framework is visualised as a design wheel, outlining the phases and movement through the design process.

[IMAGE REMOVED]

Fig.13. The Design Wheel

The ATO describe the design methodology as their own unique take on the design process (Design Facilitator, Interview, 2014; Artefact 1, ATO Design Guide, 2008, p1). Designing in the ATO involves 5 distinct phases: intent, blueprinting, co-design, build products and implementation. The first phase is defining the intent. The purpose of this initial phase is to understand and clarify the strategic vision passed on from policymakers in the government. The intent is developed between a core design team and key stakeholders. The core design team is a team of key interdisciplinary individuals who act as representatives of their respective departments. These individuals are chosen by a project leader who identifies key personnel from departments that will be either most affected by the new policy measure or fundamental to its development (Project Lead, Interview, 2014).

User-centered design is fundamental to the design process at the ATO, however, users are considered but are not the focus of work in the intent phase (Design Facilitator, Interview, 2014). Instead, emphatic, user-centered design is utilised most during the second and third phases of the design process. The second phase focuses on blueprinting and user-centered design. This phase begins with identifying users, the user experience and expectations, before developing a proposed design outcome. Blueprinting includes the core design team and two designers; a facilitator and an information designer. Blueprinting is about developing a high level design whilst brainstorming different solutions for the user. Thus, the aim at the end of blueprinting sessions is to have identified a design outcome and an accompanying user pathway and organizational blueprint that will impact and be impacted by the desired outcome.

The third phase is about co-design. It is this phase where design concepts are refined. These concepts are shaped by feedback from users; utilising various user-testing methods that include sending design solutions to the ATO's Simulation Centre in Queensland (Co-Designer, Interview, 2014). Following user testing conducted in the third phase, the fourth phase focuses on design development and building products. In addition, the wider internal system is engaged during this phase in preparation for implementation. Broader stakeholders are informed so measures that need to be in place for implementation are attended to (Design Facilitator, Interview, 2014). Finally, the fifth phase focuses on implementing the final design.

The evolution of design capability in the ATO resulted in establishing a clear design process, mandatory for any proposed change. Highlighted in the ATO Design Guide, designing for complex practice requires a design process that is fluid and not fixed. Fundamentally, the design approach in the ATO is "not about following steps, but rather applying principles, tailored as appropriate to the size and/or complexity of the project" (Artefact 1, ATO Design Guide, 2008, p.13). Here the emphasis is on adaptability and flexibility; a mindset that is enabled by design thinking, and in turn, shapes design thinking practice in the ATO.

5.3.2 High-level design thinking

Designing in and for a complex system such as the ATO begins in a high-level space focusing on intangible project visions. High-level design practice in the ATO involves systemic thinking and a holistic perspective, that avoids details and instead focuses on conceptual ideas that will overarch the lifecycle of the design project (Design Facilitator, Interview, 2014):

> Understanding what the intent of the measure is, but also in the back of our minds is what is the strategic end point that this platform could provide us, so we are running two processes in our minds when we are going through this.
> (Design Lead, Interview, 2014)

Intent is usually the first point of contact with the design process. Intent is "what the government or tax office wants to achieve as a result of change" (Artefact 1, ATO Design Guide, 2008, p.13). The intent behind a given project is the framework that guides the core design team towards a desired outcome. Thus, it provides a grounding point with which the developing design is evaluated:

> That's why we need to understand intent because it leads us down what we are actually aiming for in the Design. So that's our first step in the design process.
> (Design Facilitator, Interview, 2014)

Intent is developed in response to a desired change handed down by the government. A strategic vision is created by policy makers and commissioners and developed into a statement that is passed to the design team (Design Lead, Interview, 2014). This change statement may be as short as one sentence or provide general information, much like a brief. This strategic vision is then transformed into a succinct intent statement, co-created by the commissioner and select individuals from the core design team. Once this vision is handed to the core design team it is then analyzed and interpreted in context of ATO practice (Artefact 1, ATO Design Guide, 2008, p.27). The analysis and interpretation of the change measure, or problem framing, is what establishes the intent. Occasionally, intent may follow a preliminary phase of scoping; where core team members will decide on the scale and complexity of the desired change passed from the government

> I supposed that's one of the challenges we have with our design. We usually just get a one liner with no context behind it…and that's how we need to determine what's the ATO approach going to be with that one liner
> (Design Lead, Interview, 2014)

For more complex projects or policy announcements, the ATO design team conducts a "rapid solution design" (RSD) protocol. Under this instance, RSD is the first point of departure for the design process that happens prior to intent. The RSD workshop operates at the highest conceptual level and involves specialised thinking. Senior officials, a design facilitator and information designer are usually present. Rapid Solution Design protocols are often employed when problems are very complex and require an additional step of clarification before moving into scoping and intent (Project Lead, Interview, 2014). Scoping is used to identify the scale and size of the project before working on the intent. The guidance and input from the design facilitator and information designer is invaluable to the project and team during these early stages of development:

> The RSD technique we use for some of these complex policies that are unannounced or announced shortly. Then we need to come up a high level sketch. Again we use a facilitator and perhaps the information designer just to quickly extract the information and again usually you do the user pathway just at a higher level without going into any details. We use that to help the scoping. In terms of something that is complex, RSD helps the requirements of scope.
> (Project Lead, Interview, 2014).

In establishing the intent for any project in the ATO, understanding the underlying mechanisms behind the intent is imperative. This means getting to the 'core' of the policy measure that is passed to the ATO design team. As the intent can be established through many different perspectives, understanding the core of its purpose helps alleviate ambiguity around diverse viewpoints. Getting to the core of the intent is achieved through understanding the purpose with respect to the user (Design Facilitator, Interview, 2014). A user-centered approach is attributed to guiding the core design team in the right direction:

> So even though there is an online system, we wouldn't be looking at engagement as the primary source of it. We'd be looking at what's the easiest way for people to transact through the internet- not display information. That is why we need to understand intent because it leads us down what we are actually aiming for in the design. So that's our first step in the design process
> (Design Facilitator, Interview, 2014)

> How the user would choose that service is paramount for us developing
> what we think it would look like and how the user will try to use it...
> because it's all about them interacting with us
> (Project Lead, Interview, 2014)

The intent is a constant in the design process and is frequently reviewed as design solutions develop. Designs are malleable but changes to the intent "must be escalated back to the project sponsor who is accountable for delivering the intent" (Artefact 1, ATO Design Guide, 2008, p.14). The formative phases of the project, intent and blueprinting, focus on defining and refining the problem solution space. This involves problem framing through a user-centered perspective (Design Lead, Interview, 2014). Thus, the intent reflects complex, high-level problem framing. The intent may operate on different levels and is often balanced with a strategic mindset. It is during this phase that ambiguity is at its highest (Design Facilitator, Interview, 2014). Intent is seen as one of the most important aspects in the lifecycle of design in the ATO, for once it is established, it is the perspective framework that is used to direct teams towards design outcomes (Co-design lead, Interview, 2014). Because of this, the way the intent is shaped by the core design team has an effect on the design outcome and implementation.

5.3.3 Blueprinting

The blueprinting phase is the next crucial component in the ATO design process. This phase is unique as it showcases how design thinking can be deeply intertwined within a design method. The ATO Design Guide (2008) articulates this phase as both a verb and a noun, stating “A blueprint is a document that outlines the overall high-level design for a proposed change” followed with “It is created by a core design team through an iterative, collaborative process known as blueprinting” (p.31). This points to the notion that blueprinting may be an embodiment and example of how design thinking and methods can be deeply dependent and often inseparable:

> It’s a foundation. So providing a foundation of what we are going to do. And all of our subsequent processes through to implementation is based off that blueprint (Design Lead, Interview, 2014)

A blueprint is always created prior to developing and building design products. Blueprinting accounts for high-level impacts from both the perspective of the user and on the tax office “the project blueprint is very much the higher-level design” (Project Lead, Interview, 2014). User-centered design is often termed “outside in” thinking, and holistic and systemic perspectives are labeled “end-to-end” (Artefact 1, ATO The Design Guide, 2008, p.19). Blueprinting is reflective of common service design practice; utilising touch-points and user pathways as methods for mapping the entire design system (Kimbell, 2009; Design Lead, Interview, 2014). The outcome from a blueprinting session should see that the impact of the design has been considered across the tax system, and thus focus on “getting good design outcomes, rather than just producing a blueprint” (Artefact 1, ATO The Design Guide, 2008, p.31). In doing so, the blueprint relies on the intent and design (thinking) vision behind the project in order to achieve success “it needs to be done with design vision in mind. You can take the blueprinting process and still come up with a bad outcome” (Design Facilitator, Interview, 2014). Thus, the blueprint is considered an embodiment of best practice, an artefact that “captures the outcome of good design thinking” (Artefact 1, ATO Design Guide, 2008, p.31).

Blueprinting is also an exercise in holistic, end-to-end and systemic design thinking. This phase focuses on divergent thinking. Blueprinting is rapid, lasting only a few days (Artefact 1, ATO Design Guide, 2008, p.36). The purpose of the blueprint is strictly high level; discussions on details are deliberately omitted from this phase (Artefact 1, ATO

Design Guide, 2008, p.39). The blueprint is an embodiment of high-level, holistic, end-to-end design thinking, "The second step we call here at the moment is blueprinting. We work out a high-level design. So this is a full process which we take" (Design Facilitator, Interview, 2014). To design effectively in the ATO requires not just holistic thinking but a systemic approach. Systemic considerations are localised to the intent and blueprinting phases of the design process, and both phases acknowledge and reflect design and systems thinking:

> A clear understanding of the intent depends on a solid understanding of the system-in-use and the problem that is to be addressed. For very complex problems, some specialised techniques such as systems or critical thinking may provide a framework to help understand the problem.
> (Artefact 1, ATO Design Guide, 2008, p.28)

Employing a systemic approach is mainly used to aid in the seamless integration of design thinking and design outcomes. Thus, a systemic perspective may play a crucial role in successfully implementing design solutions in the ATO. This systemic consideration is important for enabling successful outcomes as "a good blueprinting process will come up with what your measures for success are as well" (Design Facilitator, Interview, 2014). Without a systemic understanding on the functionality of the ATO, designed solutions may fail upon implementation and it is the implementation of design solutions that provides evidence of the success of design thinking.

5.3.4 Design facilitators

The ATO have two distinct design roles that are crucial during early stages of high-level design. The first role is a design facilitator and the second an information designer. Both individuals are employed to work in collaborative brainstorming sessions during the formative phases of the design process (Design Facilitator, Interview, 2014). Intent and blueprinting are phases where input from the design facilitator and information designer are most crucial “blueprinting is the majority of our work of what we do- to design facilitate. For this project it was what we got mostly involved with” (Design Facilitator, Interview, 2014). The design facilitator engages with higher levels of authority in preliminary stages of the design process, specifically around forming the high level intent that will guide the rest of the project. The primary function of these designers is to facilitate collaborative conversations. The design facilitators role is to help assemble the core design team members who will be working through high-level design phases, and to ensure that all members participate. Design facilitators provide stimulus through design methods in order to keep conversations focused and flowing. The responsibility of the design facilitator is to enable conversations and ideas to emerge in focus with the given intent/brief (Artefact 1, The Design Guide, 2008, p.61):

> I guess my main role is about- in the workshop- how do we collaborate and brainstorm. It’s more, I guess, design facilitation is all about questioning, so it’s making sure everyone has a say, making sure everyone gets heard, and being able to manage groups so that they can all get the message across.
> (Design Facilitator, Interview, 2014)

> So the facilitator makes sure everyone has their say and obviously makes sure everyone is on track and don’t diverge off into conversation that is maybe off track
> (Project lead, Interview, 2014)

Design facilitators help define the problem and solution (Project Lead, Interview, 2014). Additionally, the design facilitator is formally recognised as ‘the’ designer, but, rather than taking on an authoritative role, it is one that is passive and informal. The facilitator enables design thinking to emerge *through* team members using participatory and collaborative methods and it is the function of the group (core design team) that actively engages in design thinking on the topic at hand:

> The facilitator's job is to get information out of the group. It's not to dictate anything. So that's what the people in the room are...they need to be aware of what they are there for, but the design facilitators are there to get the information out in a design sense.
> (Design Facilitator, Interview, 2014)

The information designer's role is to visualise ideas created by the core design team. Once again, the information designer is recognised as a formal figurehead for design, but plays as role that is more reflective of a passive bystander. The information designer's role is to listen and observe conversations from the core design team and to visualise emerging ideas. The information designer refines his/her sketches before presenting the visuals back to the core design team:

> We also have information designers at the meeting and they will start sketching out the design, feel when ideas become evolved along the way… and then they actually come back and show us the design the next day. Of a two day workshop at the end of the first day they go away with a bit [of a visual] and come up with a sketch and then we look at the sketch...so one of those key design sessions is very much interacting with those people [information designers] on the spot
> (Project lead, Interview, 2014)

The information designer is responsible for translating complex conversations into simple visualisations that reflect the solutions and ideas that have emerged during collaboration (Artefact 1, ATO Design Guide, 2008, p.61). The facilitator and information designer do not engage with latter parts of the design process, with most of their input required only during intent and blueprinting (high-level) design stages.

5.3.5 Collaboration

Collaboration in the ATO is driven by three principles known as the "3C's": collaboration, consultation and co-design. Collaboration is defined as "the act of working with others" (Artefact 1, ATO Design Guide, 2008, p.5). Consultation is described as "understanding the viewpoints of stakeholders" and co-design is "a process of involving the user in the design of solutions" (Artefact 1, ATO Design Guide, 2008, p.5). Collaboration in the ATO is inclusive and multidisciplinary. The core design team consists of design leads and individuals chosen for their relevance to the project context. Individuals on the core design team operate as representatives to their own respective departments (Business Lead, Interview, 2014). These team members have authority to approve and enable design processes to proceed within their represented department.

Co-design and user-centered design are terms that are often interchangeable at the ATO. User-centered design is the fundamental philosophy that underpins the design process. The ATO informally adheres to the International Organisation for Standardisation for Human-Centered Design (ISO 13407) (Artefact 1, ATO Design Guide, 2008, p.44) which guides their user-centered, co-design practice. Design development is iterative and always based on evolving user insights through user testing "so I guess broadly we would normally chunk co-design activity either to user research activity, collaborative design activity or detailed user testing activity depending on the stage of the project" (Co-Design Lead, Interview, 2014). The focus during iterative design development is on the user experience of design outcomes:

> Having an opportunity to actually implement the design direction where you can kind of use the user feedback to make more of the fundamental shift not the small refinements to it. I think that's a really critical thing
> (Co- Design Lead, Interview, 2014)

> Products and services that are designed with a user focus will improve compliance because it will be easier or cheaper for taxpayers to meet their obligations or receive their entitlements. Barriers and costs that are created by poor products and services can obstruct taxpayers who are otherwise willing to comply
> (Artefact 1, ATO Design Guide, 2008, p.15)

The design lead emphasises the importance of a user-centered mindset. The defining purpose of the design approach is its people-centered focus "there is always focus on the outcome and the user experience. Even when you design a new tax you still consider the user experience on how to make them comply, in order to make it less obtrusive" (Project Lead, Interview, 2014). Similarly, the co-design lead also describes a multidisciplinary user-centered approach as a critical characteristic of design and design thinking "just having a group of people that are willing to embrace it, that are willing to listen to the user feedback that you've got and act on it and change the design based on that. So I think that's really critical" (Co-Design Lead, Interview, 2014). The focus on the user and usability is understood amongst core design team members as being paramount to the success of design thinking in the ATO "more or less everything we deliver should think about user" (Project Lead, Interview, 2014).

Co-design in the ATO is not just about collaborating with internal and external stakeholders. It is largely about co-responsibility. There are clearly defined roles and responsibilities for each core design team member. Because each individual is responsible for managing and representing their own department, discussions around expectation and responsibility is prevalent:

> Different areas of the office have accountability and responsibility for the information […] so the core design team is responsible with the design and the business people to develop a high level design
> (Design Lead, Interview, 2014)

> As design facilitator part of my role with the project manager is to come up with this core design team and they are made up of some kind of set criteria, around 8-10 people, that traditionally get blown out by a few more than that. And these are key stakeholders that are involved in the process. They need to take responsibility of the design. They need to sign off the design and they are also gatekeepers to the rest of their area
> (Design Facilitator, Interview, 2014)

Core design team members are not only responsible as representatives for their respective areas, but they also share co-design work. This co-responsibility over design developments makes the complex process within the ATO more manageable. The shared understanding towards co-responsibility is often a subject missing from common practices in design thinking. This shared responsibility ensures that all individuals feel accountable for the implementation and success or failure of design outcomes.

Despite the egalitarian and collaborative approach, a project manager is present, leading the core design team. A design lead is the manager of the core design team and oversees the design process as the project unfolds. Unlike the design facilitator and information designer, design leads are holistic and consistent throughout the design project "they do have an overarching role in looking at how a solution, I suppose, would be integrated from an enterprise perspective. So those design leads are generally across the overall project" (Business Lead, Interview, 2014). Individual team members do not need to be consistent throughout the project, as long as there is a design lead present in every phase (Design Facilitator, Interview, 2014).

In addition to the core design team, each phase brings in specialised individuals to complete the task at hand, "we have the doers working through details" (Project Lead, Interview, 2014). These individuals also have the responsibility to report on and pass feedback to project members working in the following phase of design development. Face-to-face communication with both core design team members and external stakeholders is considered imperative to the success of collaborative design practice in complex environments like the ATO:

> We try to meet with people face-to-face when its more complex because we need to be able to engage people properly rather than sitting in a meeting room by themselves on the other side of Australia, in front of their computer while they are answering emails at the same time
> (Design Facilitator, Interview, 2014)

When collaborating, the design process facilitates positive interactions between people. However, an interdisciplinary design team is a double-edged sword. The benefit of utilising a multidisciplinary team is that it provides a variety of perspectives and mindsets for discussions, which enable progressive problem framing. The pitfall is that these discussions can end in disagreements, particularly from hard-wired thinking:

> At the end of the day the services are their own responsibilities that they need to sign off on and some see it as a hurdle to their process. So it's trying to get that buy in…the value. That they see that there's value to the

> process that can help get a better outcome than what they were initially, or that they could think we're going to get
> (Design Lead, Interview, 2014)

The value of the design facilitator and information designer is evident when tensions between core design team members surface during high-level collaborative brainstorming sessions. In these moments, the design facilitator synthesizes differing perspectives and unifies conflict. The information designer, on the other hand, is the visual translator for the core design team. A usual high-level collaborative session involves the design facilitator directing conversations between core design team members, with the information designer visualising the emerging ideas (Project Lead, Interview, 2014)

The purpose of a design facilitator is to aid rather than authoritatively direct design development or design thinking. Designing is a collaborative effort of all stakeholders, and all stakeholders have a say over the final design outcome. Design managers and facilitators are responsible for enabling team members to collaboratively ideate, design and complete the work, and do not authoritatively taking charge over the design.

Stakeholders external to the core design team are heavily engaged during detail design phases, such as prototyping and building products. In particular, a business representative is included within the core design team who is the 'frontline' to clients, both internal and external. The business representative is responsible for communicating developments in the design project to external stakeholders who may be affected by the designed outcome:

> Throughout the entire life of any one particular project we have quite extensive stakeholders that we work very closely with. So we keep them updated during the process and alert them to the fact that you know a change is coming and the impact that may have on their area, whether it is a reduction of work or an increase in work or a new type of work, or eliminating another piece of work whatever that might be. So through our consultation to keep staff, internal staff, updated and they form part of our review process
> (Business Lead, Interview, 2014)

These external stakeholders are described as a "lower level of stakeholder" (Business lead, Interview, 2014) implying a clear sense of hierarchy between those directly involved in the design process and those who are not. The business lead is very conscious of stakeholder input and response, including the effect decisions made by the core design team might have on various levels of staff. This representative considers the rippling effect a design solution might have on the internal system. The focus of the business lead is holistic and systemic and considers the practical, interconnecting parts in the ATO (Business Lead, Interview, 2014). The business representative is concerned with outcomes and implementation. Thus, the business representative describes the business line as the 'enabling' area. The business lead on the core design team liaises with clients in order to facilitate and enable frontline solutions and services:

> I come from a business perspective, where we are a frontline area to clients, individual clients and external clients…dealing with them on a day to day basis. So we are what is called, is what they call, an enabling area. So even though I don't have direct contact with individual clients I enable the frontline- I work closely with those frontline services and then enable our procedures and our processes to manage the issues that clients may have and come to us for advice about
> (Business Lead, Interview, 2014)

Broader stakeholders are considered a part of the design process but a factor that impedes on development. Feedback from stakeholders is part of the design process, however the business lead adds that stakeholders "delay the project" (Business Lead, Interview, 2014) making the overall process run slower.

5.3.6 Design artefacts

Design artefacts play a significant role in design practice within the ATO. Design artefacts are any form of physical and visual expression of thinking developed during the design process. Visualisations are crucial during formative stages of design development when design concepts are still at an ambiguous and intangible level. Design artefacts spur discussion, communicate knowledge and ideas and enable design thinking:

> Making the emerging design visible early through documentation and
> Prototypes that focus dialogue, sustain energy and facilitate co-design.
> This provides a practical and tangible focus for design work and enables
> the design process to proceed quickly. It also provides communication products
> explaining the design which can be used for consultation with stakeholders
> (Artefact 1, ATO Design Guide, 2008, p.16)

Visual artefacts created during design development empower and breed collaborative design thinking. These artefacts mediate conversation and spur the development of design thinking amongst core design teams and stakeholders "we just kind of present that and talk through them and that [the artefact] kind of drives the conversation" (Co Design Lead, Interview, 2014). In this context, there is no single 'design thinker' but a collaborative activity that collectively represents design thinking. This collaborative representation is enabled through artefacts that allow thoughts and ideas to be shared and evolved as a team:

> Collaborative design and co-design with users are very difficult
> without a shared, visible form of the emerging design
> (ATO Design Guide, 2008, p.16).

Intangibility exists predominantly during high-level phases in the design process. Design facilitators and information designers are used only during these high level phases. Where concepts are intangible, information designers will translate intangible ideas into visual artefacts that act as representation of collaborative design thinking. Information designers aid in the translation of complex, fuzzy design ideas from the core design team into understandable visual representations. Thus, information designers are translators of complexity; they are masters of manifesting intangible ideas into concrete realities that can be shared by the design team:

> Our information designer is about making the design presentable
> [...] so the fact they can put the ideas together so quickly means we
> can review it straight away and firm up and visualise the ideas on the day
> (Project Lead, Interview, 2014).

However, the physical design of artefacts is out of the hands of the core design team. No members on the core design team engage with visualising ideas except for the information designer. In this way, the information designer is the visual arm for team members. Thus, during formative 'high level' phases of the design process, the information designer becomes a gatekeeper for design visualisations and collaborative synchronisation. Together with the design facilitator, the information designer is also a facilitator for collaborative design thinking:

> Most of us don't have design backgrounds. So we got ideas and we can talk, but we are not good at making things visualised. So I think this is where the design areas do focus all of the information. Design is about you got good ideas, that's good... but also have the sufficient information behind it to make it presentable to a hearing group so they can make a decision about a certain design option (Project Lead, Interview, 2014).

It can be argued that if core design team members do not sketch or visualise their own ideas, this may detach them from engaging in a designerly way of thinking. This context surfaces the question: does one need to engage with the physical (creative) aspects of design practice in order to engage in design thinking? Furthermore, if the design facilitator and information designer are considered representatives of design thinking, then this raises questions around whether the core design team members consider themselves as design thinkers as well. In response to this scenario, the idea of collaborative design thinking may be incorrect, or dependent on the design facilitators to be present. If design thinking relies on the facilitators presence, then co-design sessions may only be collaborative brainstorming sessions— where having a design facilitator present transforms general brainstorming into a design thinking activity, particularly if the core design team "don't need to know they are doing it" (Design Facilitator, Interview, 2014). This brings forth a new idea in collaborative design thinking that participants do not need to actively engage in sketching, prototyping and/or other visualisation techniques in order to activate and engage in design thinking. Being present amongst unfolding visualisations and/or contributing to design representations may be sufficient in order to engage with design thinking practice.

The creation of design artefacts is not just for enabling collaborative design thinking. Design visualisations are also knowledge artefacts, with the purpose of transferring information to stakeholders and team members outside of the core design team.

Knowledge is a crucial element in effectively progressing from one design phase to another. Specifically, the design blueprint is considered the main knowledge artefact that is passed throughout the design process.

Design artefacts are symbols of transparency. The knowledge that is transferred through design artefacts allow for a transparent and fair design process to unfold. Transparency is fundamental when collaborating between internal and external stakeholders in complex environments, not only to feed updates and information but to maintain inclusive co-operation:

> I guess when you are getting members of the community or even staff as well to have these conversations, you kind of need to put something in front of them that helps them to get their head around what you're trying to design. So yeah, I think that's where the kind of high level process or pathway is really quite good because it just helps to make it a little more real and it is something that people kind of critique and wot not
> (Co-Design lead, Interview, 2014)

Design artefacts in the ATO prove to have an impact on the mediation, conversation and facilitation of design thinking practice. This adds further evidence to the importance of visualisation in design thinking practice, particularly in complex design practice.

5.3.7 Design community and expertise

The design community in the ATO are advocates for design thinking. Despite having few professionally trained designers, the internal design community within the ATO is strong, with design representatives and facilitators meeting regularly to share ideas, learnings and fears. The broader ATO community is engaged in order to help spread the culture of design thinking and to teach staff a way of thinking rather than a way of doing (Project Lead, Interview, 2014). It is the design community of experts that is at the heart of design culture within the ATO and who are also responsible for advocating and converting others to adopt a design mindset:

> So in a broader way it's basically about how we as an organisation want design to be done. Then the individual really follows the process and guidance of the experts, the people and designers and what they make and the outcome (Design Facilitator, Interview, 2014)

Design expertise in the ATO is varied. Internal design training is available for design and non-design graduates. Key external stakeholders (outside of design arm at the ATO) may be invited to join in on the training. This is often employed to transform individuals who may be considered as 'blockers' in the design process to become 'enablers' (Business Lead, Interview, 2014). Much of the design training in the ATO is about transforming 'blocking' individuals to ones who enable design thinking to unfold. In complex practice, this appears to be important where there are many more people involved in projects who could potentially disable the design process and outcome:

> Some people will, or some stakeholders will, have a greater preference to get right down into the detail, whereas some of the others will obviously say 'don't tell me what's about to happen'. But hopefully the idea is that the involvement is significant enough to identify any blockages or issues before we actually get to deployment. […] So they for me would be the blockers that I would be most concerned about. If we're building something... without having the right people there we've missed something and we haven't clearly understood that there's a downstream impact and it's actually causing something not to work for someone else (Business Lead, Interview, 2014)

The tutors, who are responsible for internally training staff in design, have design qualifications and experience (Design Facilitator, Interview, 2014). However, within the ATO, all that is required is one or two designers who act as 'seeds'. These individuals are responsible for embedding a design mindset within the internal culture of the ATO rather than employing designers as authoritative members in a project team. This adds weight to the hypothesis that design thinking is not a skill possessed by a single head designer, or formal designers, but is a by-product of collaborative efforts of all team members working within a design process methodology and philosophy.

Training in the ATO is not just for enabling and teaching non-designers. Designers and design teams in the ATO also participate in training workshops that focus on business lines of the ATO system "Business Solutions is developing training to help designers better understand the enterprise business processes and systems" (Artefact 1, ATO Design Guide, 2008, p.8). To best implement sustainable design thinking capability, it is important that both non-designers learn about the design process and designers learn about business processes.

Yet, the design facilitator explains that external stakeholders do not need training or experience in design. Interestingly, the design facilitator has no tertiary qualifications in design practice with knowledge earned on the job at the ATO "my background, my experience in design started at the ATO. So I don't have the tertiary qualifications or anything like that, mine was all on the job training and experience that was gathered that way" (Design Facilitator, Interview, 2014). However, she explains that those external to the design team often are not even aware that they are engaging with design thinking practice (Design Facilitator, Interview, 2014). From the facilitator's perspective, not everyone involved in the project team is a design thinker or needs to be. The primary objective with non-designers is to ensure that they end up 'buying in' to the design process. The design lead in the co-design team echoes this sentiment, explaining that the design lead's major responsibility is to convince others to buy into a design thinking philosophy "so one of the questions later on is about 'is everyone a design thinker in the process?' Well the answer is no, but the role of the design lead is to ensure that there is buy in into the design process— that these people are advocates for the change" (Co-design Lead, Interview, 2014).

5.3.8 Evidence and implementation

Design thinking in complex environments such as the ATO contain all orders of design thinking and practice. As the design process converges, clarifies and becomes more defined, designing in fourth order practice moves through lower orders of practice. The project process in the ATO begins with high level, systemic design thinking (intent) before identifying a service solution (blueprinting), design products (co-design) supporting the service, and finally communicative collateral (build products and implementation). Once an intangible design goal has been defined, tangible artefacts begin to emerge that are necessary to support the design of the high level solution.

As a result, design process and thinking in the ATO operates according to different hierarchies. The layers behind design practice at the ATO indicate the existence of hierarchical design processes. Higher orders of design are more complex but less detailed, with design outcomes moving through lower and more detailed and specific design practices as designs are implemented.

The success of design thinking in complex environments such as the ATO is twofold: successful implementation of designs internal and external to the ATO system. For internal implementation, design products, services and systems need to be "integrated within the existing tax system" (Artefact 1, ATO Design Guide, 2008, p.4). Effective implementation within the ATO system relies on integration. Design at this level is not about applying a designerly approach towards tackling briefs, but about incorporating both internal design capability with design solutions. Integration is also about negotiation and compromise, as "It involves achieving a trade-off between potentially competing requirements of the user experience, maintaining consistency with the current revenue system, and cost" (Artefact 1, ATO Design Guide, 2008, p.4).

The intent statement has a direct impact on implementation. Designs are evaluated prior to implementation and examined on the basis of meeting the original intent:

> A shared understanding of intent is critical to the success of any project.
> If we don't know where we're going, how can we expect to get there and
> how can we assess whether or not we have arrived successfully?
> (Artefact 1, ATO Design Guide, 2008, p.13)

> We have the strategic intent at the beginning of the process. It is always at
> the back of our mind that what we are doing along the way doesn't impede
> the capability of that in the future, and do process by process to get there
> (Design Lead, Interview, 2014)

Once the final design has been user tested and approved it is then passed to the business line to be implemented. It is at this point that the project is passed from the hands of the designers and the core design team to the business team. Despite the transfer, the design does not transform during the implementation process. Intent provides the theoretical framework that guides and directs design development and outcomes. The overarching framework provided by the intent statement is directly reflected in the implemented design solution. The foundation provided by the intent framework ensures that the design solution does not transform once in the process of implementation. The design outcome is seen as a representation of the collaborative input from internal core design team members, external stakeholders and users. Because of this, the integrity of the design outcome is preserved; no individual has authority to fundamentally tamper or alter the final designed artefact. There is an underlying importance embedded in the design artefact beyond just the success of the solution. The designed artefact is the manifestation and embodiment of teamwork and collaboration "the design is a culmination of all of those points of views" (Business Lead, Interview, 2014):

> We would be expecting to, once the design is established and we're going to implement, we would be implementing as per the design
> (Business Lead, Interview, 2014)

The design remains true to the collaborative efforts of all core design team members and stakeholders. It is preserved through constant reflection over the intent. Thus, intent becomes a base measure for evaluating final implemented design solutions and becomes a measure of investment:

> In the process we go back and review the intent statement; what we've done what we've designed…does that relate to the intent? Because what we usually do is we have an intent statement from the beginning of the process and then you go through your design, formulate the high level design and then you get to the end of it and go "ok let's have a look at the intent statement"
> (Design Lead, Interview, 2014)

A post-implementation review is often undertaken after the design has been implemented by the business line. This post-implementation review is conducted by the business line and does not involve the design team who created the designed solution. As a result of this, evaluation measures are quantitative and focus on data points than qualitative user satisfaction. Website hits and efficiency of the design outcome are common evaluation measures:

> In terms of the testing that we do, immediately after implementation, is more around does it work or doesn't it work. If it doesn't work we are not prepared to sign off on it or accept it from a business perspective. We would be looking

> to try and resolve some of those issues or areas with whatever the bugs are in the system […] generally speaking it would be picked up before its actually implemented but sometimes you know those issues will not be identified until we actually go live and have some real life data to test
> (Business Lead, Interview, 2014)

No qualitative user evaluation is conducted after implementation. This has been acknowledged by the project lead as an area for improvement in the design process at the ATO, "What we didn't do is we didn't go back and check with the real user" (Project Lead, Interview, 2014). This contradicts much of the philosophy behind the design process – where employees emphasize user satisfaction. Because of this, it appears that the design process in the ATO is more about providing a way of effectively collaborating and efficiently iterating through problems than it is about evaluating design solutions. The design facilitator acknowledges that a design process creates successful outcomes, yet designers do not have involvement in post-implementation evaluations and are not briefed on the quantitative measures that are conducted by the business team (Design Facilitator, Interview, 2014).

5.3.9 Hurdles of design thinking

Of interest to this case study was what constituted complexity. Complexity in this case study was attributed to client relationships and stakeholders in the design process where a large network of individuals is required as part of the design process. The co-design lead describes projects at the ATO as "not complex, but complicated" (Co-Design lead, Interview, 2014). He states that it is "the combination of complicated problems with complex processes that together makes design practice in the ATO complex" (Co-Design Lead, Interview, 2014). However, the co-design lead adds that the design process itself makes the inherent complexity of the ATO more manageable. In his experience as a designer, he argues that the difference between designing on smaller scale projects and large complex ones found in the ATO is that large scale design projects are more iterative and have a higher degree of engagement with stakeholders (Co-Design Lead, Interview, 2014). This engagement requires all parties to participate in the design process and be informed:

> The activity itself isn't more complicated, it's just the infrastructure and process around it. Trying to make sure you get from a to b, where you're kind of keeping everyone happy with their views and it's really kind of getting a balance between views …this goal and the business goal… and getting the constraints right in the process
> (Co-Design Lead, Interview, 2014)

> The complexity really more or less tells me that I need to engage the end user a lot more and really say "does what we build meet their expectations that is usual to them?"
> (Project Lead, Interview, 2014)

Because the nature of design in the ATO is more complex, yet inclusive, the co-design lead believes that the authority that members of the core design team hold on behalf of their respective department alleviates much of the complexity in the design process (Co-Design lead, Interview, 2014). This is crucial towards moving forward; when the design process needs to balance so many people and decisions in its development.

At the core of complexity lies one of the most common complaints around implementing a design approach: the difficulty in explaining the value of design thinking to stakeholders. This misunderstanding of value impacts on the degree of 'buy in' that stakeholders hold towards adopting a design approach:

> The most common problem that we have, that I have anyway, is the value. So people don't understand the value of design, that it's going to work. People just want to map out step-by-step what the solution is going to be without thinking the right process that needs to take place. The biggest hurdle for me is a combination of value and what I kind of say "I know the answer". If you got someone that thinks "I've got the answer to this, I'm just going to design it myself", you know, that commonly is not going to be a good outcome
> (Design Facilitator, Interview, 2014)

Another primary obstacle was client's coming to collaborative meetings with predefined problems, often accompanied with prescribed solutions. Holding onto an answer to a design problem was described as the "antithesis" to the empathetic mindset behind design thinking (Design Facilitator, Interview, 2014). At its worst, a design problem will be handed down from policy that includes a defined solution. In this instance the design team cannot change these recommendations and instead need to work within the problem-solution space given (Design Lead, Interview, 2014).

Transforming hardwired mindsets of stakeholders was an overarching obstacle that persisted throughout the design process. The design facilitator at the ATO argues that it is the thinking in design that needs to be improved, not the doing. In doing so, she believes internal culture and capability will be improved (Design Facilitator, Interview, 2014). However, the Design facilitator adds that the key to achieving this is for clients and stakeholders to be engaged in the process, through actually 'doing' design. Seeing first hand the innovativeness behind a design approach, will increase advocates for design thinking thus enhancing and building on the internal design culture:

> You are having to go through something to break peoples minds down, typically in a workshop and you've got at least 2 or 3 people there going 'I don't know what I'm doing here because I can tell you what the answer is going to be at the end of the workshop'. But we get to the end of the workshop and it's not the same as what they thought
> (Design Facilitation, Interview, 2014)

> Those that are new to it are a bit hesitant and a bit reluctant to go there [...] some see it as a hurdle to their process. So it's trying to get that buy in, the value. They see that there's value to the process that can help get a better outcome than what they were initially, or that they could think we're going to get
> (Design Lead, Interview, 2014)

The differing mindsets between business clients and the design team are pronounced. A representative from the business line in the core design team explains that "business will typically say what solutions they want delivered, as opposed to what they want the solution to do" (Business lead, Interview, 2014). This highlights the dichotomy of thought between client and designer; the design team sees problems as opportunities to create solutions that enable end users (taxpayers). In contrast, clients will focus on what the solution should do and thus have a very static 'end' thinking approach. External business stakeholders see solutions in terms of artefacts and numbers where design teams see solutions in terms of people and values (Business Lead, Interview, 2014). In contrast to these complaints, the project lead asserted that there are no hurdles in the design process, but that it is simply hard work "I think it's not so much hurdles. It's hard work. But it's necessary" (Project Lead, Interview, 2014). Overall, persisting with the design process, particularly on external stakeholders, is starting to pay off, "I think that's probably the big advantage… to really force going to this design, business areas are becoming more accepting of clearly articulating what it is that is required as opposed to how it should be achieved" (Business Lead, Interview, 2014).

5.3.10 Conclusions on a design thinking approach

Design in the ATO has a strong theoretical foundation behind its practice. The design process in the ATO has clear and definite phases, but is also very adaptive and fluid. The design methodology is rigid, as each phase needs to meet certain requirements, but it is the thinking that is fluid and adaptable (Project Lead, Interview, 2014). Without a strict design approach, the projects can become more complex and 'bogged down' in details. "In this regard, it is important to remember the design principle about being disciplined but flexible; follow a disciplined yet flexible process that stays true to our design principles and achieves higher quality in less time" (Artefact 1, ATO Design Guide, 2008, P.7). Design thinking keeps concepts at a high level and holistically pulls ideas together. Despite the reliance on rigid phases and design methods, it appears that the value of a designerly approach employed in the ATO is more about enabling adaptive mindsets than engaging with design methods.

Members of the core design team each hold varying viewpoints on the design process and on design thinking. The design facilitator argues that design thinking in the ATO is more about the mindset than the process. She believes one can engage in design thinking without engaging with the process, but adds that the process enhances the mindset (Design Facilitator, Interview, 2014). However, this contradicts an earlier statement around improving design engagement; that is, stakeholders need to engage in the process in order to achieve a designerly mindset. Still, a designerly perspective is very much a natural attribute of designers, with less experienced collaborators struggling to grasp its inherent holistic thinking due to over-emphasising on details:

> It's about being able to reduce the complexity of it at the high level design... you know talking, people often try to get into that detail and that's a struggle for facilitators to bring people up to the high level discussion. We need to make sure what do we need the system to do not how does the system do it
> (Design Facilitator, Interview, 2014)

The design lead describes design thinking as a process that considers user experiences and expectations. Design thinking guides teams to ask specific, user-centered questions which in turn guides a mindset towards more empathetic solutions. The design facilitator argues that the value behind a design approach lies in the empathetic consideration for user experiences:

> I think the value add is, in design thinking, the user experience as part of the process and it's always throughout our entire design. We always think about what are the user experiences going to be, what is it going to be in this interaction, and making sure it is well considered
> (Design Lead, Interview, 2014)

In addition, the design facilitator believes that the design process is innovative and able to unlock successful outcomes. She feels her role is to inspire collaborative teams into a design mindset. This, she believes, is a journey but also adds that design thinking is not just a reflection of a process but is also embedded in the outcome, "making sure design thinking is in the process, but it is in the outcome, it's also making sure that everyone else is taken on the journey to get to the right outcome" (Design Facilitator, Interview, 2014). Thus, design thinking is transitory and can adapt and change shape with different people and problems:

> That's what I mean about design thinking. To me it can transition, it can move around. It's not just an ATO thing. Our process is an ATO thing. So that's the way we do change management and incorporate designers in change management. Design thinking can be done in private, public and all different enterprises as well (Design Facilitator, Interview, 2014).

Despite speaking positively about design thinking and its importance, the design facilitator could not differentiate between a designerly approach from other processes. Furthermore, no definition could be clearly articulated on what exactly makes design thinking unique to design practice. When asked about the benefit of design thinking and a design approach, there was little commentary on its effectiveness in creating innovative designs and implementation of solutions. Instead, the design process is spoken of from a more personal space, and less so from a solutions-orientated focus. Many team members emphasised the benefits of adopting an empathetic and user-centered mindset, and the benefit of a design process for collaborating with multidisciplinary groups:

> I think that shifting to that iterative kind of model and having the stakeholders engaged right throughout and having people having the decision has kind of helped us a bit more
> (Co-Design Lead, Interview, 2014)

> I think design thinking is about the way which we need to come up with our solutions. The process gets us through it. So like I said, our process is trial and tested and done over and over again and we know that it works.
> (Design Facilitator, Interview, 2014)

It appears that design thinking in the ATO has had greater impact on culture and collaboration than on the development of innovative solutions. Furthermore, the design process has proven that there does not need to be a professional designer leading practice in order to generate design thinking. Designerly process methods such as visualisation techniques carry an agency to facilitate collaboration and design thinking amongst a team of untrained design professionals. This raises questions over the role of the design professional and their impact on the design process beyond that of a facilitator.

6.

Case Study 3

The final case study for this dissertation will focus on the application of design thinking in an online, collaborative environment. This case study has been selected for it extends on Junginger's (2009; 2012) positions of design practice, to provide an example of design activity that is not situated within, or on the periphery of, an institutionalised organization. This case may be considered as a fifth element to Junginger's framework, that is, an example of external design practice operating without direct relationship to an existing, institutionalized organizational system, but instead, as a decentralized open source platform. OpenIDEO was chosen as the subject for the final case study on design thinking in complex environments. This platform applies the design process in an online environment that aims to operate as a decentralized design community, free from traditional hierarchical structures imposed by an organisation or management team. This case presents a complex, de-centralised system that is an open-source network. Furthermore, the subject and focus of the website inherently tackles large-scale complex societal and environmental problems. This chapter will analyse and highlight the behavior of design thinking on this platform. OpenIDEO has been chosen as it is the first project that has formally transferred the design process, and design thinking, onto an open source, de-centralised online network with the aim of tackling complex social issues. This chapter will analyse and highlight the behavior of design thinking in an online, open source platform that has no direct engagement with the design problem that traditionally sits within an organizational ecosystem.

6.1 About the OpenIDEO platform

OpenIDEO is an online platform that encourages members to collaboratively tackle social problems through a design process. Established as a side project by IDEO employees in 2010, today the OpenIDEO platform boasts over 28,000 members (Durst, 2012). The aim of the platform is to "design better, together for social good" (OpenIDEO, "About Us", 2014, para.1) and it seeks to achieve design-focused social innovation through collaborative intelligence.

Solving complex social problems requires depth and breadth of knowledge (Paulini, 2012. p.1). Tim Brown, president of the parent company IDEO, once described his employees as "T- shaped people" (Brown, 2009). T-shaped people have a broad knowledge base combined with a deep expertise in one particular profession. With the OpenIDEO platform, IDEO is able to create a T- shaped community; where, on an individual level, participants bring specific personal expertise but as a community create a breadth of shared knowledge.

Online collaborative activity is referred to as "collective intelligence". According to Paulini, Murty & Maher (2010) collective intelligence is a term given to collaboration that exists in an online open source environment. Collective intelligence is similar to collaboration but with the exception that any individual may participate in the collaboration process. Paulini, Murty & Maher (2010) distinguish between collective intelligence and collaboration, stating collective intelligence is "contributions from any motivated individuals rather than only from a pre-selected team of individuals" (p.2). Paulini, Murty & Maher (2013) further explains that collective intelligence in design "is a type of group intelligence, characterised by high levels of collaboration, as opposed to collected design, which aggregates design solutions" (p.91). OpenIDEO is a platform harnessing collective intelligence through design practice to generate innovative solutions to social problems.

Collective intelligence is a common strategy employed by business leaders seeking to capitalize on open innovation. Open innovation is a term that originated in business strategy and innovation literature and is defined as firms who crowdsource fresh ideas outside of the firm, or who publish ideas for evaluation from the community (Seltzer, & Mahmoudi, 2012, p.3). In private sector innovation, crowdsourcing attracts users to contribute design iterations for solutions that may be used by its contributors. Crowdsourcing, a "process generally associated with private sector innovation" (Seltzer & Mahmoudi, 2012, p.9) was originally coined by Wired magazine editor, Jeffrey Howe (Seltzer & Mahmoudi, 2012, p.7). Yet, according to Seltzer & Mahmoudi (2012), crowdsourcing differs from user innovation in that "crowdsourcing attempts to draw from everyone, user and nonuser alike, whereas user innovation is really an effort by users to better meet their own needs" (p.8). OpenIDEO have introduced a new approach to crowdsourcing and collective intelligence. By combining private sector companies with open source, social innovation initiatives, OpenIDEO provide a platform to support the sponsorship of design for global social issues, tackled by the public using a design process and design thinking.

6.1.2 Data collection and analysis

The OpenIDEO platform presents social issues as "challenges" (OpenIDEO, n.d, "Challenges"). The challenges are problems related to or have been chosen out of interest by a sponsoring organisation. These challenges are accompanied by a brief that has been problem-framed by OpenIDEO employers and the challenge sponsor (Lakhani et.al, 2013). Sponsors fund the implementation of future design solutions in response to the social challenge presented. Challenges are posted to the OpenIDEO website and follow a design process.

The OpenIDEO platform is a dynamic website and in a constant state of development. As such, content obtained for analysis will focus primarily on the platform at the point in time of a selected project challenge. Wider insights and comparisons will refer to the platform as it stands today, however, emphasis is placed upon the analysis and nature of the OpenIDEO platform at the point in time of the project challenge. Analysis for this case study on OpenIDEO will focus on the project challenge, *How might we better connect food production and consumption*? This project challenge was posted in March 2011 (OpenIDEO, n.d, "How might we better connect food production and consumption") and concluded in July, 2011. The project sponsors for this challenge were Arts Queensland and the IDEAS festival, Queensland.

Information about the project challenge, *How might we better connect food consumption and production*, initiated analysis on design thinking on OpenIDEO. Information was gathered about the platform and project challenge at the point in time when the challenge was published. Analysis on this case study focuses on the presentation, functionality and social interaction with the design process and design thinking in this online, de-centralised system. Included in this analysis is the examination of design developments in response to third and fourth order problems presented on OpenIDEO.

Each phase in the design challenge, *How might we better connect food consumption and production*, was holistically analysed to maintain analytical consistency with research analysis of the design process conducted on the previous two case studies. However, the large volume of information available on the OpenIDEO platform and project challenge is beyond the scope of analysis for this case. To manage data overload, limitations on the scope of analysis for this case study was established.

Analysis on the project challenge, *How might we better connect food production and consumption,* focused on archival documentation on the design and development of four design concepts. Comment threads attached to each design concept page exist as a timeline of collaborative design activity. The first thirty comments for each design concept were collected for analysis. Thirty comments is established as the sample size as it best reflected formative stages of collaborative design development which requires a high degree of online interaction and thinking. Conversations in the latter stages of the comment threads for each concept focused on feedback evaluations rather than active and collaborative thinking.

In addition to information collected on collaborative activity for each design concept, general information on the OpenIDEO platform and contextual information about the project challenge were also collected for analysis. Information behind the project challenge brief, including “mission briefs”, was obtained. Mission briefs are mini-tasks assigned to the community during the research phase and are part of the OpenIDEO design process. For the project challenge, *How might we better connect food production and consumption,* four missions were presented to inspire the community to conduct, collect and post research knowledge. Data collected on mission briefs was selected by filtering content according to the highest number of comments. One community post was selected for each mission in the project challenge, resulting in a total of four mission posts for analysis. From the complete data set –that includes comments collected on concepts and mission briefs- a total of 281 comments was obtained for analysis.

In conjunction with archival data collected on the OpenIDEO platform and project challenge, users and stakeholders were interviewed. Five participants were recruited for this case study. Four participants were recruited from the project challenge, *How might we better connect food consumption and production*: Sarah, David, Rachel and Richard who worked as a client to the sponsor Arts Queensland. The final participant, Jake, contributed concepts to a different project challenge that was operating concurrently with this project. These interview participants were selected based on their interactions with the project challenge and/or experiences with the OpenIDEO platform and process. Conversations with participants resulted in over 8 hours of recorded interviews.

The research and analysis conducted for this case study has been designed to maintain analytical consistency. The data collected for analysis was established through comparison on the scope and size of data obtained in the previous two case studies. Coding and analysis followed the same guideline and procedure applied to the previous two case studies presented in this thesis and outlined within *3. Research Framework Framework* [See example from Appendix A, B and C]. As such, codes were assigned to content following a critical realist grounded theory methodology. As with previous case studies, emergent themes will be presented following a chronological outline of the design process on OpenIDEO.

6.2 The project challenge

6.2.1 The Brief

Challenges presented on the OpenIDEO platform are broad. The problem challenge, *How might we better connect food production and consumption*, is framed in context of strengthening relationships between food producers in Queensland, Australia and local Queensland consumers. This challenge, however, is presented in light of a larger sustainable objective; framing a problem that implies a broader focus than the local Queensland community in which it is situated (OpenIDEO, n.d, "How might we better connect food production and consumption?"). Ambiguity is thus inherent in problem challenges with a broad scope and focus such as this challenge.

The sponsor for this project challenge was Arts Queensland. Richard, a client of the project sponsor, was contracted to help develop the project challenge with OpenIDEO. In addition, Richard was contracted to organise workshops for the co-sponsor of the challenge, IDEAS festival; a festival aimed to provide Queenslander's the opportunity to "connect locally, nationally and globally with innovative and diverse ideas and thinkers" (Nolan in Queensland Government, 2011) further enhancing the global perspective of the challenge beyond just the Queensland community. These workshops included key OpenIDEO employees, facilitators and festival participants. The purpose of these workshops was to invite key OpenIDEO employees to present design thinking to a select group of invited individuals. In doing so, concepts developed during and related to the project challenge, *How might we better connect food production and consumption*, were used as ideation activities presented by OpenIDEO for workshop participants. The OpenIDEO project challenge, *How might we better connect food production and consumption*, ran online over three months: from March until June 2011.

6.2.2 Problem framing and the fuzzy front end

For the project challenge, *How might we better connect food production and consumption*, the sponsor, client and OpenIDEO co-created the project challenge statement and supporting brief. The community was not involved in this problem-framing process, nor were they made aware of this process (Interview, Richard, 2014). Thus, the OpenIDEO community must accept the brief developed and defined by the sponsor and OpenIDEO. For this project challenge and others, identifying the challenge (problem) is not made available to the OpenIDEO community. Here exists a "double framing"; where OpenIDEO help problem frame the brief for the sponsor and then for the online community.

As a consequence, OpenIDEO community members often are not solving the same problem. Without participation in the briefing and problem definition phase, a disconnection occurs between the project aim and concept designs. Aiding this disconnection are broad and ambiguous project challenges defined by OpenIDEO and the participating sponsors (Interview, Jake, 2014). The brief for the project challenge, *How might we connect food production and consumption*, asks the OpenIDEO community to:

> Consider issues such as energy use, transportation, biodiversity, food security, nutrition, obesity, the health of rural economies and the strength of inter-generational and intercultural knowledge sharing (OpenIDEO, n.d, "How might we better connect food production and consumption: the brief", para.3).

The broad scope of the project challenge forces community members to interpret and define the problem within the pre-defined project challenge. As a result, members end up problem-framing different needs and define different problems to solve. The broad and ambiguous project challenges on OpenIDEO amplify the 'fuzzy front end', leaving the OpenIDEO community to identify and specify their own problem despite framing efforts by OpenIDEO and the client/stakeholder team. Because of this, OpenIDEO community members are often not answering the same challenge question: "they are very disparate, they aren't solving the same problem" (Interview, Jake, 2014).

The OpenIDEO community do not engage in high-level strategic design thinking and/or problem framing and thus have no agency towards editing or changing the project challenge. Because of this, the OpenIDEO community experience similar frustrations that designers often experience with clients. The online community may feel the common frustration of, in this context, the client (OpenIDEO and the challenge sponsor) bringing a predefined problem within the brief (the project challenge). Jake expressed a feeling of disconnection between the briefing phase conducted by OpenIDEO and the challenge posted, adding that he would have “preferred to have more input in the problem framing and briefing stage for the project challenge” (Interview, Jake, 2014). Jake also added that the ambiguity behind the challenge brief provided by OpenIDEO doesn’t “get to the point where their information is clarifying the problem they are solving” (Interview, Jake, 2014). In order for the online community to effectively engage with the design problem, and design thinking, the problem must be clearly articulated (Seltzer & Mahmoudi, 2012, p.7). When the community has no choice over the shape of the problem or brief, framing the problem correctly becomes a significant challenge for both OpenIDEO and its online community.

6.2.3 Research and Inspiration

Research is the first phase of the design process on OpenIDEO. The research phase encourages community members to conduct both primary and secondary user research (OpenIDEO, n.d “How it works”). For the project challenge, *How might we better connect local food production and consumption*, research is conducted under the title of ‘inspiration’ (OpenIDEO, n.d, How might we better connect food production and consumption?: Inspiration”). Inspiration is a stage where the community conducts research and shares knowledge in order to increase understanding on the challenge topic.

Within the inspiration phase OpenIDEO facilitate “missions” in order to guide the community towards key considerations and perspectives on the project challenge. Missions encourage the community to engage with formative stages of the design process and help the community conduct and collect research for the challenge at hand. Mission statements are tailored to the problem challenge, but broadly speaking, encourage users to conduct primary and secondary research. Missions direct the community towards conducting research in preparation for the following phase, concepting. Missions help the community to gain contextual understanding of the project challenge whilst gathering appropriate insights in order to generate design ideas. With such general project challenges, missions are required for focus but failed to inspire members to conduct or post primary research and obtain direct experience with design research methods.

> " [...] If you live in an urban community try visiting or talking to people you know in rural areas - what are the differences in the way food is consumed (and vice versa)? If you've moved from the city to a rural area or rural to urban - what do you miss in your food experiences? Try talking to parents, grandparents or other elderly people you know. What inspires you about the way we used to view food production and consumption? Are there any other connections between local communities that are not food related but could provide useful insights? Take photos, sketch out maps or diagrams of inspiring connections, tell us stories of how communities come together around food. [...]"
> (OpenIDEO, n.d, "Mission statement 1, Inspiration: How might we better connect food production and consumption?")

Despite encouragement to conduct primary research, the majority of the OpenIDEO community posted information that was sourced from the internet. For the research challenge, *How might we better connect food production and consumption*, an analysis of the first 50 mission concepts posted (filtered by the highest number of comments) contained only three accounts of primary research (Artefact 1, Keys, 2011; Artefact 2, Del Ser, 2011; Artefact 3, Munshi, 2011). In contrast to this observation, interviews with community participants indicated that for some, primary research in the form of user testing and interviews were conducted (Interview, Rachel, 2014; Interview, Jake, 2014). This suggests that more users may have conducted primary research but had not shared this research online due to time and technological constraints.

The next phase, concepting, focuses on ideation and applying knowledge gained from the inspiration (research) phase. OpenIDEO's strength lies in its concepting and refinement phases. These phases afford the OpenIDEO community with the highest degree of autonomy and activity towards the project challenge. Text based dialogue in the form of a chronological comments thread is the main method of communication on OpenIDEO. Thus, analysis of the brainstorming and ideating behaviors between community members requires in depth analysis of conversations between users through comments posted within the concepting phase and phases that follow.

6.2.4 Communication and conversation

For the project challenge, *How might we better connect food consumption and production*, 281 comments recorded from four design concepts and four project missions were analysed. Analysis of conversations during concepting and refinement phases revealed that comments could be placed in two main categories: passive and pro-active participation. Passive participants provide comments that often stand-alone; the aim and purpose is not to trigger or respond to active conversation threads. Instead, passive comments provide support, offer subjective and personal opinions, or add general un-constructive banter. Pro-active participants provide comments that require two-way communication; the aim is to trigger dialogue and actively build upon existing ideas:

> I really like the inter-generational quality of this concept! Also, the photo is awesome. (Comment, passive participant, 2011)

> I really like this idea too and Michael Pollan wrote a great article last year about communities in Italy that have communal hearths that stay lit all day and night; people bring their unbaked bread, their pizza dough and whatever else they might fire in the hearth and end up talking, eating and sharing stories too. Really inspiring-http://www.nytimes.com/2010/10/10/magazine/10dinner-t.html. I wonder how this will bring the production aspect closer though - people are obviously bringing the ingredients to the communal kitchen but where are the ingredients coming from? How much can be grown, prepared and cooked in the same place? (Comment, pro-active participant, 2011)

Pro-active comments were identified as comments that critique, question or actively engage with iterating ideas. Pro-active comments are less common than passive comments. Of the 281 comments transcribed, 114 were deemed pro-active and 167 passive (which includes 12 comments from facilitators). Included within the comments transcribed were conversation threads. Comments that contained three or more respondents was considered to be a collaborative team thread. Comments between only two respondents may be considered pro-active but are not considered a collaborative thread. Similarly, not all conversation threads are pro-active or constructive to the design concept at hand:

P1: I have an idea linked to your concept: can we also add fish to the eatclopedia, and have a 'virtual chapter' called 'fishcopledia' or something like that? The reason: overfishing is a major issue around the globe, including Australia. We all know how healthy it is to eat fish, but we often don't know where the fish we eat comes from, what it takes to have it served on our dinner plate, is it from somewhere close by, etc? I refer to these inspirations: http://bit.ly/glqOlz and http://bit.ly/ffZ26Q. Let me know what you think. My two cents: for the sake of simplicity, I believe we can set up a new concept, but I also want to hear your thoughts...

P2: Yes, good idea. Make it transparent the difference between caught wild fish and farmed fish (and show what these farmed fish eat) because some areas have overfishing only because of the hunt for cheap food for farmed luxury fishes

P3: Sorry been sooo absent. My other full-time job (the one that pays) got crazy. [To P1] I like this a lot! You could totally have add-ons or expansion packs. However, I think this idea can be an app in and of itself as well. I was thinking about it some more, and after reading your posting, I could actually see how it functioned.
(Example of pro-active comment thread, 2011)

The characteristics of conversation threads mirrors characteristics found in face-to-face design ideation sessions. Face-to-face collaboration is "best done in small groups of five to eight participants" (Junginger, 2007, p.62) as small design teams create more focused and efficient conversations. Of the 281 comments recorded from the project challenge, the highest number of comments within a thread was 7. This thread contained four active participants. Conversation threads containing fewer individuals appear more fluid. It appears that face-to-face design issues, such as having too many participants in a design team, are also problems when co-designing online. Individuals appear more engaged when conversing directly between few members in a thread. Furthermore, a smaller group of active commenters appear more engaged with the project at hand and thus create a more personal, collaborative conversation. However, when online, smaller conversation threads may create 'exclusive' conversations; once a thread evolves between few individuals it becomes hard for other members to keep up or 'jump in' on the conversation:

P1: I've been thinking about this a little bit—not just about this app but any of the services that require some buy-in/interest. At the end of the day, you got to create something that people want to use (in addition to it being easily usable) [...] So to build on your awesome question: what other concepts here could be a "gateway/portal" that might do the job of and fit in well with? *I could use your help here

P1: Here is Sarah's idea:
http://openideo.com/open/localfood/concepting/any-ideas-campaign/

Here is Kara's idea:
http://openideo.com/open/localfood/concepting/make-it-a-maze-ing/
I'm sure there are tons more (if anyone sees them let me know)

P2: here are two of mine, that could work in combination:
Enabling off-line social gaming and other fun things, IRL:
http://openideo.com/open/localfood/concepting/funny-trendy-ironic-improvised-influences-and-inspiration/

Giving monetary incentive, by simply choice of recipes and method of cooking:
http://openideo.com/open/localfood/concepting/-power-diet-2013-economy-focused-home-cooking-manual-wiki-or-app/

P3: I like the three ways you're describing of getting folks engaged. For me the most powerful is the third one- how to get people's interest; what shall be the trigger? I'm thinking of a trigger like...you get tagged in a photo on Facebook with very high probability most people would check the picture and see which photo, who tagged them, etc. Two ideas along these lines: 1) why not have fruits/vegetables that are associated with certain months? [...] 2) you describe in feature 6, that the consumer can pin a farmer; what about giving a rating to the farmers produce. Every farmer will be interested to know what customers say about his/her produce. What are your thoughts?

P1: Your wall of creative logic is solid! Will have to go back to the batcave and build these out a bit into optional builds- especially rating the farmer! [to p2] ill take a look at these thanks

> P4: Amazing concept! I love [P2's] idea of a rating/review of the product, which would be an incentive to use the app, and also stimulate demand for the products deemed by the crowd to be the best"
> (Example of a long comment thread, 2011)

In contrast, progress is hindered by long conversation threads. It appears that online co-design and brainstorming discussions are more sensitive to interruptions. Unlike face-to-face conversations, a break in online discussions through the introduction of a focused conversation thread appears to affect the flow of collaboration and emergent, collective thinking. In addition, progress is hindered by the repetition of ideas. A large network of members increases the tendency for posts that repeat what has already been said. Members are aware, and sometimes admit that they did not read earlier comments, "I must admit that I haven't read all the comments below, but I just wanted to add something that might help, on the technical side of things." (Comment, 2011). Submitting comments without knowledge of prior iterations slows the ideation and refinement process. This again reduces the effectiveness of perceived collaboration that is advocated on OpenIDEO, as members rarely interact as a group and instead comment independently.

Active conversation threads are few and far between. The majority of the comments observed are directed either at an individual (usually the owner of a concept) or posted as a general comment on the project idea. There is a wide variety of individual commenters interacting in each project challenge, yet, very few ask questions in order to prompt conversation such as posing questions to the community. Comments that do pose questions to prompt conversation often are lost amongst the general thread. To eradicate this issue, commenters hoping to spark conversation will do so directing their questions to another member. This may initiate an active thread, but it does so at the possible exclusion of other members. Contrary to research conducted on open source collaboration (Luther et al 2010; Paulini, Murty & Maher 2011, p.11), there did not exist a high degree of banter between commenters. However, observations on collective activity on OpenIDEO proved that there exists a core group of pro-active individuals who comment regularly across and within different concept threads, corroborating research conducted by Fuge et. al. (2014). These are considered highly active participants.

6.2.5 Language

The language on OpenIDEO is personal and introspective, but not reflective-in-action. Comments observed describe preference on behalf of oneself rather than of a user group or community. Expressions such as “I think”, “I like” or “I love” dominate discussions. There is little consideration given to a team, overarching community, or the community where the solution will be delivered. Commentary based on personal preference was often given as means of support. This observation confirms research conducted on open source collaboration by Paulini, Murty & Maher (2010) who also observed that “voicing agreement to other’s ideas was high, indicating an emphasis on social support” (p.10):

> P.1: I like this idea a lot. I also like Janet’s comment about taste, and I think that a good approach is to emphasize the good qualities and not call it ‘imperfect’ implying that there is a ‘perfect’ that is better. Maybe even try charging a premium for ‘high-flavor tomatoes’ or ‘exotic enormous strawberries’.
> (Example of supportive comment, 2011)

> P.2: Nice I really like this idea. I imagine it could tell you what produce is in season as well. I also appreciate the mobile device stats though I imagine these numbers to be growing, which is even better news
> (Example of supportive comment, 2011)

Inclusive language is a rare occurrence amongst discussions on OpenIDEO. Very few members commented using inclusive language, such as “we”. Personal and introspective comments on an online platform such as OpenIDEO creates a dominating characteristic within conversation threads that appears to corrode collaborative design thinking activity. With the majority of individuals offering personal opinions, conversations on OpenIDEO do not encourage, reflect or inspire feelings of collective collaboration. This contradicts research referred to in the introduction to this chapter; that online collaborative activity exudes collective intelligence (Paulini, Murty & Maher 2010; 2013). Rather, the platform predominantly operates as a mechanism for one-way feedback directed to an individual’s design idea. Furthermore, the positive culture creates a high degree of support but low degree of critical thinking. This creates a positive consensus or collective bias; a characteristic that is counterproductive to generating innovative ideas (Seltzer & Mahmoudi, 2012, p.8; Fuge et. al., 2014).

6.2.6 Divergence and convergence

Convergent thinking dominates discussions during collaborative activity on OpenIDEO. Conversations during the concepting and refinement phases of the design process centered on design details. Community members, particularly passive commenters, offer ideas and improvements that focus on finer details of the concept at hand. Very few members offer comments that aim to establish the design idea within the overarching brief, or emphasise holistic and divergent ideas. As a result, conversations often are "caught up" in the details of ideas. This habit may disable a fundamental characteristic that is required when design thinking for complex environments: the inclusion of systemic and/or strategic thinking. The lack of problem definition and framing may be disabling the community's ability to refer concepts back to the larger problem challenge "it doesn't really have the divergent convergent thing that you would normally have in a design process. It diverges and converges once. There's one diamond in the entire process and in normal ones there's two or three" (Interview, Jake, 2014). Jake argued for greater emphasis and interaction with the problem definition phase, with purpose for better enabling the community to design concepts against the problem to resolve:

> I felt there should be another stage where you go back and go "ok all this information people are collecting, what we are trying to solve is this? The problem we are trying to solve...here are the things to solve it, here are your constraints" and I definitely wanted to be involved in that stage
> (Interview, Jake, 2014)

Once again, the broad and ambiguous problem challenge may also hinder the ability for OpenIDEO members to think strategically as there is no engagement with formative high-level design thinking that exists during problem framing and problem identification:

> Well, I think especially items that combine several ingredients in them could be good targets. How many miles have the ingredients travelled combined to the site of production, and then from the site of production to the store. That would mean that the app would also have a GPS reading in it, so that it can calculate the last miles. It would be a very good add to the GoodGuide app that already exists as well. Great thinking! (Example of convergent thinking, comment, 2011)

However, divergence was not completely lost. While a few individuals exhibited divergent thinking, the divergent thinking that was observed was not strategic. Divergent comments focused on meta-narratives of the concept at hand:

> This might also be a great way to begin conversations on a whole range of other issues surrounding unconventional. Since we can so tangibly touch and feel fruit and veg, it is a great analogy to get young people thinking about norms and conventions. Great idea!
> (Example of a divergent comment, 2011)

These comments describe philosophical reflections and identified the broader importance of the idea.

6.2.7 Quality of interaction

A great merit of OpenIDEO is the quality of communication and interaction between community members. Members are extremely positive and encouraging towards each other. Almost all comments observed for analysis included a statement of support. David states that he would have been "demotivated by deteriorating conversations" that is often prevalent with online social media platforms (Interview, David, 2014). The nature of the OpenIDEO community emphasises and inspires respectful and positive interactions. However, quality communication does not equal quality collaboration. As mentioned, collaboration is more representative of feedback with few active threads containing conversations that actively and collaboratively build upon ideas. Collaboration on OpenIDEO is more representative of a mass of individuals offering advice and opinions than active co-creation through online conversation. This may be largely attributed to a lack of critical thinking. Comments containing reference links to inspirations and similar ideas are common, however, of the 281 comments observed, none posted references to a vetted source. David commented on the lack of evidence behind ideas and the assumptions posted on the OpenIDEO platform, adding that this significantly declines the "quality and merit of collaboration on OpenIDEO" (Interview, David, 2014). As a result of low co-creation, user feedback is not constructive. Amidst passive opinions, Rachel observed that she did not find user feedback useful when building or refining her idea (Rachel, Interview, 2014). Jake concurred, also describing conversations as "un-useful", "lacking merit" and vetted information (Interview, Jake, 2014). With passive, personal opinions dominating discussions there are few constructive conversations from which to pragmatically co-create ideas.

6.2.8 Visualisation

Visualisation is a vital element in design thinking and design practice. On OpenIDEO, visualisation is utilised when users present a concept that requires visual imagery to support, transfer and communicate their idea to the community. Visualisations are created by owners of concepts, or are contributions sourced from the internet. Yet, visualization is not highly utilised amidst collaborative discussion threads during ideation. During these discussions members often share web links to existing examples, however, of all comments collected for analysis, none posted visual artefacts one would normally find in face-to-face collaborative design environments during phases of concepting and ideation; such as iterative sketches, diagrams and maps. In addition, commentary on the aesthetics of ideas was not a common occurrence.

OpenIDEO highlights the impermanent and ephemeral characteristics of visualisation activity in the design process. Interestingly, interviews with participants revealed that visualisation methods were utilised in order to clarify and evolve ideas, but were conducted offline. Rachel admits to sketching, adding that a downside to participating in an online design platform like OpenIDEO is "needing to transfer photos of offline work" (Rachel, Interview, 2014). Echoing sentiments around the research phase, Sarah also admitted to taking the design process offline, through sketching visualisations, but noted that these offline visuals were "spur of the moment" and conducted only when required for communicating ideas to the OpenIDEO community (Sarah, Interview, 2014). These reflections may signify that the act of visualisation during design activity is best enabled when individuals can immediately connect and reflect over the visual artifact emerging before them. Thus, visualisation in the design process may depend on immediacy in order for the act of sketching and visual co-creation to occur. The impulsive nature of visualisation activity in the design process emphasises the need for immediate and organic interactions that enable unrefined ideas to evolve within a team.

6.2.9 Knowledge sharing and experience

Multidisciplinary experience is a key characteristic of online collaborative activity on OpenIDEO. Design thinking is often described as utilising multidisciplinary teams that combine a mix of professional expertise (Dunne & Martin, 2006; Owen 2005, p.14; Sato et al., 2010). However, on OpenIDEO, multidisciplinary collaboration is not an example of professional expertise but of personal experience. Thus, experience levels amongst the community on OpenIDEO vary; from members new to design practice through to design professionals. These diverse experiences bring a range of perspectives on complex problems and design thinking.

Contributing ideas on the OpenIDEO platform does not depend on one's level of design experience, but knowledge on the content of the project challenge (Interview, David, 2014). One of the most common forms of knowledge sharing conducted on OpenIDEO is sharing experiences from one's own lifestyle. Knowledge shared that is based on experience often refers to anecdotal or cultural references related to the challenge or concept idea:

> If I didn't really have a background in it [the project challenge], it was really difficult for me to then jump in and contribute. That's where I really only looked at the ones that I felt I could add value to (Interview, David, 2014).

> I really kind of just participated in challenges that I knew the content about or things like that so I didn't participate in those that I didn't know anything about
> (Interview, Sarah, 2014).

As many members do not possess in depth knowledge on the challenge at hand, subjective opinions based on preference and cultural experience is all many members can comment with authority (Interview, Sarah, 2014). Contributions of this nature are heavily influenced by their surroundings (Interview, David, 2014). This may also influence or explain the many comments expressed using personal language such as "I think" or "I like".

In addition, a large proportion of knowledge shared is from recollection. It was observed that many commenters provided information from memory and provided no formal source or reference. Compared with more professionally driven design projects requiring client buy-in, the activity on OpenIDEO lacks rigor, expertise and resources to validate design ideas:

> As a child I used to be terrified of siamese twin bananas, tomatoes with extra bumps on them […] but I've always advocated loving people in all shapes and sizes. This is the first time I am empathizing with 'love all vegetables' at least in theory. I don't know if my knee jerk fright will go. But I wouldn't mind if someone cut up or juiced it for me. Lol."
> (Example of anecdotal comment, 2011)

Without users explicitly stating so, it is difficult for participants to gauge the level of expertise and experience of fellow users. This blurs the line between inexperienced commenters and experienced professionals. Without a sense of intellectual hierarchy, contributions made to the platform are seen as equal. Contrary to research on online collaborative forums conducted by Paulini, Murty & Maher (2010, p.10), the OpenIDEO community rarely signpost personal and professional expertise. Conversations centered around preference rather than proving authority or expressing professional experience. The supportive and inclusive attitude of OpenIDEO may deter individuals from posting authoritative comments of this kind. However, those that did state an authoritative position became central to discussions. Of the 281 comments observed for this case study, only two individuals explicitly stated professional expertise and knowledge on the challenge topic at hand.

Authoritative “expert” commenters are central to development and discussions on project concepts. These individuals are active and display a higher degree of critical thinking; highlighting gaps and problems in the current design concept. Furthermore, these individuals are more confident with pushing ideas outside of the “comfort zone”; discussing sensitive issues and pointing out errors in ideas presented. These individuals aim to actively challenge the concept rather than passively support ideas. Authoritative and expert members are more practical and realistic in their support and advice:

> I am currently in the middle of building a website which is pretty much doing exactly what you so excellently propose, only consumer created. […] So, a few quick notes from someone with several months of research…
> (Example of an expert member comment, 2011)

> Thank for sharing your expertise and knowledge of this area. Do you think vertically integrated retailers who run their own farms (such as the Co-op in the UK), have the detailed product information this concept would require available internally?
> (Example of a response to expert member comment, 2011)

Interestingly, members who make themselves known as experts with authority on the topic at hand are not questioned over their experience. Professionals are readily accepted and their advice absorbed by the community without evidence. Conversations threads also appear more efficient during ideation; with community members seeking help from perceived experts. This may signal a need for combining expert mentors to aid with online open source collaboration.

6.2.10 Roles and Archetypes

Common archetypes emerged amidst interactions on OpenIDEO. Without clear hierarchies or pre-determined positions, self-forming roles amongst members on OpenIDEO have been observed through the identification of archetypes. These archetypes have been split into two groups pro-active and passive as identified above.

Pro-active archetypes comprise: the pragmatist, the inquirer, the conceptor, the cross-pollinator and the expert (Table 2). The pragmatist is practical and critical, focusing on critiquing ideas for feasibility and implementation. The inquirer stimulates conversation by posing questions for discussion. The conceptor is an active member by default, as this person is the creator of a design concept and has a vested interest to actively participate in feedback from the community. The cross pollinator makes connections between different challenges and ideas presented on OpenIDEO. Cross pollinators are often active within a few different project challenges. The expert is an authoritative figure, asserting their position and expertise to the community. These individuals typically situate the idea within a wider narrative and discuss its broader importance.

Archetype	**Example**
The pragmatist	Transparency will be key in a market where many times the farmer doesn't know what the final price or final product of what he produced is. [...] I agree with Steve that it would work well with product that is already certified since they already have some infrastructure to capture that story (Comment, 2011)
The inquirer	I love this idea, Laura! It not only informs the end consumer, but also obligates the companies to think about their footprint and make that information accountable and accessible to the end user. I wonder who could objectively develop the app for the companies, trying o be as transparent as possible? (Comment, 2011)
The conceptor	Sorry for the late rely, Mark! Thanks for the links, I haven't seen this before- it's great! Building on an existing infrastructure is pretty much essential for this to launch successfully (Comment, 2011)

The cross-pollinator	Great idea, Laura! I just posted a similar idea before I saw this of create labeling to tell the same stories (http://openideo.com/open/localfood/concepting/print-the-process-on-the-packaging/?status_message-Sucessfully+Updated) (Comment, 2011)
The expert	Reverse engineering the origin labeling is possible with a simple routing engine based on estimations. See "on information availability' para. This routing-classification data method is used on http://www.sourcemap.org/ in the short term it's probably the most realistic (Comment, 2011)

Table 2: Pro-active archetypes on OpenIDEO

Passive archetypes consist of: the supporter, the filler, the add-on, the promoter, and finally, the facilitators of the platform including the client (Table 2). The supporter is a person who offers nothing but encouragement and affirmation on the idea presented. The filler provides un-constructive information and sometimes engages in banter. The add-on is an individual who briefly builds upon an idea or provides a reference to a similar concept. The promoter is an individual whose sole purpose is to spread publicity and direct conversations to their own concept page. On the more administrative side, facilitators work on behalf of OpenIDEO including the client. Facilitators have a passive role and function primarily to provide encouragement.

Archetype	**Example**
The supporter	Hey Valerie, I really like the inter-generational quality of this concept. Also the photo is awesome (comment, 2011)
The filler	Strawberries are my #1 favorite fruit. That huge one looks delicious ☺ (comment, 2011)
The add-on	Nice I really like this idea. I imagine it could tell you what produce is in season as well. I also appreciate the mobile device stats though I imagine these numbers to be growing, which is even better news (comment, 2011)
The promoter	Great idea, louise! (comment, 2011)
The facilitators	lost for words. But there's 14k of you on OpenIDEO these days who

	should all have something to add to this exceptional conversation starter (comment, 2011)

Table 3: Passive archetypes on OpenIDEO

Of all the archetypes described, the conceptor holds the most important position. Being a conceptor demands active participation and as such, affords the highest level of interaction with the design process and design thinking on OpenIDEO. The conceptor is the most engaged individual on the platform and must address ideas and support within their concept thread. Ultimately, conceptors gain the most out of participating with OpenIDEO.

Despite the exclusion of problem framing from the OpenIDEO community, conceptors still try to engage with framing the challenge in order to situate their ideas. The community also enable the conceptor to shift their perspective on their own designs. The OpenIDEO community offer feedback that not only provides support but diverse viewpoints. Through this, the conceptor engages with a form of problem framing and re-framing, or at the very least, to shift their own perspective. Thus, the perspective of the conceptor broadens as feedback from the community is provided, particularly on differing cultural world-views. However, this act of perspective re-framing seems to exist as benefit only for the conceptor who has the greatest vested interest in synthesising feedback:

> Thank you for this observation, Aaron! I didn't notice it, but it's true. I think it is easier for people to relate to it that way and I am often inspired by those personal stories that mostly take place within your most inner social circle (Example of a conceptor comment, 2011)

Following concepting is the refinement phase. This phase is where the conceptor must engage with information presented by the community and synthesise feedback into a refined solution. Thus, conceptors act as synthesisers of information. Throughout ideation and refinement, a conceptor must pay attention to feedback threads; iterating and updating their idea as threads evolve. Conceptors are more likely to pull conversations out of convergent details and direct focus back to the overarching purpose behind their idea. Thus, they are more likely to see when ideas are becoming too detailed and complex and aim to keep conversations holistic. For the conceptor, iteration is often about building a different viewpoint.

6.2.11 Facilitation

Facilitation on OpenIDEO focuses on motivation, ensuring all community members have a say and are actively contributing to the project challenge. Facilitation on OpenIDEO is conducted through OpenIDEO employees and selected high profile users titled "community managers" (OpenIDEO, n.d, "Kadri"). These individuals are responsible for facilitating community involvement throughout the design process.

Facilitation on OpenIDEO is passive. There is little direction from professional designers, with OpenIDEO employers engaging with the community in an unstructured and un-authoritarian manner. Facilitators motivate the community and provide communication when required. This context has shifted design collaboration from what was once led by a design expert (thinker), towards de-centralizing the design expert may be perceived as the embodiment of design thinking. Fundamental to this decentralisation is for OpenIDEO managers to "learn how to become effective facilitators of innovation for co-creation initiatives" where "understanding what motivates innovation" is key to "mastering the facilitator role" (Gibson, 2012, p.62). This provides more autonomy prescribed to the community, enabling members to better engage with design thinking as independent designers.

6.2.12 Refinement and evaluation

Refinement and evaluation follow the concepting phase. Once concepting has finished, OpenIDEO and the challenge sponsor step in to select the top 20 ideas they believe have potential to move to the refinement phase (Gordon, 2014, p.39). This selection is conducted privately between OpenIDEO employees and the challenge sponsor. Community members have no sway in selecting the best concepts for refinement. Concepts can be self selected by the community through the number of 'applauses' that are given to an idea (OpenIDEO, n.d, "How might we better connect food production and consumption?: Refinement"). This crowdsourced selection is taken into account when OpenIDEO and the client decide on final concepts for refinement (Richard, Interview, 2014).

Refinement is a phase that emphasises polishing ideas and prototyping concepts. Members make refinements on their concepts based on community feedback, yet these iterations are often text based. Offline sketches and refinements conducted by members are rarely published back online and there is no obvious feedback phases or actions (either individually or collaboratively) on the OpenIDEO platform besides evaluation surveys. Jake criticised the platform, stating that he felt there "should be more iteration" once members began to focus on refinement, to see "if they addressed the problem that they identified" (Jake, Interview, 2014). David also critiqued OpenIDEO on iteration, adding that there was "no oversight on the platform and thus no review over ideas" (David, Interview, 2014). This provides further evidence supporting the claim that OpenIDEO members may not be holistically interacting with key activities and phases in the design process. As a result, strategic thinking, reflective iteration and problem evaluation is not evident amongst conversations on the OpenIDEO platform:

> Another update: Included A-Z listing, and some mock-ups with attribution and explanation of functionality. NEW STUFF includes: 1) Laura and Aaron's idea about environmental impact of food, and Richard's suggestion to include variations (Example of conceptor iteration, comment, 2011)

Evaluation follows the refinement phase and requires the community to contribute a more focused effort towards selecting top concepts. This phase includes evaluative criteria provided by OpenIDEO and the project sponsor to guide the community in their analysis and evaluation of refined concepts (OpenIDEO, n.d, "How might we better connect food production and consumption?: Evaluation"). It can be speculated that OpenIDEO introduce evaluation surveys to direct people towards a consensus, as it is not possible for such a large community to constructively select a winning concept other than through superficial applause (Salminen, 2012, p.21). Furthermore, the introduction of interactive evaluative criteria allows the community to feel that they have made a contribution towards assessing ideas that will be chosen for implementation.

Once evaluation is finalized, winning concepts are selected by OpenIDEO and the challenge sponsor. There is no set number of winning concepts; as many as 10 or as few as four can be announced in a project. Ten winning concepts were selected for the project challenge, *How might we better connect food production and consumption*, (OpenIDEO, n.d, "How might we better connect food production and consumption?: Winning concepts"). Soon after winning concepts were announced, a realisation phase was introduced in the design process, showcasing concepts that are in the process of implementation (OpenIDEO, n.d, "How might we better connect food production and consumption?: Realisation").

Yet, there is no guarantee that winning concepts will be implemented. Interestingly, realisation is not exclusive to winning concepts submitted by community members who have dedicated themselves to this challenge; any idea related to the challenge that is in the process of implementation can be included as part of the realization phase. This raises the question over the purpose of the winning concepts phase if none of the selected ideas are expected to follow through to implementation. The purpose of the winning concepts phase may simply be an incentive for OpenIDEO members to contribute ideas and interact with the platform. Surprisingly, the realisation phase for the project challenge, *How might we better connect food production and consumption*, contains no user generated concepts. Six project concepts in this phase have been created and submitted by either the OpenIDEO team or the project sponsor (OpenIDEO, n.d, "How might we better connect food production and consumption?: Realisation").

6.2.13 Implementation, ethics and responsibility

Prior to the project challenge, *How might we better connect food production and consumption*, the design process ceased when winning concepts were announced. The OpenIDEO community were quick to recognise the lack of practical implementation that had inspired many members to join. Members on OpenIDEO had no information or assurance that their ideas were to be used and that contributions were not in vain. Due to public demand, a realisation phase was included shortly after the project challenge, *How might we better connect food production and consumption,* to update the public on the implementation of winning concepts:

> In order to address the community's feedback on the realisation phase, OpenIDEO revised its definition of what implementation meant and encouraged users to participate actively in this phase (Lakhani et al., 2013)

The demand for an implementation phase can be attributed to a lack of transparency on behalf of OpenIDEO, as crowdsourcing requires "a lot of transparency on the part of the sponsor" for participants to engage positively (Seltzer & Mahmoudi, 2012, p.8)

> Basically you come up with this idea and then sometimes it just doesn't go anywhere…you came up with the idea or it's a good idea and that's where it ends (Rachel, Interview, 2014)

Furthermore, Lakhani (2013) documented that it was not just community members demanding transparency and engagement with the realisation phase, but sponsors were also asking for a way to report on progress. Since the project challenge, *How might we better connect food production and consumption*, OpenIDEO have renamed their realisation phase (dedicated to implemented solutions) to "Impact" (OpenIDEO, n.d, "How it works"). OpenIDEO have also dedicated a section on its website to showcasing implemented solutions from past challenges (OpenIDEO, n.d, "Impact"). Not all solutions are featured in this section, with many challenges omitted. This raises questions over the practicality and success rate of OpenIDEO and for design thinking in online, open source collaborative environments.

Implementation on OpenIDEO also raises questions over responsibility and accountability (Faste, 2012, p.1). Is it the sponsor, IDEO, or the OpenIDEO community who takes responsibility for implementation and has accountability when concepts fail? Conversations and comments from OpenIDEO members rarely focus on implementation. Few individuals on the platform discuss the practicalities of implementation, including critical evaluations. This signifies that the OpenIDEO community may not see themselves as responsible for concepts they submit. Instead, the majority of discussions focus on positive brainstorming and elaboration of design ideas.

Interviews with participants provide an indication of the attitudes that the OpenIDEO community hold towards implementation, particularly with regards to responsibility. Jake argued that the motivation for him to join OpenIDEO was partially due to the fact that he was under the impression design concepts would be implemented:

> I see the point of design thinking is not to think about it, it is to eventually do something. The platform is actually going to do something in the end. If not, I would have never participated if I thought there was no chance of something actually being done (Interview, Jake, 2014)

Jake contributed a winning concept to another project challenge (operating concurrently to the *How might we better connect food production and consumption* challenge) and took implementation into his own hands. He acknowledged the difficulty in implementation but wanted to "see things happen" (Jake, Interview, 2014). This participant embarked on a journey that landed him in the host country of the sponsor backing the project challenge he participated in. What he discovered was that no individual working for the sponsor was responsible for implementing winning ideas for the project challenge, let alone having any idea of their involvement with OpenIDEO:

> I was like "have you heard of this? Has anyone?" and he [the sponsor] said "I don't know" and he followed up with other people and got back to me and he said "I'm not sure who said to run this" [project challenge]
> (Jake, Interview, 2014).

Jake concluded that sponsor involvement on OpenIDEO was motivated by a desire to increase corporate social profile and/or utilising "left over budget" from the marketing department. As a result, Jake stated he felt "deceived" and "disheartened" by the platform, adding:

> I told them [OpenIDEO] if they are going to get people to sponsor this thing they should probably get the sponsor to do something with it. Because that's the assumption participants would have
> (Jake, Interview, 2014).

Confirming Jake's assumptions, other members of the platform felt abandoned and helpless over implementation. Rachel stated that there was no support for members who wanted to be pro-active in implementation. Rachel believed bigger impact could be made elsewhere, and that the platform was a personal "dead end":

> So that's my problem with it [OpenIDEO]. There's no support system in place and no real benefit to winning other than passively being noticed by the people at IDEO if you want a job (Rachel, Interview, 2014).

Sarah describes a similar story from both online and offline perspectives. Sarah was involved in workshops hosted by the sponsor, Arts Queensland, in relation to the project challenge, *How might we better connect food production and consumption*. She explained that these workshops were facilitated by OpenIDEO staff and aimed to present winning concepts from the project challenge as design activities for the workshop participants. Sarah's impression of the workshops was not that the sponsor or OpenIDEO were responsible for implementation, but IDEO had hoped to see participants offering to implement the concepts presented:

> It was basically not for IDEO to implement, it was for, to be able to see the beginnings of an idea that I guess they hoped someone around the table would fund or take forward and tried to get stakeholders in the room as the decision makers- so the people there who'd be able to take the concept forward (Sarah, Interview, 2014).

In contrast, Sarah admitted that she had no desire to implement her own design solution (Sarah, Interview, 2014). Sarah believed it was the "sponsor's responsibility to implement" her idea, not IDEO's (Sarah, Interview, 2014). Similarly, Rachel felt that it should be the "co-responsibility of IDEO and the sponsor" to implement winning concepts (Rachel, Interview, 2014). Furthering this point, Jake felt that the sponsor should take full responsibility, but IDEO "should provide aid" during this phase (Jake, Interview, 2014). Richard also believed that it is the responsibility of the sponsor to fund and implement ideas (Richard, Interview, 2014). Richard stated that, as the client assisting the sponsor, he felt that responsibility over implementation was partially his but ultimately the sponsor should assume full responsibility for implementing solutions:

> I felt somewhat responsible in making sure something had happened. So that was one of the negative feedbacks of the OpenIDEO platform; that there's lots of ideas but no real responsibility on the part of the challenge sponsor to actually do anything with them (Richard, Interview, 2014)

Clarification was required from OpenIDEO over who is responsible for implementing design solutions. Since the completion of the project challenge*, How might we better connect food production and consumption,* the OpenIDEO platform has made some changes. Today, implementation is described as a joint effort between any active members on OpenIDEO (OpenIDEO, n.d, "How it works"; OpenIDEO, n.d, "How might we make low-income urban areas safer and more empowering for women and girls?": Impact"). This decision to alter information on implementation may have been a conscious move to withdraw assumed responsibility from both OpenIDEO and the sponsor.

Ethics becomes an issue if community members are considered as co-creators and are expected to share responsibility over implementation. It may be beneficial for members to actively engage with the implementation of concepts, however, OpenIDEO members do not abide by legal practicing standards that exist for professional designers and stakeholders. David notes that "it's a casual platform but when taking it offline it becomes professional practice" (David, Interview, 2014). This statement highlights problems with ethical standards when designing through open source collaborative environments, particularly ones like OpenIDEO that deal with serious social issues. A lack of professional expertise may eradicate merit behind the OpenIDEO platform and raise questions over professional and ethical standards in design practice and design thinking.

Measures need to be established that better enable and manage the implementation of design outcomes should the design process and design thinking be enabled through an online open source platform. Doing so may enable more pragmatic and feasible design concepts that will facilitate high quality design thinking. Furthermore, transparency over the implications and responsibilities of implemented concepts requires further clarification so as not to damage OpenIDEO's reputation and indirectly, design thinking.

6.2.14 Transparency of platform

The remote operations of OpenIDEO brought forth the importance of transparency in design thinking practice, especially when applied in online open source environments. The open structure of the platform allows the OpenIDEO community to see each stage of concept development. This encourages the community to be transparent with each other throughout ideation. Members provide as much information and credit as they choose to publish during the development of their ideas. Transparency between members on the OpenIDEO community is constructive and enables members to learn about design thinking, particularly from each other.

However, three factors of the OpenIDEO platform are considered opaque: implementation, iteration and intent. Coincidentally, these three factors are also fundamental to the structure and success of design thinking practice. Jake was quick to recognise areas of ambiguity inherent in the OpenIDEO platform, "So it almost seemed like there was someone trying to use this information as part of a bigger project that I wasn't aware of" (Jake, Interview, 2014). A lack of transparency doesn't just affect OpenIDEO, but the sponsoring organization as well. On the OpenIDEO platform there is little information about the process behind selecting final solutions, including where and how these solutions will be used and implemented. In its early stages of development, the OpenIDEO platform ceased communication once concept winners were announced. Community members began to question where and how their solutions were being implemented, as a lack of transparent information surrounding implementation was generating negative critiques "if it was basically the same and nothing had been implemented I would talk heavily badly about the platform and also OpenIDEO and maybe even IDEO itself." (Jake, Interview, 2014). As a result, this backlash resulted in OpenIDEO introducing a "realisation" phase.

Ambiguity surrounding the implementation of solutions introduces questions over intent. Opinions over the intent and purpose of the OpenIDEO platform are diverse. Rachel felt that part of the underlying intention of the platform was for IDEO to crowdsource "work for free" (Rachel, Interview, 2014). Echoing this sentiment, Sarah stated:

> Kind of masking it under the umbrella of social good but really it's a cheap way for IDEO to service clients and a lot of people do work for them for free ...and yeah, if it wasn't under the umbrella of social good it wouldn't have how many thousand of users that they have
> (Sarah, Interview, 2014).

As a result, speculation emerged over OpenIDEO acting as a platform for job recruitment (Richard, line 62). High profile users who are active on the platform have been selected to work either for OpenIDEO or professionally with IDEO (Rachel, Interview, 2014). This was not made explicit on the OpenIDEO platform, but users could see the promotion of active community members to OpenIDEO facilitator roles. Rachel argued that if this was the intention of OpenIDEO, then "the platform was a success" (Rachel, Interview, 2014). However, she added that if the intention of OpenIDEO is for social good and design implementation, then the platform had failed (Rachel, Interview, 2014).

Large corporations may utilise OpenIDEO to increase their corporate social responsibility in an attempt to harness a positive image. Richard expressed his impressions on the motivations behind both users and sponsors interacting with OpenIDEO. Richard felt that the perceived motivation and function of OpenIDEO, social good, was not the case (Richard, Interview, 2014). Richard added that he felt the motivation behind OpenIDEO was about "building brand profiles" and relationships with sponsors to help "increase the sponsors social corporate responsibility index" (Richard, Interview, 2014). Perhaps for this reason, major corporations such as Coke have become involved with the OpenIDEO platform (OpenIDEO, n.d, "How might we establish better recycling habits at home?"). The question remains whether OpenIDEO, and specifically large corporations such as Coke, are participating for 'social good' or to increase their public profile as OpenIDEO relies on large companies to fund design project challenges. Greater transparency around intent of the sponsor, project challenge and the OpenIDEO platform is required to alleviate negative critique that may also impact perceptions on design thinking practice.

6.2.15 Impact

Personal impact was a motivating factor for joining OpenIDEO. Corroborating research conducted by Seltzer & Mahmoudi (2012), Takeyama et. al, (2012), Gibson (2012) and Faste (2012), motivations for joining the OpenIDEO platform were described as intrinsic (Jake, Interview, 2014; Sarah, Interview, 2014; David, Interview, 2014). From interviews conducted with OpenIDEO participants, OpenIDEO was seen as a place to learn about design thinking and to discover what the process and practice is about. Two participants explicitly stated they were motivated to join in order to discover a new career path (Jake, Interview, 2014; Sarah, Interview, 2014). Social good was a secondary motive and one that allowed participants to explore design thinking whilst "feeling good" about their contribution (Rachel, Interview, 2014).

Social media contributed to the perceived impact of winning challenges on OpenIDEO. When probed about the impact participants felt they had on OpenIDEO, social media was quoted as both an enabler and hindrance. Rachel argued that there was "a lot of control" afforded to members over promoting their idea through social media (Rachel, interview, 2014). She admits her idea would not have been considered as a winning concept "had it not been recognised by an OpenIDEO employee over twitter" who re-tweeted her concept to his own audience (Rachel, Interview, 2014). It is for this reason that Rachel felt there was little impact as a collective, compared to the individual (Rachel, Interview, 2014). David also argued that individuals have more control if using the platform in conjunction with other social media outlets and thus sees OpenIDEO as a form of social media (David, Interview, 2014).

6.2.16 Feedback vs. collaboration

Despite perceived collaboration advertised on the OpenIDEO platform, community members are largely independent from one another. Analysis on collaborative activity revealed interactions on OpenIDEO are individualistic. Of the comments observed, the nature of interactions was more akin to 'noise' and reflected a collection of independent comments than active collaboration, conversation and co-creation. Jake attributed the lack of co-creation to the medium "the medium restrains, you don't see people having a chit chat or yelling at each other. So to create collaboration online is particularly difficult and they tried to do it in a fairly traditional manner" (Jake, Interview, 2014). The number of individuals interacting in an online collaborative environment creates dynamics that differ from design collaboration in face-to-face contexts. Online, text based conversations that don't operate in real time often disable the organic evolution of ideas. The result is a platform containing few active threads that reflect collaboration amongst key individuals; threads which are sometimes lost amongst the noise of independent commenters. Furthermore, as mentioned earlier in *6.2.3 Communication and conversation*, these comments are more reflective of one-way feedback than two-way collaborations that inspire co-creation. Jake added that OpenIDEO was not reflective of design thinking as it did not enable the same characteristics that emerge in face-to-face collaborative brainstorming sessions, "it doesn't feel like how you'd collaborate in real life" (Jake, Interview, 2014).

How truly innovative are design-driven collaborative networks like OpenIDEO? Bonabeau (2009, p.51) argues that ideation and evaluation in online communities is weak, and decision-making requires specialised expertise. From the analysis conducted, OpenIDEO is a platform that enables 'designerly' brainstorming, rather than design thinking innovation. With fundamental phases of the design process missing, interactions on the platform reflect diverse opinions rather than strategic ideas, and participants are becoming aware of this "it's not a full design process, but only one part" (Sarah, Interview, 2014). The design activity afforded to the OpenIDEO community centers on ideation and evaluation. This creates a community of brainstorming; activity that offers diverse ideas that are detached from the heart of the project problem. As a result, practical and implementable solutions are not challenged as participants prefer to engage with the 'fun part' of the design process than deal with the details necessary for generating feasible design solutions.

6.2.17 Innovation, authenticity and the traditional studio model

OpenIDEO is advertised as a de-centralised, open source, social innovation platform led by design thinking. Superficially, the OpenIDEO platform appears innovative; harnessing crowdsourcing to resolve complex problems using a design process and design thinking paradigm. Yet, closer analysis on the OpenIDEO has revealed that the platform reflects a traditional design studio structure [Fig.14].

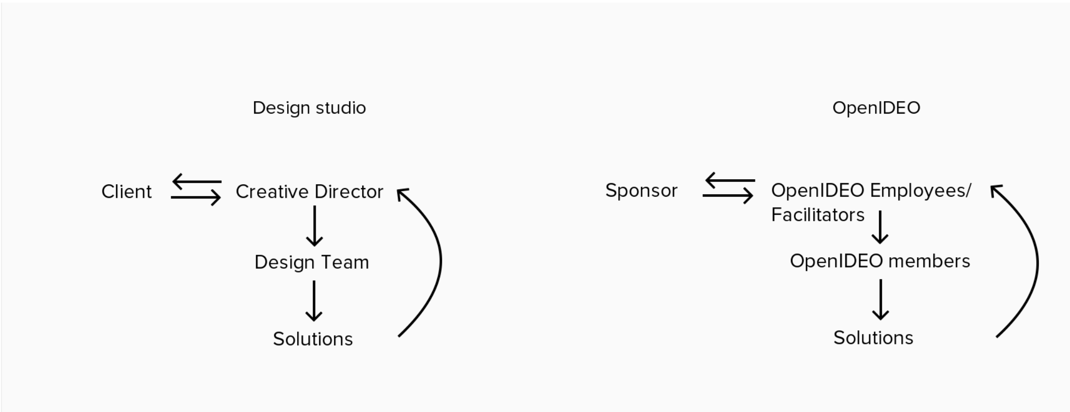

Fig.14 Design studio and OpenIDEO structure

OpenIDEO operates like a design firm where a team of employees (OpenIDEO members) work on client briefs. Facilitators working for OpenIDEO behave as creative directors, and sponsors represent clients who come to OpenIDEO with problems they would like resolved. OpenIDEO employees problem-frame and co-create a brief with the sponsor, as a creative director would with a client. The refined brief is then passed from the creative director (the OpenIDEO employees) to the design team (OpenIDEO members) to help ideate and brainstorm design solutions. The creative director (OpenIDEO employees and facilitators) will provide input during ideation and evaluation, before selecting the most effective solutions to present to the client (OpenIDEO sponsor). The creative director (OpenIDEO employees) and the client (sponsor) then discuss the viability of the ideas created by the design team (OpenIDEO members) before selecting a final solution to be implemented. Once selected, the creative director passes the final design solution to the client and concludes business.

Open source environments are sometimes presented as an online utopia. OpenIDEO appears to offer collaborative freedom but it is not completely open, egalitarian or free. The lack of transparency and ability around choosing social issues, problem framing and implementation, erodes the freedom that should be accessible within open source platforms. The OpenIDEO environment is open and structured in a way so that any individual is free to contribute and take ownership over project challenges. Yet, this freedom exists only within the guidelines of the phases that OpenIDEO make available to the community. The OpenIDEO employees and the sponsor are ultimately in control of the project's problem, conception and implementation. As a result, the design process is not made available in its entirety; the design process is restricted to research, concepting and evaluation. From analysis conducted on this case study, OpenIDEO appears to be more akin to an idea engine, aimed at brainstorming and crowdsourcing ideas than an innovative example and implementation of design practice and design thinking on a digital open source scale.

OpenIDEO identifies itself as "always in beta" to maintain iteration and improvement on the platform (OpenIDEO, 2014). As such, OpenIDEO is dynamic. However, since the project challenge, *How might we better connect food production and consumption initiated* in 2011, minor improvements have been made on the OpenIDEO platform. A few of the participants interviewed felt that OpenIDEO should "practice what they preach" (Jake, Interview, 2014) and iterate on their own platform (Sarah, Interview, 2014; David, Interview, 2014). Many conversations with interview participants centered around improving implementation (Jake, Interview, 2014; Rachel, Interview, 2014; Sarah, Interview, 2014; Richard, Interview, 2014) indicating that a fundamental incentive for the community to participate is the expectation that concepts will be realised. David argues that "OpenIDEO should conduct user research on their users to see what challenges are important to them" and attributes a lack of iteration on behalf of OpenIDEO as "inauthentic" (David, Interview, 2014).

6.2.18 Balance between offline and online interaction

A positive effect from interacting with OpenIDEO is that it enables offline connections. Contrary to its primary function, OpenIDEO enabled some members to use the medium as a platform for creating offline interactions. Sarah articulated how OpenIDEO had created offline networks through enabling conversations with supporters of her idea:

> I remember going to New York for a service design drinks and just by chance one person came up to me and asked me if I had put something on OpenIDEO. He was one of the students from NYU Polytechnic who had implemented some big thing there, like an OpenIDEO club or something. So there's kind of offline, random connections
> (Sarah, Interview, 2014).

Additionally, David also connected with members of OpenIDEO who wished to collaborate offline on his idea (David, Interview, 2014). Offline interactions seemed to hold the most value when engaging with OpenIDEO. In conjunction with learning about the design thinking process, OpenIDEO worked as a medium for connecting individuals with passions for different social challenges.

Offline interactions had a significant influence on the level of engagement members had with the OpenIDEO platform. David states that what kept him motivated on OpenIDEO was the culture of the community he was residing in at the time of the project challenge, *How might we better connect food production and consumption.* David commented "offline I was involved in a lot of different and diverse communities and because of that it helped me to continue that online. The biggest change was in 2012 I left and the offline experience was just not the same so I wasn't involved in anything besides my work" (David, Interview, 2014). Similarly, Sarah who participated in an offline workshop related to the project challenge argued that the workshop had the most impact than her interactions with the platform (Sarah, Interview, 2014 line 23).

6.2.19 Conclusion

Professional design practice and design thinking may be leveraged en masse based on the theory that crowds operate more intelligently than individuals (Seltzer & Mahmoudi, 2012, p.8), The question motivating this analysis is how the OpenIDEO platform leverages or hinders design thinking.

OpenIDEO describe their design process methodology using a five-step design process of: research, ideas, applause, evaluation and impact (OpenIDEO, n.d, "How it Works"). In its formative stages, the OpenIDEO platform defined its design process as simply inspiration, concepting and evaluation (Makower, 2012). However, the methodology advertised on OpenIDEO does not display the full design process. Framing the project challenge and brief is part of design development that is conducted offline between OpenIDEO staff and the challenge sponsor. Furthermore, engagement in implementation with the project sponsor is not a phase that is accessible to the OpenIDEO community. Impact (previously termed "realisation") is a phase that the OpenIDEO community have little access to, and was not made available during early challenges posted on the platform including, *How might we better enable food production and consumption?* Today, the impact phase encourages both sponsor and community to upload implemented solutions (OpenIDEO, n.d, "How it works").

Utilising a design process methodology in an online community allows for a 'transfer' of formal design knowledge to the layperson en masse. When an open source community is established as an online design environment, communication is crucial for directing amateurs towards correctly engaging with the design process (Paulini, Murty & Maher, 2013, p.110). By providing clear goals beneath well defined design phases, amateur collaborative online communities are better adept at adopting design thinking and thus "behaving like designers" (Paulini, Murty & Maher, 2013, p.110). Implementing a design process in an open source platform such as OpenIDEO provides the opportunity for laypeople to engage with design thinking.

However, design thinking does not appear to be leveraged on OpenIDEO. Three of the most crucial phases and activities in the design process and design thinking, problem framing, iteration and implementation, are not directly accessible or visible to the OpenIDEO community. The community cannot contribute towards framing the challenge, struggle with implementing solutions, and do not showcase evidence of design iterations. Because of this, the question of whether the community are holistically engaging with the design process and thus 'design thinking' is considered.

Opinions on the success of design thinking on OpenIDEO are mixed. Rachel feels that the transfer of the design process to an online environment was successful, and adds that the design process can work in an online environment (Rachel, Interview, 2014). Contradicting this sentiment, Jake felt that it is not impossible to transfer the design process to an online environment, but that OpenIDEO had not done so successfully (Jake, Interview, 2014). David provides a neutral standpoint, stating he is "not sure if the design process can work online or not" (David, Interview, 2014). However, David, Rachel and Sarah all agree that regardless of its success or failure, the design process had been 'dumbed down' to make it accessible to the masses (Rachel, Interview, 2014; Sarah, Interview, 2014; David, Interview, 2014).

The simplification of the design process may mislead those new to design thinking. Jake argued that a non-designer would be "mislead" on design thinking if they were to learn about design thinking from OpenIDEO (Jake, Interview, 2014). Furthermore, a non-designer may be misled if not actively participating in a range of human-centered design methods. Furthermore, Jake stated that the platform "breeds God delusion" and that many members were designing based on assumption and personal opinion (Jake, Interview, 2014). This is counter to a fundamental aspect of design thinking; user (human) centered research. User and human-centered design requires immersing yourself in the context or activity of the user, than simply considering the user from your own perspective (Brown, 2008; Lockwood, 2010, p. Xi; Porcini, 2009; Sato 2009). Yet, as evidenced in this case, many members did not post any information on primary user research.

The perceived benefits behind crowdsourcing often relies on the theory that "innovative solutions to problems could be found within diverse, decentralized and independent crowds, which include acknowledged experts as well as those with no formal expertise" (Seltzer & Mahmoudi, 2012, p.8) where the group can often be more intelligent than any one individual. This implies a collective strength, or groupthink, that often emerges amidst collaborative design teams. Contrary to this phenomenon, analysis revealed that collaboration and co-creation appeared to be superficial, and conversations on the platform demonstrated disjointed connections focusing on one-way feedback.

Cain (2012) argues that groupthink "excludes rather than elicits good ideas". This raises questions over whether applying a design process in a mass online collaborative environment could potentially devalue the power of design thinking. These questions are further validated by research conducted by Salminen (2012) who states "analysis of wisdom of crowds revealed that the crowd is not accurate enough to identify the best ideas, but could still be used to filter out the very worst" (p. 21). This also directs our questions to a competing ideology on collective intelligence; that crowds are not experienced enough to identify the best ideas, thus requiring the knowledge and experience of a professional designer.

Collective brainstorming on OpenIDEO was not cohesive or efficient. Many comments were impractical and suffered from "blue sky thinking" (Jake, Interview, 2014). Without interaction in the problem-framing phase, ideas may lose focus. Furthermore, without active engagement in iterative prototyping and implementation (two phases that require offline interaction) the ability to refine not just concept ideas but practicalities that lead towards feasible implementation may be further disabled. In addition, considering limitations and constraints may deplete the fun and ease of interacting with OpenIDEO. Jake observed this problem, arguing that the community were, as a result, not considering limitations or constraints behind the problem challenge "people weren't from a realm of thinking about implementation" (Jake, interview, 2014). Providing feedback and design concepts is the creative and pleasurable part of the design process. Members work through the design process but few provide proof of key design considerations through methods such as sketching and user testing. Furthermore, few provide evidence of engaging with key cognitive aspects that underpin design thinking, such as: empathetic, critical and reflective thought. It may be that individuals are in fact developing or exhibiting design thinking offline but are too busy to relay their process back online. However, observing activity on the platform as verbatim, there is little evidence to suggest community members are engaging with a design mindset or approach in its entirety. Out of all phases afforded to the community, the platform only allows ideation, refinement and evaluation to be conducted online, with implementation, user testing and prototyping to exist offline. In addition, there is a clear disconnect between the OpenIDEO community and the context and place of the problem challenge (Seltzer & Mahmoudi, 2012, p.12). The remote nature of the platform separates the community from the problem challenge and can yield solutions that are culturally and socially misunderstood, and/or superficially resolved (Faste, 2012, p.4):

> By understanding the capabilities and methods of OpenIDEO, one can understand how Human-Centred Design can better influence the innovation process. One of the most acute criticisms of the platform is that it is a prime example of remote designing.
> (Gordon, 2014, p.33).

The evidence presented through conversations show that individuals on OpenIDEO are not developing a designerly way of thinking, as feedback focuses on design details. Two of the most fundamental phases of the design process, problem framing and implementation, are unavailable to the OpenIDEO community. This case study highlights the importance of interacting with the whole design process that is fundamental for holistically engaging with, and developing, design thinking.

7.

Cross-comparison analysis

This chapter presents a critical, cross-comparison analysis on the nature of design thinking in complex environments by comparing themes that have emerged across each case study. The case studies presented in this dissertation will be cross-examined to formulate analyses guided by a critical realist framework. To thoroughly understand the behavior of design thinking in complex environments, an investigation of the relationship between three key areas will establish focus for cross-comparative analysis: the complex environment, design process and design position. Drawing from Buchanan's orders of design practice, this thesis investigates the application of a designerly approach in third and fourth order environments (Buchanan, 1992)[See Fig.5]. These two orders have been identified as complex environments as they reflect and encompass large-scale social, systemic and service issues that are situated in the second quadrant of Flach's (2011) model of complexity in problem spaces [See Fig.6]. The word *environment* has been used to articulate the context and characteristics of complex problem spaces where the case studies in this thesis take place.

This chapter exposes the interconnected and interdependent relationships between the nature of a complex environment, design process and position that influence, affect and transform the behavior of design thinking. In doing so, this chapter will uncover the emergent behaviors, barriers and enablers to a design approach in complex environments. Figure.15 visualises this relationship that will be used as a framework for cross-comparison analysis:

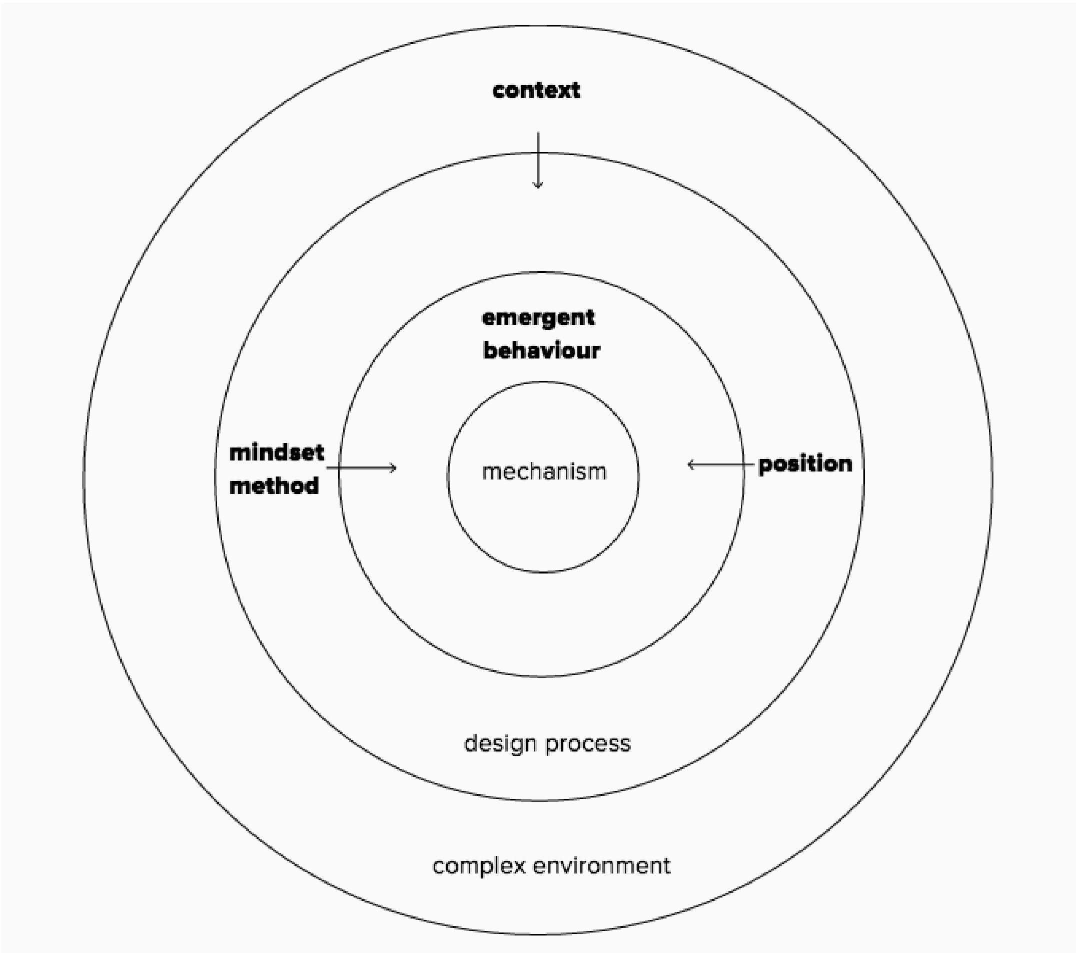

Fig.15 Framework for cross-comparison analysis

Much of the analysis and discussion on design thinking in complex environments, such as policy and organizational design, have focused on building design capability and culture (Carlgren, 2013; Terrey, 2012; Junginger, 2014) and increasing innovation (Carlgren, 2013; D'Ippolito, 2014; Wylant, 2008; Olsen, 2014). Some literature also provides evidence on the perceptions of complex design practice by professionals in and outside of design practice (Liedtka, 2013; Goldschmidt & Rogers, 2013). Yet, there is limited discussion on the behavior of design thinking and the relationship between design practice and the context of the environment it is applied within.

The purpose of discussing the relationship between environment, design process and design position is to holistically understand how design thinking is affected by the context and nature of the environment it is applied within. Understanding the impact of the context of the environment, and identifying causal relationships that may affect design outcomes, is crucial for effectively analysing how to improve design capability, culture and solutions. Current knowledge on design thinking in complex environments has provided a "significant body of evidence marking the emergence of a new kind of designer" yet there remains "little evidence of any systemic understanding of the methods of this emergent art" (Graham, 2013, pp. iv-7). This analytical discussion contributes a systematic understanding of the relationship and impact that context (environment), design process and design position have on shaping design thinking in complex environments [Fig.16].

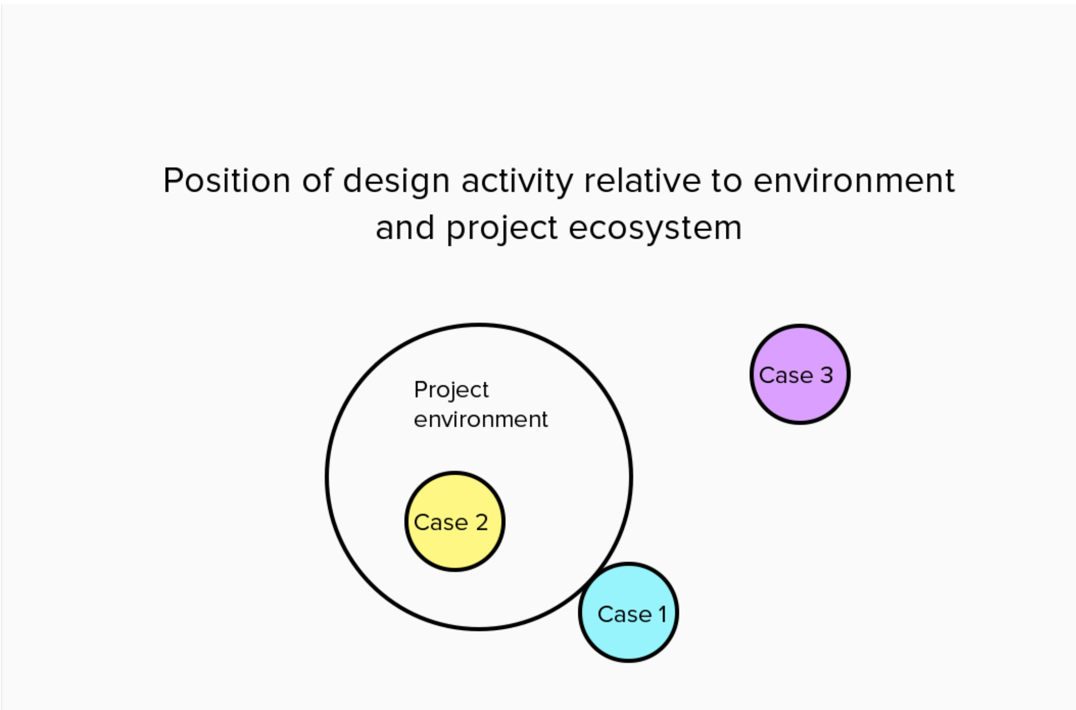

Fig.16 Position of case studies to project ecosystem

Each case used in cross-comparative analysis for this chapter has been selected following a set of criteria detailed in 3.5.4 *Criteria.* To summarise, each case was chosen to fulfill three broad criteria: application of a design process framework, projects situated in third or fourth order environments or in the second and third quadrant of Flach's (2011) model of complexity in problem spaces, and an emphasis on intangible (non-product centric) outcomes during formative phases of design activity.

Before discussing the emergent behaviors of design thinking in complex environments, it is necessary to highlight and define the characteristics of complex environments found to be consistent within and across each case study. Three key characteristics of complex environments was consistent to each case: a high degree of ambiguity and uncertainty in the problem and environment ecosystem, large-scale design outputs that affect a large community of users and/or stakeholders and an emphasis on intangible services and systems. These characteristics underpin the complex environments that require design thinking to adapt its approach.

7.1 Characteristics of complex environments

7.1.1 Ambiguity and uncertainty

Designers are recognised as individuals who are adept at dealing with ambiguous and complex ('wicked') problems. Designers embrace ambiguity and display comfort in dealing with unknown future states (Laakso & Hassi, 2011, p.9; Rylander, 2009, p.7; Brown, 2008; Cross, 2006). Many authors acknowledge ambiguity as a characteristic of design thinking, as design thinking is increasingly used as a process to 'tame' ambiguous, wicked and uncertain problem-contexts (Scheer, Noweski & Meinel, 2011; Liedtka, 2000, p.16; Meinel & Leifer, 2011, p. Xix; Klemmer & Carroll, 2014, p.416). This may come as no surprise as design practice has been associated with taming 'wicked problems' since designers affiliated their work to the seminal paper, *Dilemmas in a General Theory of Planning* (Rittel & Webber, 1973). This association is attributed to the idea that "design firms [..] proceed from a different epistemological tradition, in which ambiguity is accepted as a natural part of the process" (Rylander 2009, p.7). However, few authors have explored in depth how design thinking tames ambiguity and how ambiguity affects the design thinking process in complex environments. These are best explained through a holistic analysis of the relationships between design position, design process and environment.

Each case study presented in this thesis portrayed a high degree of uncertainty and ambiguity in and around the project brief. The core design team in case 1 expressed that ambiguity was inherent in the ill-defined brief provided by the client. This design team was faced with uncertainty from both the client and the project environment with which the outcome was to be situated. The brief in this case required a design solution to a future state that did not yet exist. In case 2, the project brief provided to the design team was short and vague, forcing the team to interpret and identify problems, gaps, stakeholders and users. In case 3, project challenges appeared and briefs proved to be vague, broad and often encompassing a wide network of variables and problems [See table 4].

Case 1	*This is very unusual in terms of the way the project works. We don't know what the outcome is, what the tangible output will be…* (Designer, Interview, 2014)
Case 2	*I supposed that's one of the challenges we have with our design, we usually just get a one-liner with no context behind it. That's when we need to determine what is the ATO approach going to be with that one liner. So the Cooper Review was no different, some paragraphs, but basically that was it.* (Design Lead, Interview, 2014)
Case 3	*The Challenge asks us to consider ways to improve and enhance the relationships and interactions between producers and consumers, rural and urban communities, growers and retailers, retailers and consumers. We'd like the community to consider issues such as energy use, transportation, biodiversity, food security, nutrition, obesity, the health of rural economies and the strength of inter-generational and intercultural knowledge sharing.* (OpenIDEO, n.d, "How might we better connect food production and consumption: the brief")

Table 4. Evidence of ambiguity in each case

7.1.2 Large stakeholder and community networks

All three cases consisted of design projects where the process and outcome included and affected a large community of designers, stakeholders and users. Consistent with literature on the subject, service and systemic design practice pertaining to third and fourth order design involve and impact large networks of users and stakeholders (New & Kimbell, 2013, p.5; Patel, Moore & Blaney, 2014; Armstrong et.al, 2014). The project in case 1 required a service and organisational design that would impact a large external community of users as well as internal departments, stakeholders and staff. Thus, the design process needed to account for the complexity of internal and external relationships.

The design team in case study 2 operated internal to the organizational environment, the ATO. Team members were required to design for and around the complexity of the ATO system whilst accounting for design impact on a community of users on a national scale. Case 3 presented complex design challenges focused on large-scale, socially orientated issues such as poverty, education and sustainability. In all cases, design development needed to account for large networks of stakeholders and user communities [See Table 5]

Case 1	*The work itself is probably not in different parts of the organization. So we threw serendipitous conversations that we have in other parts of the organisation. It's an organisation of forty thousand people so its like a nation* (Design Manager, Interview, 2014)
Case 2	*This is what we're doing with the community and their compliance to make it a bit easier to access and manage their super.* (Co-Design Lead, Interview, 2014)
Case 3	*At the heart of this challenge lie issues of global sustainability and local happiness to improve life for rural and urban communities.* (OpenIDEO, n.d, "How might we better connect food production and consumption: The Brief", para.3)

Table 5. Evidence of large community networks in each case

7.1.3 A focus on intangible solutions

In each case study design thinking focused on high-level intangible concepts during the formative phases of the design process. Design artefacts were not central to the design process. The design of intangible and conceptual frameworks is characteristic of design thinking in complex environments (Dubberly, 2008; Young, 2008; Jones, 2010). The "artefact" to be designed in case 1 was highly conceptual and centered on an organisational service. Case 2 also emphasised service solutions and focused on the creation of high-level strategic and systemic frameworks. Furthermore, case 3 presented a broad project challenge that required members of the online community to focus on core human values and social ecosystems. In each case, the project brief did not explicitly dictate or identify an artefact to be designed. Tangible artefacts may be later designed to support or accompany overarching, intangible frameworks, but physical artefacts were not the focus during formative phases of design development in each case [See Table 6.]

Case 1	*We are a strategic service design agency. Sometimes we do deep dives but most of our projects are strategic and high-level and that's because we are dealing with a different fractal of the issue from a place that can actually be changed, where real change can actually happen.* (Designer, Interview, 2014)
Case 2	*I guess with that high-level focus in mind, a lot of the current design activities done in the tax office map into those stages as well* (Co-Design Lead, Interview, 2014)
Case 3	*We hope to cast a wide net for inspirations and concepts that will address the challenge in a holistic way. Think about new services, campaigns, policies, products, systems that could address these issues.* (OpenIDEO, n.d, "How might we better connect food production and consumption: the brief")

Table 6. Evidence of a focus on intangible solutions

7.2 The behaviour of design thinking in complex environments

The focus of this chapter is to answer the main research question, *What is the behaviour of design thinking in complex environments*? The purpose is to provide a cross-comparative analysis of emergent themes supported by causal propositions that may influence the emergent behaviours, barriers and enablers of design thinking in complex environments. Two sub-questions will also be addressed: 1) what effect does the position of design thinking to the project ecosystem have on designing in and for complex environments? and 2) what are the underlying mechanisms that enable design behaviours to emerge in complex environments?

The emergent behaviours presented in this chapter are the result of a cross-comparative analysis directed by a critical realist grounded theory methodology [See Fig.12]. These behaviours are representative of themes that were observed within each case and have been interpreted as emergent behaviours of design thinking in complex environments. Evidence of each emergent behaviour will be triangulated using case study data and design literature. Each case study will be referred to as case 1, 2 and 3 for readability.

However, themes from case 3 proved inconsistent under cross-comparative analysis with themes from cases 1 and 2, and as such, case 3 will be used as a benchmark for cross-comparative examination on the enablers and barriers of design thinking in complex environments. In doing so, the abnormality of case 3 helps to answer the second sub-question, *what are the underlying mechanisms that enable behaviours to emerge?* The analysis for this sub-question will be guided by a critical realist framework, utilising the process of retroduction to excavate underlying causal mechanisms. Analysis of case 3 provides a point of differentiation that helps to explain the emergent behaviours of design thinking found in cases 1 and 2. The table [Table. 7] below outlines the themes in case 1 and 2 that have been grouped to reflect six emergent behaviours of design thinking in complex environments:

Emergent Behaviours	Case 1 Themes	Case 2 Themes
Holistic Perspective	Systems thinking, divergence, ambiguity, uncertainty adaptivity	Systems thinking, divergence, adaptive methodology, scoping
Vision Framing	Envisioning future states, user research, holistic reasoning, abduction, user journey	Intent statement, envisioning ideal states,empathy/user focus, abduction, blueprinting
Decentralisation of the Designer	Prototyping, sketching, Role playing, user journeys	Multidisciplinary collaboration, sketching, prototyping, visual artefacts
Disrupting perceptions	Collaboration, teaching, service enactment, facilitation	Teaching/training, visualisation, facilitation
Designers in flux	Balancing opposing states	Tension between design and user, system, stakeholder

Table 7. Themes in case 1 and 2 that led to emergent behaviours

Each behavior was identified to have emerged through a combination of design themes observed in each case. Through the critical realist framework of stratification, these themes have been identified as being situated on the empirical layer, as they were “observable” moments [See Fig.8]. Emergent behaviours lie on the “events” layer, for they exist in time and space and are an emergent result of the interactions between key, observable themes outlined in the above table. Underlying mechanisms are identified as existing on the “real” layer. These mechanisms are postulations formed by using the process of retroduction to identify key unobservable influences that may enable behaviours to manifest and emerge as observable themes. Thus, as outlined in chapter 3. *Research Framework*, retroductive analysis operates backwards; starting with what is observable, interpreting observations that together formulate an intangible “event” to then proceed towards identifying the underlying influence that enables each causal layer to emerge.

7.2.1 Holistic perspective

> One must understand that the main points of design thinking are to enhance creativity, understand the community, and to think holistically.
> (Gordon, 2014, p.23)

A holistic perspective guides designers through broad, ambiguous and complex environments. A holistic perspective was observed as a key behaviour during formative stages of the design process in case 1 and 2. This behaviour is dependent on a combination of interactions between the complexity of the project environment and key design mindsets. Holistic perspective is an emergent behaviour that is comprised of and enabled by: systemic thinking, divergent thinking and an adaptive attitude.

A holistic perspective aids in the development of overarching conceptual frameworks in complex and ambiguous environments, directing teams towards an ideal design outcome. This emergent behaviour corroborates with literature on design thinking activity in third and fourth order practice. Holistic thinking is referred to in the descriptive sense, and without clear explanation on how design thinkers are, or become, holistically minded:

> Issues of re-framing a project scope and focus, and its associated fiscal and time-pressures are rarely discussed in service design, even though it's a common complaint conversed around the designer water cooler. Placing an emphasis on human-centred, experiential, holistic approaches to designing 'services' and systems are ideal models to strive towards
> (Akama, 2009, p.5)

A holistic *approach* has been acknowledged as part of the design thinking repertoire and is described as a strength (Brown, 2008, p.3; Blizzard, 2013; Bucolo & King, 2014; Martin, 2009, p.88; Gordon & Burns, 2014, p.23). Yet, few articles explain why a holistic approach is a behavioural quality of design thinking by articulating the reasoning that leads to a holistic perspective and how this reasoning impacts on the design process. It was observed in case 1 and 2 that systemic, divergent and adaptive thinking are characteristics that enabled a holistic perspective to emerge [See Table 8].

Holistic Perspective	Divergent Thinking	Adaptivity	Systems Thinking
Case 1	Some of the ideas could be quite broad (Observation, Phase 1, 2011) It goes into more detail now. First it was more holistic in terms of the organisation (Observation, Phase 1, 2011)	It's kind of like an iterative and evolving kind of thing (Observation, Phase 1, 2011) We did revise some things as we did the enactments (Observation, Phase 1, 2011)	There were bits where we were interviewing stakeholders just getting a head around who's who in [the client organisation] and also figuring out who to workshop and what are the workshop activities (Observation, Phase 1, 2011)
Case 2	Scope document is created at the beginning of the project and really is about limiting what you want to do now. (Project lead, Interview, 2014)	We employ a range of design processes we can utilise and it also depends on [...] what the appropriate design process for different things. What's the best thing for the design of the final product you are looking for (Project Lead, Interview, 2014) Flexible design methodology, approaches and tools should be applied, taking into account the realities of delivering change in the Tax Office, however through the design work	For very complex problems, some specialised techniques such as systems or critical thinking may provide a framework to help understand the problem. (Artefact 1, ATO Design Guide, 2008, p.28) The level of information that I'm usually involved in is what we call high level design [...] we don't get involved in the details of what needs to be exact with the details in the system. I think we are saying the system

		the principles articulated here must be met. (Artefact 1, ATO Design Guide, 2008)	needs to be able to do this. (Interview, Design Facilitator, 2014)

Table 8. holistic perspective

Systemic thinking

Systemic thinking is a mindset observed in both case 1 and 2. Systemic thinking observes the ecosystem around the problem and/or organization, taking into account parts that make up and affect the whole. This mindset is influenced by complex environments and begets a holistic perspective. A systemic approach was an initial starting point for projects in both cases 1 and 2. Both design teams in cases 1 and 2 tackled complexity by conducting an initial review of the organisational system they were designing within and for. However, despite similarity between these two cases, the design team in case 2 devoted more time focusing on the organisational system than the design team in case 1. Case 1 initiated an understanding of the organisation system through preliminary research gained through interviews with employees and web-based research. Yet, user research had a greater emphasis in managing the complexity and ambiguity of the project in case 1. User research was central to shaping high-level insights that directed the design team towards a holistic perspective. In contrast, case study 2 initiated design thinking through *scoping workshops*. A scoping workshop aims to identify the scale and complexity behind the project brief. As such, the design team in case 2 spent a greater time focusing on the organisational system and used this understanding to manage complexity and scale of the brief before diving into user research.

Divergent thinking

Divergent thinking is a cognitive attribute that seeks to generate a broad variety of concepts. Convergent and divergent thinking are often mentioned amongst depictions of mindsets that constitute design thinking (Kimbell, 2009; Owen, 2007; Connell 2013, p. 41; Seidel & Fixson, 2013, p.2; Wang, 2013, p.13; Hatchuel, Le Masson & Weil, 2011, p.78; Brown, 2008; Blizzard, 2013, p.31; Martelaro, et. al, 2015, p.47; Benson & Dresdow, 2013, p. 7-11). The double diamond is the most concise design model that depicts convergence and divergence in the design process, particularly during formative design phases (Design Council, 2005). Observations of divergent thinking in cases 1 and 2 corroborate with this literature, however, a divergent mindset persisted throughout the design process and played greater importance to design development than the literature suggests.

The complexity and ambiguity inherent in the project environment influenced design teams in both case 1 and 2 against converging on details prematurely. This apprehension against convergence emphasised divergent thinking that contributed towards enabling a holistic perspective. In case 2, divergent thinking was observed alongside systemic perspectives during scoping workshops. Similarly, case 1 relied upon user research to tackle ambiguity, forcing the design team to focus on broader values and insights from users. Design teams in both case 1 and 2 emphasised overarching ideas. The complexity of the project domain influenced a need for divergent thinking that contributes towards a holistic perspective.

Adaptivity

Adaptivity is an attitude that requires a malleable approach and is observed as another mechanism for managing design projects in complex environments. Where an infinite number of variables and problem-solutions may solve the project at hand, designers remain open and adaptive to emerging insights and ideas. Similarly, with divergent thinking, an adaptive attitude prolongs the “fuzzy front end” and restricts premature convergence. In case 1, adaptivity was observed through iterative rounds of user research. In this case, the design team changed the project’s frame and focus, adapting their process framework as user information was obtained. This allowed the design team to remain adaptive towards emerging insights, further adding to a holistic perspective. Similarly, for case 2, adaptivity was expressed through the malleable nature of the design methodology and principles that make up the foundation for design practice at the ATO.

Underlying Mechanism

Underlying mechanism driving a holistic perspective: direct involvement with the project ecosystem encourages a holistic perspective

Layer	Mechanisms
1. Empirical	Systems thinking, Divergent thinking, Adaptivity
2. Events	Holistic perspective
3. Real	Direct interaction with project organization and ecosystem

Table 9. Underlying mechanism: holistic perspective

The holistic perspective that emerged in both cases, enabled by systemic thinking, adaptivity and divergent thinking, ensured that both teams would not settle into a fixed or linear process. Systems thinking, divergent thinking and adaptivity kept design teams on the 'bigger picture' and restricted premature convergence on false design solutions. By preserving an open and adaptive process, both design teams were able to maneuver through and manage complex variables, whilst reducing the risk of converging on a faulty idea. For both cases 1 and 2, systemic, divergent and adaptive thinking enabled a holistic perspective that appeared invaluable for managing the formative, fuzzy phases of complex design projects in complex environments.

A holistic perspective seemed to emerge from direct interaction with the project ecosystem for which the design solution is required. This supposition has been formulated through an analysis of the themes that make up a holistic perspective, in conjunction with the position of design thinking to the project ecosystem. The underlying mechanism for a holistic perspective is based on analysis of cases 1 and 2. Design activity in case 1 is positioned on the periphery of the project ecosystem, with case 2 positioned inside of the project environment [See Fig.16].

In contrast, observations of design activity in case study 3 did not reveal aspects of holistic perspectives in the formative phases of design activity. Design teams in case 3, operating as a de-centralised network, are not positioned to have direct engagement with either organisations or communities for which design solutions will be implemented. A predetermined design challenge means participants have no direct relationship to the project context and/or ecosystem, and may direct focus away from wider systemic and contextual behaviours that were observed by design teams in cases 1 and 2. Without direct engagement with the context of the project ecosystem, community or organisation in which the project challenge lies, a design team may have less reason to induce a systemic and divergent mindset and thus disable a holistic perspective during formative phases of the design process. In addition, the presentation of a linear design methodology in case 3 may also mislead members into a static and formulaic design process that may disable adaptivity.

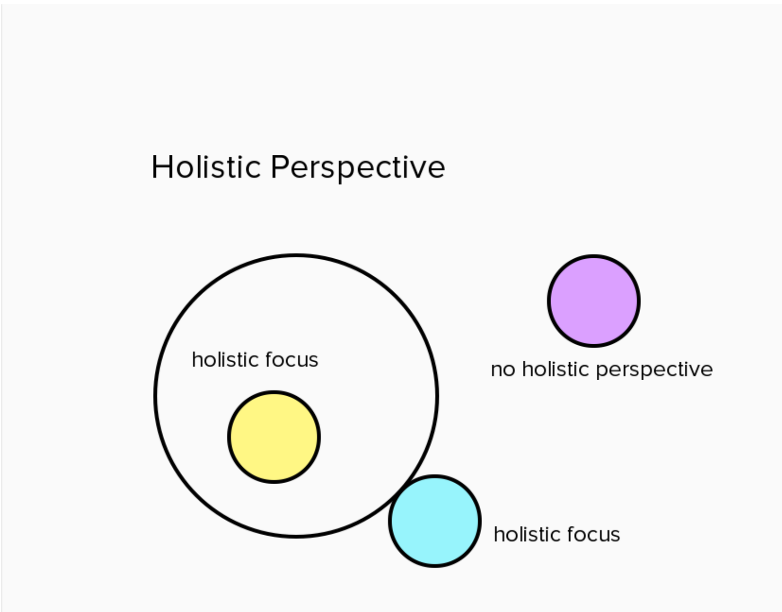

Fig. 17 Holistic Perspective

As a result, formative developments in case 3 focused on convergent design details. Observations of design activity in case 3 did not show an adaptive attitude as many members portrayed a fixation on details and lacked divergent attributes associated with formative phases of the design process, observed in cases 1 and 2. Comparative observations between case 3 and cases 1 and 2 have led to the conclusion that direct involvement with the project ecosystem encourages divergent, adaptive and systemic thinking that combine and create a holistic perspective.

7.2.2 Vision framing

Vision framing is the creation of an ideal future state that is used as a framework to guide design teams through complex and ambiguous project environments. A vision framework is constructed with the user's 'preferred state' in mind and focuses on envisioning an ideal end-state or scenario. A vision framework operates as a format for focus and reasoning throughout the design process. It enables both adaptivity and direction through ambiguity where the problem-solution space may not be clearly identified. Vision framing operates not only as a framework, but provides a grounding point for communicating purpose, direction and intent. Vision framing relies on three design characteristics: mapping, abduction and user-centered empathy.

Vision framing is not the same as problem-framing or problem identification. Design thinking is commonly depicted as a process that focuses on problem-framing. Framing was first proposed as a method unique to design practice by Donald Schön. Schön (1984) describes framing as "a setting of some problems to be solved" (p.132). Elaborating on this concept, Kees Dorst echoes that "experienced designers can be seen to engage with a novel problem situation by searching for the central paradox, asking themselves what it is that makes the problem so hard to solve" (Dorst, 2011, p.527). Multiple scholars refer to problem-framing as a purposeful re-conceptualization of a wicked problem viewed through various perspectives to inspire innovative solutions (Hassi & Laakso, p.8; Kolko, 2010, p.23; Lindberg et al, 2010, p. 247). Most of these accounts assume that a problem or problem-situation has been explicitly identified in order for the re-framing to occur. Furthermore, these accounts describe problem framing as unique to the formative phases of design development. However, problems were not the emphasis during formative phases of design thinking in case 1 and 2. Rather, the creation of a higher, overarching framework that embodied an ideal state was observed as central to the early stages of design development in complex environments. A vision framework acted as a guide through emerging problem-solution spaces.

Hence, the design process observed in case 1 and 2 did not initially focus on problem-framing as the brief contained too many unknown and ill-defined variables. The ambiguity and diversity of variables inherent in the project brief could not holistically be accounted for, specifically as project briefs in both cases 1 and 2 had little concrete information on which the design teams could ground problems. Thus, problem-framing was not a method that could dominate design decisions during the fuzzy front end, and was not observed as integral to early stages of design thinking. Instead, vision framing was observed as a dominant characteristic for managing complex environments during the early and most ambiguous stages of project development. The construction of a vision frame allows for ambiguous and adaptive design activity to remain focused and grounded towards an optimistic ideal rather than directed by an identified problem.

The phenomenon that is vision framing is related to what Dorst terms "Abduction 2". In his paper titled, *The Core of Design Thinking*, Dorst (2011) defines Abduction 1 as representing conventional problem solving in which "we know the value we want to create and how" (p.524). Abduction 2 is another form of reasoning, it is "more complex because at the start of the problem solving process we only know the end value we want to achieve. This 'open' form of reasoning is more closely associated with (conceptual) design" (Dorst, 2011, p.522). Vision framing reflects the 'end value' Dorst describes of Abduction 2 reasoning and is acknowledged as an appropriate perspective for "the open, complex problems for which organisations are seeking new approaches" (Dorst, 2011, p.524). Once again, rather than "identifying the key issues in a problem arena, and the framing of these in a new and original manner" (Dorst, 2010, p.133), design teams in case 1 and 2 focused on formulating an overarching goal of intent prior to identifying the problem to be solved.

In cases 1 and 2, holistic perspective provided an end-to-end pre-evaluation on the design project and its ecosystem. From here, design teams focused on envisioning the ideal state for the user. A vision framework emerged through mapping, abductive thinking and empathy for the user during early phases of design development. This framework was then used as a guide to direct designers towards preferred design outcomes.

Vision Framing	Mapping	Abduction	Empathy
Case 1	We mapped the current journey; so what was the journey you had experienced in the past and we mapped that out together, including pain and light points. What are the things that annoy you or are frustrating or that are working really well that you enjoy, and then we did the future wall (Observation, Phase 1, 2011) We are actually physically mapping ideas (Observation, Phase 1, 2011)	From our personal insight (Observation, Phase 1, 2011) None of the people we talked to have the [product], that's where we have to come in and kind of make that up (Observation, Phase 1, 2011) Enactments were created by just putting ideas together that we had that we could try (Observation, Phase 1, 2011) It's kind of conflicting, how it was going to really work. That's why we eventually had to go with what's our idea of the ideal (Observation, Phase 2, 2011)	Point of the journey is to gain empathy to understand how the process works (Observation, Phase 2, 2011) It could be that we need to constantly be thinking about the nuances of experience. It's fundamentally important for us to understand the customers perspective (Observation, Phase 2, 2011)
Case 2	Then we took our design principles as a coherent for blueprint change. It's providing a foundation of what we are going to do and all of our subsequent processes through to implementation is based off that blueprint (Interview, Co-design Lead, 2014)	We recognise there is a lot of assumptions made and there is a lot of gaps in there as well. (Interview, Facilitator, 2014) A key task during blueprinting will be to identify additional user research and to commission or undertake it. If a team starts making assumptions about what they	It takes two important perspectives – outside-in and end-to-end – and considers the implications of the design across the Tax Office and the community. (Artefact 1, ATO Design Guide, p.6) "It was all about developing a service we

		think users might do, more discovery or user research is needed to check these assumptions.” (Artefact 1, ATO Design Guide, p.12)	want them to use and we want them to see it as a valuable and easy process” (Interview, Co-design Lead, 2014)

Table 10. Vision Framing

Mapping

Mapping was observed to play a central role in design thinking for complex environments. Mapping seeks to visualise the end-to-end system or service. In cases 1 and 2, mapping was used as a method that compliments and aids in the development of a systemic and holistic perspective and in the refinement of a vision framework:

> The user research sessions will produce pages of verbal transcript, hundreds of pictures, and dozens of artifact examples. Because of the complexity of comprehending so much data at once, the designer will frequently turn to a large sheet of paper and a blank wall in order to “map it all out.” (Kolko, 2010, p.16)

Case 1 began with a focus on user research that led to high-level user insights. These insights were then mapped out as a user journey. Similarly, case 2 initiated design development through scoping workshops to clarify the formative stages of intent, focusing heavily on identifying the system and capability in order to achieve the desired intent. As a result, the system in case 2 was mapped out as a “blueprint”. This blueprint outlined the anticipated user journey, focusing on how the user’s journey interacts with and impacts on the organizational system. In contrast to a more user-centered emphasis in case 1, case 2 placed an emphasis on mapping (blueprinting) the system in order to move forward in the design process. In both cases, these holistic, end-to-end maps and blueprints are carried throughout the design process, operating as a tangible framework of reference to solidify and support design development and to achieve the intangible project vision (intent). The mapping process in case 1 and 2 was observed as a method for solidifying and simplifying ambiguity around the vision framework.

Abduction

In addition to mapping, abductive thinking guided design teams in the creation of a vision framework during formative stages of the design process in cases 1 and 2. Abductive thinking:

> Can be thought of as the argument to the best explanation. It is the hypothesis that makes the most sense given observed phenomenon or data and based on prior experience. Abduction is a logical way of considering inference or "best guess" leaps. (Kolko, 2010, p.20).

In case study 1, abductive thinking was identified through expressions such as "I feel" and "I guess". Case 2 portrayed abductive thinking through interviews, articulating assumptions around anticipating future states during formulations of intent. In these cases, abductive thinking was identified as a method for substituting for missing information due to ambiguity and uncertainty in the complex environment. In harnessing abductive thinking, "abductive logic allows for the creation of new knowledge and insight" (Kolko, 2010, p.20). Thus, abduction and intuition acted as mechanisms for enabling foresight and the generation of an ideal future state.

Empathy

Empathy is a fundamental characteristic of design thinking and an objective for design teams in the creation of design outcomes (New & Kimbell, 2013; Von Thienen, Meinel & Nicolai, 2014; Kim & Ryu, 2014; Mattelmaki, Vaajakallio & Koskinen, 2014; Faste, 2011; Wetter-Edman, 2009). Thus, empathy was observed as a key mindset in the creation of an ideal future-state and vision framework, "The empathic understanding of everyday life is triggered by imaginative proposals of alternative futures." (Mattelmaki, Vaajakallio & Koskinen, 2014, p.73). In case 1, the formulation of a vision framework began with user research that guided the design team towards the formulation of a preferred user experience. Similarly, the design team in case 2 focused on formulating a vision framework through the generation of an intent statement. Intent in case study 2 required the design team to think holistically about both the system and the user, focusing on envisioning the desired future state for the user. Like case study 1, the intent statement emphasised intangible, high level experiences that are grounded in empathy for the user.

Underlying mechanism

Underlying mechanism driving vision framing: direct involvement with the project ecosystem encourages vision framing

Layer	Mechanisms
1. Empirical	Mapping, abduction, empathy
2. Events	Vision framing
3. Real	Direct interaction with project system

Table 11. Underlying mechanism for vision framing

Vision framing is performed during the formative stages of the design process in case 1 and 2. Vision framing is influenced by a holistic perspective and provides direction through the ambiguity inherent in complex design practice. Vision framing in case 1 and 2 is enabled by three key factors: empathy, mapping and abductive thinking. However, vision framing was not observed in case 3. Instead, it was observed that the design community in case 3 devoted formative stages of the design process to concepting ideas; producing solutions much sooner than in the previous two case studies.

Individuals in case 3 also relied on a "gut feeling" in order to complete the project challenge and focused on assumptions based on personal preferences. Guessing was witnessed through statements such as "I feel", "I like" and "I think". The fundamental difference between assumptions and guesswork in cases 1 and 2 with those in case 3 is that abductive activity in cases 1 and 2 are educated guesses based on preliminary user research. Both design teams in cases 1 and 2 conducted preliminary user and/or client research whereas designers in case 3 were not observed to have conducted in-depth user research. Thus, assumptive statements may not be an informed or educated guess and may not be classified as abductive, as statements draw from subjective personal preference. Furthermore, the "guesstimating" activity in case 3 did not appear to be in light of an overarching vision framework.

Design activity in case 3 operated externally to the project environment, and as such, had no direct interaction or relationship with the project ecosystem. This weak relationship between design activity and the context of the project may reduce engagement with the complexity inherent in third and fourth order environments. Complexity plays a large role in enabling a holistic perspective and for vision framing to emerge. Without direct interaction with the complexity of the project ecosystem, the natural emergent qualities of divergent and systemic thinking may be disabled. As a result, designers in case 3 did not engage with a holistic perspective and thus did not articulate a vision framework or ideal end user state. Instead, designers converged on design solutions prematurely. In addition, a lack of direct interaction with end users may decrease the desire for formulating a vision framework in light of user preferences and, in turn, increase designs based on personal preference.

Positioning was observed to have an effect on how each design project is initiated. Design thinking on the periphery of the organization and/or project ecosystem, as observed in case 1, may influence design teams to initiate design thinking through user research before focusing on systemic considerations. Designing on the periphery is also observed to hold a weaker relationship to the day-to-day nuances of systemic operations in an organization, as opposed to design that is situated internal to an organisation. In contrast, the design team in case 2 initiated vision framing and design thinking through a systemic perspective. This is possibly due to design operating internally to the organisational system, thus holding a stronger relationship to the project and its ecosystem.

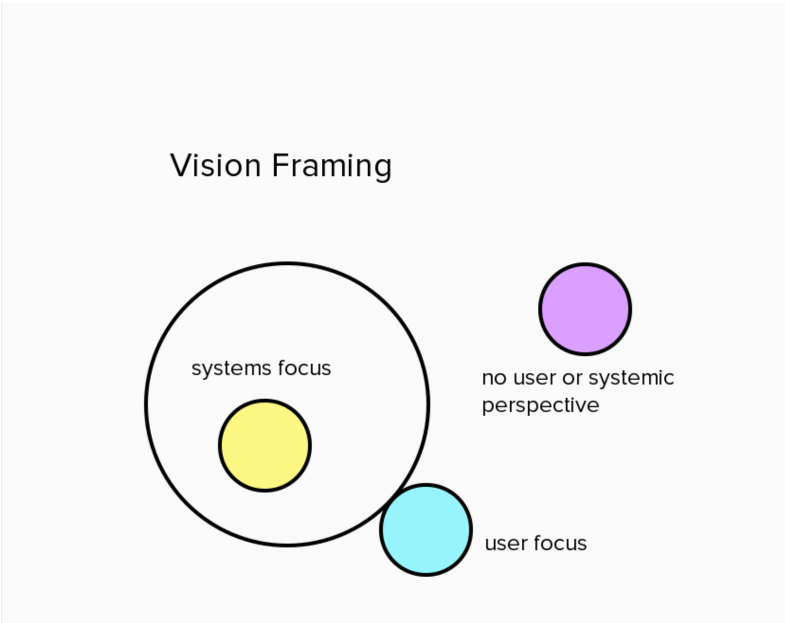

Figure 18. Vision Framing

Team members in case 3 had no relationship with the ecosystem or project organisation and thus focused most of the design development on guesswork and/or individual preference. Based on emergent patterns evident in cases 1 and 2, it is proposed that without direct interaction with the complexities inherent in the project ecosystem, convergent thinking will increase and the potential for vision framing during formative phases of design development will be reduced. It is proposed that a strong relationship with the project and/or the organisational ecosystem enhances the ability for systemic and strategic mindsets to emerge, thus enabling a holistic perspective and a vision framing to occur.

7.2.3 Collaboration and Facilitation

Characteristics emerged in case 1 and 2 that provided indicators for describing the collaborative behaviour of design thinking in complex environments. During formative phases of design development, collaboration in case 1 appeared less inclusive of external stakeholder involvement but highly inclusive of user input. Furthermore, as design development in case 1 occurred primarily within the design agency, collaborative efforts were mainly isolated to the design team. In comparison, case 2 involved an interdisciplinary team of professionals with little to no formal training in design. In this design team, the only trained designers involved were dedicated design facilitators. Collaboration in case 2 involved working closely with stakeholders, whom formed part of the core design team. Collaboration in case 2 was more inclusive and interdisciplinary and emphasised equal co-responsibility over the design solution between members (stakeholders) of the core design team (Artefact 1, ATO Design Guide, p.37).

Facilitation is a characteristic widely discussed in design literature and a topic well established outside of design theory. Facilitation in design is commonly attributed to a design lead whose role is to facilitate trans-disciplinary conversation (Christian Wahl & Baxter, 2008, p.72; Kajalainen, 2012, p.34; Razzouk & Shute, 2012, p.334) using visual methods and tools to enable and enhance this facilitation (Donar, 2011, p. 89). In contrast to the literature, a lead designer did not dictate the design process in either case 1 or 2. Instead, facilitation was managed collectively by the design team in case 1 and encouraged by a dedicated design facilitator in case 2 and 3. In each case there was no lead designer, and professionally trained designers involved in development did not dictate or own the design process. Three main behaviours emerged from cross-comparative analysis on collaboration in complex environments. These behaviours are: de-centralisation of the Designer, perspective shifting and embodiments of design thinking.

7.2.3.1 De-centralisation of the Designer

The de-centralisation of the designer was observed as an emergent phenomenon when designing in and for complex environments. The ambiguous activity of design is commonly depicted under the direction of a single, lead designer who embodies and directs design thinking (Carlgren et. al., 2013, p.12; Gero et. al., 2001, p.271; Martin 2005, p.2; Owen 2007, p.24; Porcini, 2009, p.7). As design thinking is applied in higher and more complex areas of professional practice, less emphasis is focused on a single, leading designer.

Instead, design thinking in context of complex environments manifests through collaborative thinking. This is an effort that is not identified within any one designer but an emergent and collective consensus in response to the project at hand. Visualisation, passive facilitation and multidisciplinary collaboration was observed in case 1 and 2 as characteristics that enabled a de-centralization in complex design practice. These observations provide the basis that support the emergent behaviour that is the de-centralisation of the designer [See Table. 12]

De-centralisation of the designer	Visualisation	Passive facilitation	Multidisciplinary collaboration
Case 1	Draw everywhere! So it looks like you've got these two things like that and then you've got these things like this,which, do that … maybe? (Observation, Phase 2, 2011)	With these multi stream teams there's force for collaboration between them. What we will do is: there's three of us and we will help facilitate talks amongst these people (Observation, Phase 2, 2011)	Tuesday is about consolidating, it's about getting them to understand as a collective, as a team, how and what it is they need to do together to actually tell that (Observation, Phase 2, 2011)
Case 2	Sketch out really rough how it might work, and then we use that as a starting point for the discussions that go round (Interview, Co-Design Lead, 2014) This principle has been referred to as 'getting physical fast'. It means drafting, sketching, prototyping and creating mock-ups or other visible	My main role is in the workshop; how do we collaborate, brainstorm. It's more design facilitation of team needs so it's all about questioning. It's making sure everyone has a say making sure everyone gets heard (Interview, Design Facilitator, 2014) The facilitators job is to get information out of the group. It's	The blueprint should also be used as the basis for conversations with other stakeholders to explain the design to them. (Artefact 1, ATO Design Guide, 2008, p.13) The formation of that high level design with our internal business partners, our core design team members, each

	representations of the design early so that they can be shared with users and other stakeholders. (Artefact 1, ATO Design Guide, 2008, p.15)	not to dictate anything. That's what the people in the room need to be aware of-what they are there for. But the design facilitators are there to get the information out in a design sense. (Interview, Design Facilitator, 2014)	bringing in their experience and knowledge of those interaction so it's a considered design. (Interview, Design Lead, 2014)

Table 12. De-centralisation of the designer

Visualisation

Visualisation has long been characterised as the heart of design thinking. It has been discussed primarily as a process of reasoning (Gero et al., 2001, p.272; Schön, 1983), an aid for understanding and sensemaking (Rylander, 2009, p.6; Ward et. al., 2009, p.80), a stimulus for rapid ideation (Boland & Collopy, 2004; Boyer, et.al 2010, p.327; Brown, 2009, p.89; Laakso & Hassi, 2011, p.7) a tool to make ideas tangible (Blomkvist & Holmlid, 2010, p.3; Kimbell, 2009, p.251; New & Kimbell, 2013, p.2) and a medium for enabling conversation (Jones, 2008, p. 226). Thus, visualisation provides a common ground for communication, ideation, inspiration and mediation within multidisciplinary design teams. However, for the most part, discussions around visualisation in design largely revolve around descriptions of its effectiveness in isolation and rarely investigate the deeper, holistic impact and interaction visualisation methods have on the design process as a whole.

As intangible ideas are central to higher orders of design practice, visualisations play a more prominent role in the design process. Visual methods have a tremendous influence over enabling cooperation for collaborative thinking. The facilitation of conversations in design practice; between designers, designer - client or designer-user, relies heavily on visual tools (Manzini, 2008, p.8), allowing participants to share ideas using visualisation as a common ground for communication, ideation, inspiration and mediation (Tvesky, 2010, p.500; Ward et al., 2009, p.80). Corroborating with literature on the topic (Boyer et.al, 2010, p.48; Murray et. al, 2010, p. 24; Ward et al. 2009, p.80) both design teams in cases 1 and 2 chose the visual method of mapping and sketching as a support for synchronising understanding and clarifying complexity during collaboration.

Furthermore, prototyping, sketching and mapping was observed to be central to design thinking activity instead of the designers themselves. In this instance, members of the design team become "tools" that enable design thinking to collectively emerge. Visualisation was observed to be an adaptive and immediate externalisation of "active" thought that allows other team members to synchronise their thinking as ideas unfold. Visual tools enhance the collective "brain" of the design team, throwing the focus away from any single designer. This creates a new perspective on collaborative design thinking activity- that the sum of the members in a design team is greater than its individual parts.

Passive facilitation

Collaborative activity in case 1 existed mainly amongst members of the design team. Within this team, no designer emerged as the 'expert'. Instead, collaboration and ideation evolved organically and was identified as a representation of unified and collective design consciousness. Case study 2 utilised visualisations to enable collaborative synchronisation of design cognition in conjunction with dedicated design facilitators. As members of the core design team in case 2 do not come from design backgrounds, trained design facilitators were used to create visual artefacts in response to emerging conversations so as to enable collaborative design thinking. Most importantly, the design facilitators did not take a leading role in design activity or design thinking. These facilitators acted as stimulus and visual arm and their role was deliberately passive. A design facilitator's role is to inspire and enable design thinking to emerge within the core design team. It was observed that the role of design in case 2 is de-centralised. Instead, the emergent collaborative thinking enabled by visual artefacts that dominated case study 1, and existed through the aid of facilitators in case study 2, signifies the destruction of the lone or lead designer as an embodiment or director of design thinking. Instead, design thinking in complex environments is observed as an emergent process enabled through multidisciplinary collaboration.

Multidisciplinary collaboration

In complex environments, the design process becomes the focal point and not the designers themselves. Large, complex networks that include a wide community of users and stakeholders creates an ecosystem with problems that are beyond the expertise of an individual designer. Thus, multidisciplinary design teams are necessary to manage complex design issues that impact a large network of stakeholders. Through multidisciplinary collaboration, design thinking is an emergent property enabled by a collection of individuals applying and interacting with the designerly approach.

A focus on users and a synchronisation of perspectives from multidisciplinary teamwork creates an environment that prohibits design thinking to emerge and be owned by one individual. In such complex networks the concept of a lead designer has become obsolete. This brings the design process, instead of the designer, to the fore and creates a phenomenon that is less about design thinking attributed to a designer and more about the emergence of a design thinking process, team and culture. As design activity continues to be utilized in and for large-scale complex environments, it is sensible that the notion of the designer shifts from a traditional authoritative position to a passive facilitator. Therefore, design thinking should be perceived as a manifestation of collaboration under a design approach in this context.

Underlying mechanism:

Underlying mechanism driving the decentralization of the designer: immediacy from face to face collaboration encourages a de-centralization of the designer

Layer	**Mechanisms**
1. Empirical	Multidisciplinary collaboration, Passive facilitation, Visualisation
2. Events	De-centralisation of designer
3. Real	Immediacy (face to face interaction)

Table. 13 Underlying mechanism for decentralization of the designer

Collaboration in case 1 and 2 operated in a de-centralized manner, without a leading designer directing design activity. Case 2 and case 3 employed dedicated design facilitators to manage collaborative discussions. In both cases, these facilitators played a very passive and unobtrusive role.

Case study 3 showed a significant lack of visualisation in the formative phases of the design process during online collaboration. In contrast to facilitation in case 2, visualisation methods were not used by online facilitators in case 3 to inspire or stimulate ideas and conversations. Visuals that were (rarely) provided during design discussions in case 3 were usually in form of links and were not generated through immediate interactive discussions or built upon existing visualisations created by contributing members. Case 1 and 2 utilised visual artefacts to facilitate communication between team members, enabling a synchronisation of perspectives and decentralization of design collaboration.
In comparison to cases 1 and 2, a lack of visualisation during design discussions may be a result of design activity positioned outside of the project environment and operating remotely from stakeholders, users and team members. This position may further disable a de-centralisation of design activity as there exists no tangible artefact for team members to focus on, in comparison to visualisations that were central in face-to-face collaborations conducted in cases 1 and 2. Facilitators of the platform could have alleviated this problem by visualising design concepts developed by individual members to help enable collaboration and synchronisation between active individuals.

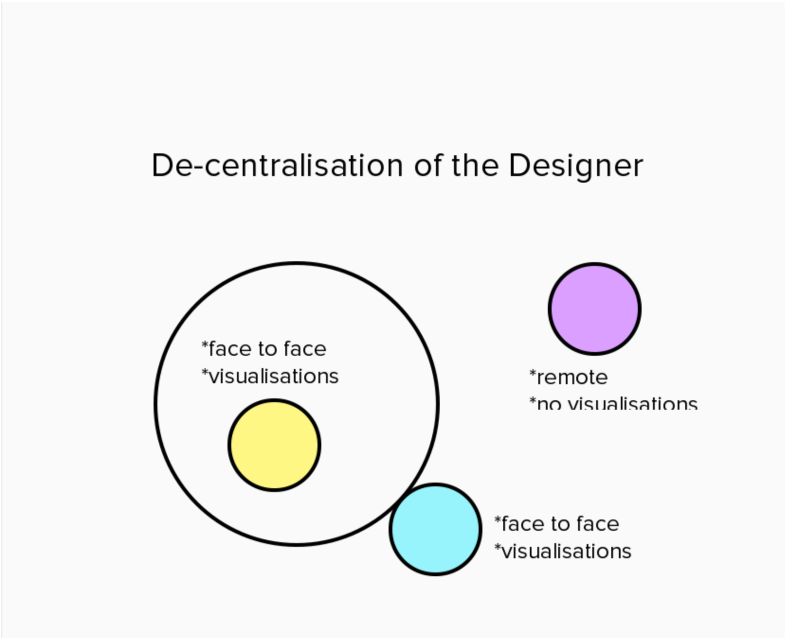

Fig. 19 De-centralisation of the designer

On the surface, it appears that there exists a de-centralisation of the designer in case 3 as a network of individuals collaborate on design challenges in an online open-source environment. Additionally, the community collaborated on challenges that are not directed by a design manager, but rather, facilitated through platform operators. Yet, case 3 did not exhibit the same degree of collaborative design thinking activity evident in cases 1 and 2. The contributions made by community members in case 3 were often static and isolated from engaged conversation. It was observed that community members provided direct feedback rather than engaging in sustained collaborative discussion. This behaviour is possibly due to the remote and delayed mode of interaction, as community members interacted solely through an online network at their own time and pace. Furthermore, as members are working remotely from one another, each individual designs in isolation, particularly when it comes to utilising visualisation methods for ideation. Without immediate interaction between other individuals as conducted in face-to-face collaboration, the remote designer struggles to remove his or herself from their own worldview. This results in the individual focusing on their own ideas as ideation exists in their own time and space and without direct and immediate input from outside sources. This isolation may explain the emergent characteristic found in case 1 and 2; that immediacy through face-to-face collaboration enhances the de-centralisation of the designer.

The behaviour of participants in case 3 compared to the collaborative behavior observed in case 1 and 2 signals that immediacy is a necessary element to enable design thinking and to de-centralise the designer. Allowing visualisations to manifest in real time during design discussions strengthens the synchronisation of group interactions allowing for a more organic iteration and evolution of design concepts. The online, remote position of design thinking in case 3 reduces immediacy between team members and facilitators which may be preventing the emergence of the de-centralisation of the designer as design thinker.

7.2.4 Disrupting perceptions through design thinking

Disrupting perceptions has been accepted as part of design thinking practice in complex environments (Bucolo & King, 2014, p.25; Liedtka, 2014, p.45). The art of disrupting perceptions through design thinking is conducted with the aim of changing fixed mindsets (Vetterli et.al, 2013, p.93; Carlgren, Elmquist & Rauth, 2013, p.6). In cases 1 and 2, perspectives shifted during collaborative design activity. Case study 1 and 2 involved multidisciplinary stakeholders from fields outside of design and who are foreign to a design thinking approach. In both case studies, the focus of design thinking is thrown away from the designer as a leader dictating a design thinking approach, to one that facilitates the design process as mechanism for shifting perspectives within and beyond the design team. Disrupting perceptions is observed as a precursor to the development of a design thinking culture within an organisation. Design thinking activity was not just utilised to resolve complex problems, but to influence organisational culture. Disrupting perceptions became as fundamental to design thinking practice as vision framing, as the design team collaborated with a diverse group of stakeholders.

Disrupting perceptions	**Direct engagement with stakeholders**	**Demonstrating design process**	**Diversity of perspectives**
Case 1	We said "ok we can only do two so choose the ones you want" and they [the client] chose these two and we thought they were good choices as well. (Observation, Phase 2, 2011) We are capturing the raw data and they [the client] are consolidating theirs and then we will get them to give a tutorial and put it all together (Observation, Phase 2, 2011)	Getting the service acted out gets them [the client] to start seeing it from a customers perspective. But the crux for this stuff will happen as the stream leads out and actually narrates and speaks over- what is happening to them in the organisation during this part of the scenario (Observation, Phase 2, 2011) There was a gradual shift towards the end of the day where the organization was actually thinking from within and not projecting what they think the customer needs. So that's a massive, massive, shift in thinking (Observation, Phase 2, 2011)	We are not talking in silos we are talking risks, opportunities, as a group. Each dependency as a group (Observation, Phase 2, 2011) I think its about consolidation and not questioning out.[...] Tuesdays about consolidating, it's about getting them [the client] to understand as a collective as a team, how, what it is they need to do together to actually tell that (Observation, Phase 2, 2011)
Case 2	The role of the design lead is to ensure that there is buy in into the design process that these people are advocates for the change (Interview, Design Lead, 2014) It's good for those to	Just by experience and association with the design process they develop this design thinking methodology. It just becomes part of their natural way of doing things, so that's how we try and develop this concept of design thinking	The complexity of most current organisational issues means that it will almost never be the case that one person or one perspective will be able to design an effective change. An interdisciplinary

	participate and those that are interested in getting in design or were in design in other companies, both Gov and private entities, they need to know how we do design in the ATO (Interview, Design Facilitator, 2014) Once we've got the prototype developed for our co-design sessions, they probably have a reasonable amount of input at that stage as well. Those testing scenarios are shared with a wide range of stakeholders (Interview, Business Lead, 2014)	within the ATO. (Interview, Design Lead, 2014) We use advocates. It's about doing and showing rather than talking about it. So hopefully a project that gets design facilitators and information designers and user-centered designers involved they are seeing the value out of it. (Interview, Design Facilitator, 2014)	approach reduces the risk of poor integration between different but related products such as transaction systems and information products. (Artefact 1, ATO Design Guide, 2008, p.5) Productive design depends upon input from a range of perspectives. In the design world, these perspectives are often referred to as the 'voices of design'. Each voice may be represented by more than one person; and in some cases one person may represent more than one voice. (Artefact 1, ATO Design Guide, 2008, p. .6)

Table 14. Disrupting perceptions through design thinking

Direct engagement with stakeholders

The design team in case 2 used the design process as the voice for demonstrating design thinking to external stakeholders. Direct engagement with stakeholders is defined as interactions conducted either verbally or in a co-physical location with client stakeholders during design development. Direct interaction requires the design team to talk directly to individuals from the client and not to be collecting information through another individual on behalf of the client. In case 1 the design team conducted workshops to obtain first hand collaboration with the client. Similarly, the design team in case 2 invited project leads and stakeholders from areas outside of the design team in order to gather information that will ensure successful implementation of the design solution. In both cases, the design team had a direct conversation and impact on the client stakeholder.

Demonstrating the design process

Demonstrating the design process did not rely solely on the expertise of a designer or design team per se, but on collaboratively performing the design process to persuade stakeholders through design demonstration. The emphasis is on the process itself as an enabler of and focus of design thinking. Demonstrating the design process was an emergent characteristic evident in both case 1 and 2. The design team in case 1 invited the client and their stakeholders to participate in design thinking activities. This was conducted not only to demonstrate the design process but to demonstrate ideas through a design perspective. Case 2 also utilized the design process for this purpose, using it as a mechanism for solving complex problems and also as a way to demonstrate solutions through the usability of design thinking. The intention behind this effort is to obtain maximum 'buy in' from the client into the design process.

Diversity of perspectives

Diversity of perspectives is represented through multidisciplinary collaborative practice. The design team in case 1 utilised diversity for their collaborative design workshops by inviting stakeholders from broader parts of the client organization. The design team in case 2 also adopted this approach, through the understanding that design problems in complex environments cannot be resolved by just the core design team. For both case 1 and 2, diversity of perspectives was a method for managing design problems in complex environments by bringing in diverse experiences and expertise. This was conducted not only to inspire innovation, but to add diverse knowledge in order to strengthen complex design decisions.

Underlying mechanism

Underlying mechanism driving disrupting perceptions: design inexperience or fear of the unknown

Layer	Mechanisms
1. Empirical	Diversity of perspectives, direct engagement with stakeholder, demonstrating design process
2. Events	Disrupting perceptions
3. Real	Design inexperience or fear of unknown

Table. 15 Underlying mechanism for disrupting perceptions

Disrupting perceptions was observed to operate for three purposes: to inspire cultural change, drive client 'buy in' to design thinking, and to enhance holistic thinking. Case 1 and 2 showed evidence for disrupting perceptions through the design process in order to influence innovative work practices. The design team in these two cases engaged directly with the stakeholder and client. In contrast, designers in case 3 had no direct interaction with the project system, client or stakeholders. Operating on the periphery to the project ecosystem (case 1) or internally (case 2) demands interactions with the client and stakeholders external to the core design team.

In case 3, community members had no direct engagement with clients, users and/or stakeholders associated with the project challenge. In this case, disrupting perceptions operated between members. Design facilitators were not observed to influence the mindsets of the online community. Instead, community members drew from individual experiences and knowledge, offering diverse personal viewpoints during feedback on design concepts. The purpose in this situation is not to influence a culture shift within an organisation or in a client-stakeholder network, as demonstrated in case 1 and 2. The purpose of disrupting perceptions in case 3 was to help fellow community members see the project beyond their individual perspective so they may produce more refined and holistically sensible conclusions. Yet, despite community members providing diverse viewpoints, the mind shift is primarily of benefit only to the receiver of such feedback.

Disrupting perceptions observed in case 3 appeared to have less impact than observations of this emergent characteristic found in case 1 and 2. In contrast, disrupting perceptions in case 1 and 2 had a wider impact, affecting the culture of the project ecosystem.

Disrupting perceptions is required when collaborating with internal or external stakeholders, outside of the design process and core design team. Case 1 conducted collaborative activity primarily between professional designers in their design agency. Multidisciplinary collaboration between stakeholders was not as embedded in the design process as was in case 2. In contrast, collaboration in case 2 comprised of a core design team with more diverse, multidisciplinary expertise and few professional designers. Both cases 1 and 2 conducted collaboration sessions in person, whereas collaboration in case 3 was conducted solely online. In case 3, community members were encouraged to collaborate by interacting on comment threads embedded within each member's design concept posts. Superficially, interactions appeared collaborative, but upon closer inspection, the collaboration between individuals was rarely constructive and instead resembled feedback. This is a stark contrast to cases 1 and 2 where collaboration took place within the context of the project ecosystem and amongst a core design team interacting face to face.

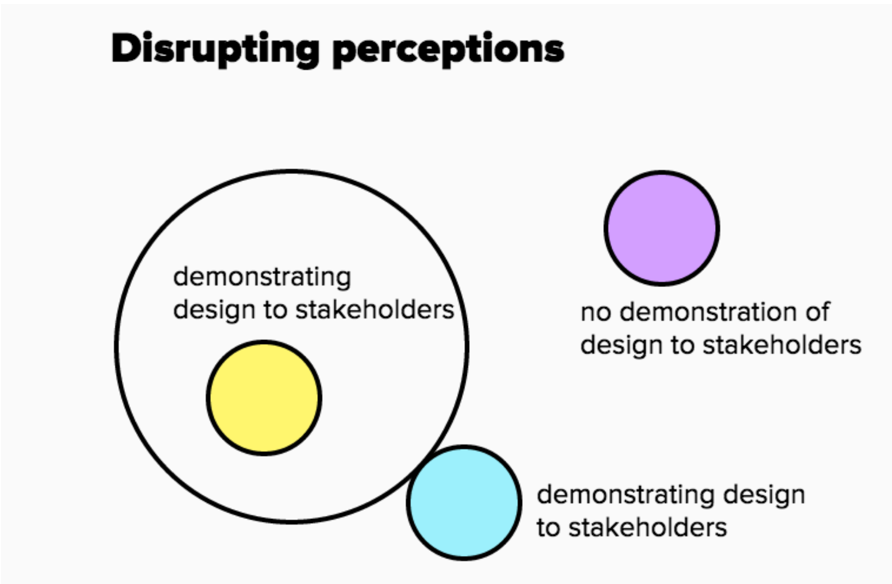

Fig.20 Disrupting perceptions

Disrupting perceptions appears to emerge if stakeholders are unfamiliar with the design process and/or are fearful due to the unknown that is prevalent in complex environments. Without friction from design inexperience or fear for the unknown, there is little need to convince stakeholders towards an alternative, designerly approach. If there exists no friction or fear yielding a need to change, disrupting perceptions for design teams internal or on the periphery of the project ecosystem may simply reflect the behaviour observed of external design team members in case 3.

7.2.5 Design thinking in a constant state of flux: balancing states

Design thinking in a state of flux depicts design as a balancing act, with mindsets in constant oscillation between two, often opposing, states. This emergent behaviour was observed as an effort to balance competing variables evident in complex environments. This observation correlates with literature on design practice, particularly as described by Adams (2011) "The experiences in this category illustrate an awareness of design as balancing and addressing multiple pieces of a larger whole" (Adams et. al, 2011, p. 595). Balancing is acknowledged, but only in a descriptive way, to articulate a part of the design thinking process (Lindberg et, al, 2010, p.247; Carlgren, 2013, p.66; Hassi & Laakso, 2011, p.10) or as an enabler of innovation (Meyer & Marion, 2010, p.26). Many instances referring to balancing states do not describe design thinking as a process of balancing competing states, but instead pinpoint individual design characteristics that are sometimes balanced within the process. Thus, an articulation beyond descriptive accounts is absent from the literature.

Design thinking was observed to exist in a constant state of flux in cases 1 and 2. This emergent characteristic was portrayed through design teams constantly battling and balancing states of conflict, bouncing between extreme variables. Many competing attributes were observed in cases 1 and 2. The main areas of conflict included: balancing a high-level and detailed focus, balancing an adaptive and a structured process and the balance between customer and client needs.

Balancing many opposing variables ensures harmony within often conflicting and ambiguous contexts found in complex design practice. The fluctuations within the design process aim to reach an equilibrium in order to reduce ambiguity and increase stability.

Thus, design thinking in complex environments is observed to exist in a constant state of fluctuation in order to balance competing variables to reach a practical equilibrium.

Constant state of flux	**Balancing user and client needs**	**Balancing a high-level and detailed focus**	**Balancing adaptivity and structure**
Case 1	We've mainly concentrated on the customer journey and the customer needs and wants and pain points, but we need to translate that now into the organisation. (Observation, Phase 1, 2011)	We started off quite high level and then kind of went in deep but not consistently. The level of deepness is more like this, sometimes something needs to be well developed (Observation, Phase 2, 2011) This is like a concentrated version, and that is the bigger version (Observation, Phase 1, 2011)	If I had to do it again: maybe plan the blueprint and play it out. Do this very natural cycle and actually see what it feels like (Observation, Phase 1, 2011) You really need to be organised, come up with the whole system so you know if they choose this or that kind of prop. A lot of the times we would be sitting round going we don't have this...so you need to be responsible, or else it can get very unnatural. (Observation, Phase 1, 2011)
Case 2	It needs to meet a good user design but also needs to meet the ATO's administrative role because we need to make sure whatever we are doing it needs to smoothly run so its a fine line between the Gov intent and the optimal user experience.	As you imagine there is a number of people in the room and they can get bogged into details and its about bringing them up to the right level (Interview, Design Facilitator, 2014) It is also important to ensure that: the individual	I think the ability to be flexible throughout the design stages and the revisiting of the framework of potential solutions even to the stage where you know, where there's a lot of prototypes that might be user tested (Interview, Business Lead, 2014)

	(Interview, Co-Design Lead, 2014) Good design achieves a balance between what the Government or Tax Office wants to achieve and what users need. (Artefact 1, ATO Design Guide, 2008, p.4)	products are tested to ensure that they meet the business and user requirements, and the products are tested together as a whole to ensure that the system works coherently from end-to-end. (Artefact 1, ATO Design Guide, 2008, p.18)	The Design practice statement says: Following a disciplined yet flexible process that stays true to our design principles and achieves higher quality in less time. (Artefact 1, ATO Design Guide, 2008, p.5)

Table 16. Design thinking in a constant state of flux

Balance between high-level and detailed perspectives

Balancing high level and detailed perspectives reflects the process of bouncing between strategic details whilst considering the effect of details on the end-to-end design. Convergent and divergent thinking is a common example of balancing high level and detailed perspectives. Literature commonly refers to convergent and divergent thinking on a surface level (Lawson, 2006), as part of the design process and approach (Hassi & Laakso, p.7), relating to phases in the design process (Brown, 2008, p. 68; Le Masson et. al., 2011) and fundamental to problem and solution exploration (Lindberg et. al., 2010, p.2.44; Owen, 2007, p.23).

Yet, high-level and detailed perspectives are not synonymous with convergent and divergent thinking. High-level perspectives are holistic, systemic and view the design process and development end-to-end. Detailed perspectives zoom into smaller and localised facets of design development. In contrast, divergent and convergent thinking is defined as a method of thought that is activated during ideation and synthesis and employed for the creation and clarification of design solutions:

> Divergent thinking means dealing with a problem by discovering a broad range of its aspects, such as the divergent perspectives constituting a design problem or the divergent possibilities that make up the solution space. Convergent thinking, on the other hand, brings together those divergent aspects to comprehensive frameworks and concepts (Connell, 2013, p.40)

High-level and detailed perspectives are not identified as modes for problem-solution generation, but emerge through the need to consider the wider context and system of the project and keeping the system in harmony with the details that enable emerging design solutions to be implemented. Furthermore, the tension between convergent and divergent thinking is often depicted as sequential and specific to individual design phases, rather than existing simultaneously within each phase. In case 1 and 2, balancing between holistic and detailed perspectives persisted throughout the design process. In case 1, high-level user insights that formulated a vision framework was consistently considered throughout the design process as the design team focused on details to enable the ideal future state to emerge. Case study 2 maintained both a detailed and systemic focus. This may be attributed to the multidisciplinary core design team; business leads bring expertise specialised in providing strategic details needed for high-level design discussions and as such, reduce ambiguity when shifting from divergent high-level ideas to convergent, detailed designs.

Balancing user insights and client needs

A balance between customer needs and organisational wants was at the core of complex design practice. This has introduced a balancing act between client objectives and the user experience, "Design thinking—inherently optimistic, constructive, and experiential—addresses the needs of the people who will consume a product or service and the infrastructure that enables it" (Brown & Wyatt, 2010, p.32). Nigel Cross notes that this confliction breeds creativity, "creative design arises especially when there is a conflict to be resolved between the [designer's] high-level problem goals and the [client's] criteria for an acceptable solution" (Cross, 2002, p.17). Design teams in case 1 found themselves consistently balancing customer insights with organisational needs. Similarly, the organisation in case 2 formally acknowledged how important it is to achieve this balance in their manual, the *ATO Design Guide*. Achieving a successful equilibrium between user and client depends upon the creativity from design thinking to ensure the design outcome will be effectively implemented in practice and be well received by both the organisation and target market. All design projects that inhabit third and fourth order environments will ultimately seek to achieve a design solution that unifies user and client polarities.

Balance between adaptivity and structure

Adaptivity emerged as a necessary component of design since the late 1980s, through emerging computer technology, "Such systems can have a life of their own, adapting to their own environments, learning from users, changing their behaviour, growing and developing into product niches, and protecting themselves from misuse." (Krippendorff, 1989, p.32) Since then, design has evolved as an adaptive practice, enhanced through prototyping, intuition and process malleability (Mootee, 2011, p.4). Today, design thinking is recognised as an adaptive process because of these fundamental traits, and its adaptivity holds value for complex environments "the adaptive nature of design thinking is at the root of its value in confronting uncertainty and ambiguity, in confronting the future" (Meinel & Leifer, 2011, p. Xix).

Adaptivity is considered a valuable asset in design thinking, however, this needs to be balanced in order to achieve successful outcomes. The balance between adaptiveness and structure in the design process appeared to generate tension in both case 1 and 2. The design team in case study 1 found themselves conflicted between keeping the design process open and adaptive to new information and ideas, and the need for focus and direction. The design team in case 1 adopted a more organic approach to balancing this polarity, while the team in case 2 managed this tension by implementing a rigid design methodology. Design thinking practice in case 2 utilised a strict design methodology that still allowed for adaptive and fluid thinking.

Underlying mechanism:

Underlying mechanism driving a constant state of flux: interaction in formative phases of the design process and the desire for equilibrium

Layer	Mechanisms
1. Empirical	Client vs. user needs, High level vs. detailed perspectives, adaptivity vs. structure
2. Events	Design thinking in constant state of flux
3. Real	Interaction in formative phases of design process and a desire for equilibrium to add stability

Table 17. Underlying mechanism for design thinking in a constant state of flux

Mastering the art of balancing opposing states is fundamental to successful design thinking in complex practice. Balancing opposing states restricts designers from focusing in on a design direction too early, leading to premature refinements. Design thinking in a constant state of flux disables linear thinking. This emergent behaviour provides evidence that design thinking in complex environments exists to oscillate between extremes. When design thinking finds itself stalled in one extreme, the process may become imbalanced. This may make it harder to translate and transfer knowledge needed to ideate. Design thinking operates in a constant state of flux in order to keep competing complexities in a state of harmony, to increase stability in the design process. In highly complex and ambiguous environments, design thinking has found itself in a rapid swing between opposites whilst balancing multiple variables.

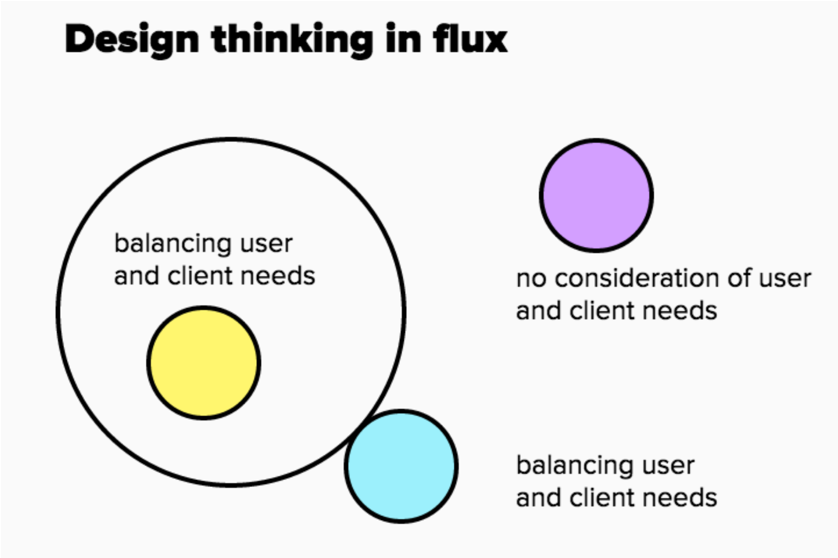

Fig.21 Design thinking in a constant state of flux

However, fluctuation between opposing states was not observed in case 3. Case 3, operating externally to the project ecosystem and environment, was not directly involved in the formative phases of design development. Designers in case 3 are not able to discuss the complexities and competing variables that may limit and restrict design development with the client. Furthermore, they are not exposed to the complexities of the project ecosystem that houses competing variables. Instead, the design community in case 3 are offered a predefined project challenge in order to direct and frame the problem context. In contrast, design teams in case 1 and 2 had engagement with the project ecosystem and client which required formative discussions over competing variables and the project intent. This formative development exposes competing complexities within the design project to the project team; the needs of the client and the needs of the user that requires balancing these opposing states.

7.2.6 Conclusion

It has been presented in this cross-comparative chapter that the design process, position and context of the environment affects and enables emergent behaviours of design thinking, particular to complex third and fourth order environments. The comparison between themes in each case study has surfaced key behaviours of design thinking applied in complex environments. This chapter has demonstrated the similarities between case 1 and 2 and the significant differences that emerge when design is operating externally to the project ecosystem as in case 3. This chapter demonstrates that design thinking on the periphery and internal to the project ecosystem affords positives and negative effects on design thinking in complex practice. However, this chapter concludes that design thinking operating externally to the project ecosystem and remotely in an open-source online environment has significant negative effects on the design thinking process. Thus, design thinking may be not readily or successfully translated to a remote online environment in order to design in and for complex environments.

8.

Discussion

This chapter will discuss the broader implications on design thinking research and practice in light of the knowledge obtained in this dissertation. It will provide further clarification of design thinking, focusing on a high-level discussion of what design thinking is, how it may be identified, what is required for future research and what may be needed to support the development and application of design thinking in complex environments.

Many questions have been posed throughout recent literature on the topic of design thinking, such as: “what is the nature of design thinking? […] What could it bring to other professions? (Dorst, 2010, p.131), “On what principles is it based? How different is it to other kinds of professional knowledge? Do all designers exhibit it? What are its effects within the worlds where design takes place?” (Kimbell, 2011, p.296), and “Is there a need for a design thinking process?” (Lindberg et. al, 2010). These questions capture the ambiguity that still surrounds design thinking and indicate a desire for further clarification. The questions that persist in design theory and practice will be addressed in this chapter through five key topics:

1. What is design thinking?

2. Who is a design thinker?

3. Design thinking shapes and is shaped by its environment

4. Implementation of design thinking in complex environments

5. Design thinking returns to its genesis

This chapter suggests that a consensus on the fundamentals of design thinking has been established. In addition, this chapter presents the argument that design thinking in complex environments is not a process exhibited or attributed to one designer, but instead, an emergent property that is embodied within a design team. This chapter will also highlight the impact context and positioning has on design thinking; where design thinking shapes and is shaped by its environment. Finally, this discussion chapter makes recommendations for future practice in complex environments, arguing for a greater inclusion of a systemic and holistic approach in designing for complex environments, a deeper understanding of the impact position has on implementation and a review of where design thinking stands today.

8.1 What is design thinking?

The design community understand the challenge of defining but not oversimplifying design thinking (Dorst, 2010, p.131). Yet, this has not alleviated demands for a common consensus of what design thinking is. Kees Dorst (2010, p.138) shares the concern over defining design thinking, arguing that contemporary definitions often merge many characteristics and activities causing foggy descriptions. Dorst believes that clarifying design thinking is imperative to realising its value for design –inside and out of design practice (Dorst, 2010).

Confusion over design thinking is pinned to clarification and definition. Many authors have stated that there exists no common definition of design thinking (Kimbell, 2011, p.296; Yin, 2009, p.6; Von Thienen, Noweski, Meinel & Rauth, 2011, p.82; Aijala & Karjalainen, 2012, p.25; Hassi & Laakso, 2011, p.1; Herrmann & Goldschmidt, 2013, p.29). However, despite these complaints, fundamental attributes of design thinking have been consistently noted in design literature. This indicates that whilst interpretations of design thinking may vary, the design community is not as inconsistent as many believe. Attempts have been made at assimilating the knowledge on design thinking into a succinct and general description. Lucy Kimbell (2011), for example, summarised knowledge on design thinking, showing that it exists under three guises: design thinking as a cognitive style, design thinking as a general theory of design and design thinking as an organisational resource [See Fig.22]. Hassi & Laakso (2011) have made similar attempts at unifying our understanding on design thinking, identifying it as a form of practice, thinking style and mentality [See Fig.23]. More recently, Carlgren, Elmquist & Rauth (2013) summarise design thinking as operating on three levels: on the first level are principles, the second level practices and mindsets and the third level are techniques [See Fig.24].

	Design thinking as a cognitive style	*Design thinking as a general theory of design*	*Design thinking as an organizational resource*
Key texts	Cross 1982; Schön 1983; Rowe [1987] 1998; Lawson 1997; Cross 2006; Dorst 2006	Buchanan 1992	Dunne and Martin 2006; Bauer and Eagan 2008; Brown 2009; Martin 2009
Focus	Individual designers, especially experts	Design as a field or discipline	Businesses and other organizations in need of innovation
Design's purpose	Problem solving	Taming wicked problems	Innovation
Key concepts	Design ability as a form of intelligence; reflection-in-action, abductive thinking	Design has no special subject matter of its own	Visualization, prototyping, empathy, integrative thinking, abductive thinking
Nature of design problems	Design problems are ill-structured, problem and solution co-evolve	Design problems are wicked problems	Organizational problems are design problems
Sites of design expertise and activity	Traditional design disciplines	Four orders of design	Any context from healthcare to access to clean water (Brown and Wyatt 2010)

Fig. 22 Kimbell (2011)

PRACTICES	THINKING STYLES	MENTALITY
• **HUMAN-CENTERED APPROACH** E.g. People-based, user-centered, empathizing , ethnography, observation (e.g. Brown 2008; Holloway 2009; Ward et al. 2009)	• **ABDUCTIVE REASONING** E.g. The logic of "what could be", finding new opportunities, urge to create something new, challenge the norm (e.g. Fraser 2009; Lockwood 2009; Martin 2009)	• **EXPERIMENTAL & EXPLORATIVE** E.g. The license to explore possibilities, risking failure, failing fast (e.g. Brown 2008; Fraser 2007; Holloway 2009)
• **THINKING BY DOING** E.g. Early and fast prototyping, fast learning, rapid iterative development cycles (e.g. Boland & Collopy 2004; Lockwood 2010; Rylander 2009)	• **REFLECTIVE REFRAMING** E.g. Rephrasing the problem, going beyond what is obvious to see what lies behind the problem, challenge the given problem (e.g. Boland & Collopy 2004; Drews 2009; Zaccai in Lockwood 2010)	• **AMBIGUITY TOLERANT** E.g. Allowing for ambiguity , tolerance for ambiguity, comfortable with ambiguity, liquid and open process (e.g. Boland & Collopy 2004; Cooper et al. 2009; Dew 2007)
• **VISUALIZING** E.g. Visual approach, visualizing intangibles, visual thinking (e.g. Carr et al. 2010; Drews 2009; Ward et al. 2009)	• **HOLISTIC VIEW** E.g. Systems thinking, 360 degree view on the issue (e.g. Dunne & Martin 2006; Fraser 2009; Sato 2009)	• **OPTIMISTIC** E.g. Viewing constraints as positive, optimism attitude, enjoying problem solving (e.g. Brown 2008; Fraser 2007; Gloppen 2009)
• **COMBINATION OF DIVERGENT AND CONVERGENT APPROACHES** E.g. Ideation, pattern finding, creating multiple alternatives, (e.g. Boland & Collopy 2004; Drews 2009; Sato et al. 2010)	• **INTEGRATIVE THINKING** E.g. Harmonious balance, creative resolution of tension, finding balance between validity and reliability (e.g. Brown 2008; Fraser 2009; Martin 2010)	• **FUTURE-ORIENTED** E.g. Orientation towards the future, vision vs. status quo, intuition as a driving force (e.g. Drews 2009; Junginger 2007; Martin 2009)
• **COLLABORATIVE WORK STYLE** E.g. Multidisciplinary collaboration, involving many stakeholders, interdisciplinary teams (e.g. Dunne & Martin 2006; Gloppen 2009; Sato et al. 2010)		

Fig.23 Hassi & Laakso (2011)

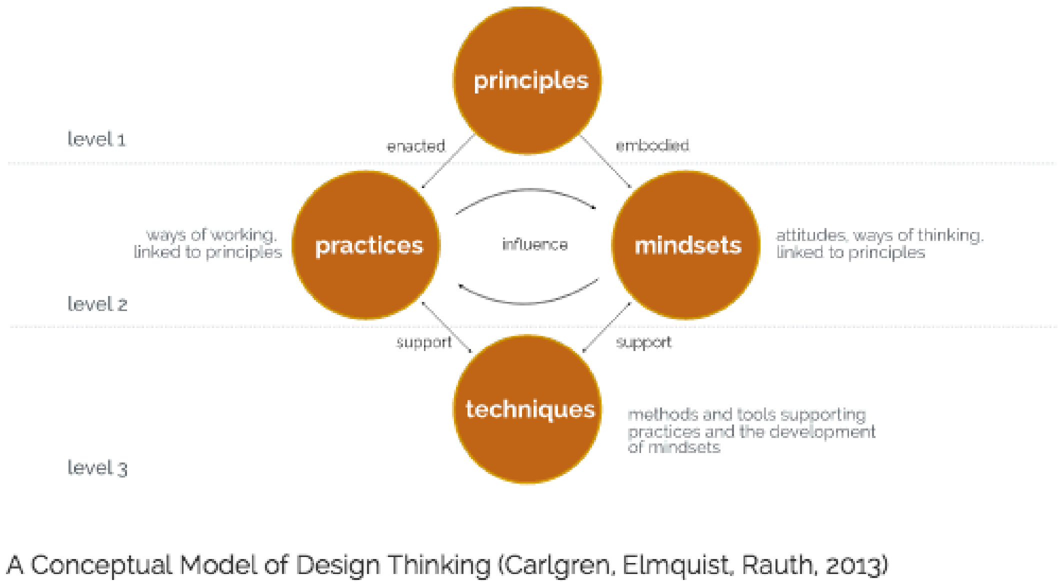

Fig.24 Carlgren, Elmquist & Rauth (2013)

The models presented by these authors offer a brief synthesis of our understanding on design thinking, with references to support each characteristic. Elaborating on these efforts, a list of common descriptions has been compiled in Table.1, introduce in chapter 2. *Literature Review*. A random sample of literature was collected across a range of disciplines through the search term "design thinking". A total of 70 articles explicitly discussing design thinking were collected from research databases, sorted by relevance. These articles have been read and reviewed, with characteristics in each article that have been associated with design thinking extrapolated into a spreadsheet. The most commonly cited characteristics of design thinking surfaced based on frequency of reference from the total number of articles and have been tabled below [Table 1]

Empathy	(Brown, 2008), (Clark & Smith, 2008), (Dunne & Martin, 2006), (Holloway, 2009), (Junginger, 2007), (Lockwood, 2009), (Lockwood, 2010), (Porcini, 2009), (Von Thienen et. al., 2014, p.101)
Abductive	(Brown, 2009), (Lockwood, 2009), (Fraser, 2009), (Martin, 2009, p.65), (Dew, 2007), (Jones 2008, p.219), (Dorst, 2010, p.136)
Prototyping	(Rittel 1987, p.1), (Benson & Dresdow 2013, p.7), (Lockwood, 2010, p. xi), (Rylander 2009, p.5), (Drews, 2009), (Fraser, 2007, 2009), (Holloway 2009), (Bevan et al., 2007, p.140), (Kimbell, 2011, p.287), (Seidel & Fixson, 2013, P.1), (Liedtka, 2013), (Von Thienen et. al., 2014, p.102), (Lindberg, Noweski & Meinel, 2010, p. 33), (Brown & Wyatt, 2010, p.32), (Shluzas, Steinert & Katila, 2014, p.136)
Problem – solution framing	(Farrell & Hooker, 2013, p.689), (Bevan et al., 2007, p.143), (Friedland & Yamauchi, 2011, p.70), (Lindberg, Noweski & Meinel, 2010, p. 33), (English, 2006, p.5), (Dorst, 2010, p.136)

Optimistic	(Rittel 1987, p.8), (Owen 2005, p.13), (Gloppen, 2009), (Owen, 2006, p.24), (Leinonen & Durall, 2014, p.108), (Brown & Wyatt, 2010, p.32)
Fuzzy front end	(Porcini, 2009), (Löwgre & Stolterman 1999, p.17), (Ranjan 2012, p.31), (Drews 2009, p.41), (Le Masson et al., 2011, p.219), (Young 2010, p. 15), (Blyth & Kimbell 2011, p.12), (Jahnke 2013) in (Carlgen 2013, p.22), (Smulders & Subrahmanian, 2013, p.362)
Wicked problems	(Benson & Dresdow 2013, p.6), (Gharajedagi 2010, p.108), (Bharathi 2013. p.83), (Farrell & Hooker, 2013, p.686), (Westcott et. al, 2013, p.4), (Dorst 2011, p.522)
Inventive and innovative	(Owen 2005, p.5), (Brown, 2009), (Gharajedagi 2010, p.108), (Bevan et al., 2007, p.140), (Kimbell, 2011, p.287), (Benson & Dresdow 2013, p.7), (Lockwood, 2010, p. xi), (Westcott et. al, 2013, p.3), (Plattner, Meinel & Leifer, 2011, xiii) in (Laakso & Hassi 2011, p.2), (Owen, 2006, p.24)
Human-centered	(Owen 2005, p.12), (Lockwood, 2010, p. xi), (Brown, 2008), (Porcini, 2009), (Ward et al., 2009), (Sato 2009), (Buchanan, 2001, p. 9), (Owen, 2006, p.24), (Kimbell, 2011, p.287), (Liedtka, 2013), (Leinonen & Durall, 2014, p.108), (Von Thienen et. al., 2014, p.101), (English, 2006, p.5), (Brown & Wyatt, 2010, p.32)
Visualisation	(Owen 2005, p.13), (Lockwood, 2010, p. xi), (Brown, 2009), (Carr et al., 2010), (Drews, 2009), (Lockwood, 2010), (Jones 2008, p.219), (Owen, 2006, p.24), (Kimbell, 2011, p.287), (Liedtka, 2013), (Von Thienen et. al., 2014, p.102)
collaborative	(Owen 2005, p.14), (Gloppen, 2009), (Dunne & Martin, 2006), (Boland & Collopy, 2004), (Jones 2008, p.226), (Herrmann & Goldschmidt, 2014, p.33), (Owen, 2006, p.24), (Liedtka, 2013)
multidisciplinary	(Owen 2005, p.14), (Brown, 2009), (Benson & Dresdow 2013, p.11), (Westcott et. al, 2013, p.2), (Clark & Smith, 2008), (Dunne & Martin, 2006), (Holloway, 2009), (Lockwood, 2010), (Sato et al., 2010), (Kimbell, 2011, p.287), (Von Thienen et. al., 2014, p.102), (Lindberg, Noweski & Meinel, 2010, p. 35)
Iterative	(Benson & Dresdow 2013, p.11), (Rylander 2009, p.7), (Herrmann & Goldschmidt, 2014, p.33), (Kimbell, 2011, p.287), (Von Thienen et. al., 2014, p.102), (Friedland & Yamauchi, 2011, p.68), (Lindberg, Noweski & Meinel, 2010, p. 33), (Shluzas, Steinert & Katila, 2014, p.136)
Intuitive	(Rylander 2009, p.5), (Porcini, 2009), (Jones 2008, p.219), (Lindberg, Noweski & Meinel, 2010, p. 33), (Brown & Wyatt, 2010, p.32)
Ethnographic	(Beckman & Barry, 2007), (Brown, 2008), (Carr et al., 2010), (Dunne & Martin, 2006), (Lockwood, 2010), (Owen 2005, p.14)
Systemic thinking	(Owen 2005, p.14), (Dunne & Martin, 2006), (Jones 2008, p.219), (Owen, 2006, p.24), (Brown & Wyatt, 2010, p.32)
Rapid	(Lockwood, 2010, p. xi), (Carr et al., 2010), (Holloway, 2009), (Lockwood, 2010), (Brown, 2009), (Herrmann & Goldschmidt, 2014, p.33), (Liedtka, 2013), (Brown & Wyatt, 2010, p.32)

Table 1. Commonly cited characteristics of design thinking

Most definitions present design thinking as a mindset, method, process, attitude or a combination of all four. Descriptions of design thinking often hint at a relationship between each of these different attributes. From the table of literature by Kimbell, Hassi & Laakso, Calgren, Elmquist & Rauth, it appears that, for contemporary theorists, design thinking is understood to comprise of mindsets, methods, processes and attitudes. However, a deeper explanation of the relationship between these attributes is to be clarified.

Despite the efforts to compile a set of common characteristics on design thinking, these attempts do not seem to satisfy both industry professionals and academics:

> we realized that any attempt to create an essentialist, normative definition of the concept would be impossible, and more importantly, would be of limited value for a constructive discussion of design thinking. Eventually we came to conceive design thinking as a loose concept that is given new meaning and becomes something different in each context, but that still needs to be articulated. (Carlgren, 2013, p.41)

This implies the argument that design thinking is transitive and may differ depending on the context in which it is applied. We require a both a stable vocabulary and boundary to teach, describe and identify design thinking, yet the boundary must also be fluid and adaptive. A suggestion would be to consider design thinking as a malleable and evolving process, and with it, a fluid and evolving definition.

Evidence to support the malleability of the design thinking process raises questions over whether we can coherently articulate a unified nature of design thinking. Kimbell questions this position through design diversity, "attending to the diversity of designers' practices and the institutions in which they work makes it questionable to generalize about a unified design thinking exhibited across all of them" (Kimbell, 2011, p.289), yet, it is clear in the literature presented in Table.17 and through Fig.19, Fig.20, and Fig.21, that, whether realized or not, a common ground for consensus is emerging across individual accounts on design thinking. This consensus is what should provide consistency and a foundation for identifying and articulating the nature of design thinking. Having identified a foundation of attributes that describe design practice and thus a working definition of design thinking, research must also focus on and be sensitive towards the nuances of a design approach in each order of practice:

> Design thinking process models therefore have to struggle twofold: firstly, they must depict context-sensitivity and situational adaptability of workflows without losing 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 (Lindberg et al., 2010, p.246)

The indeterminate nature of design thinking owes much of its wickedness to the transient nature of design practice. It is this evolving and adaptive nature of design thinking that makes it appropriate for tackling uncertainty in complex environments, as exemplified through the design case studies in this thesis. As a result, design thinking evolves with complex environments and in turn shapes, and is shaped by, emerging processes:

> 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. (Lundberg & Pitsis, 2010, p.281)

This situation raises a few questions: as design thinking responds to changing complex environments, will fundamental characteristics remain? Furthermore, should designers and researchers continue to attempt to define design thinking, or allow it to remain open to evolve with the dynamic environment that surrounds it? If the design community attempt to establish boundaries for the purpose of definition, will it limit design's innovative potential? More importantly, how is design thinking currently applied in complex practice and what affect does complexity have on design process and innovation in complex environments?

> To start, Cooper & Press (1995) have found that there is little uniformity in the definition of design, while the notion covers many different disciplines, and our understanding of the concept also seems to be changing over time. (Äijälä & Karjalainen 2012, p.25)

Design thinking's adaptivity has also surfaced concerns over what constitutes professional design thinking practice. Some attribute design thinking to complex, third and fourth order environments as this area has gained most public attraction and action:

> 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. (Jones, 2010, p.219).

Chapter 2. *Literature Review* established that design thinking has grown and matured through an evolution of design practice, and that it is not a new concept but instead an approach that reflects characteristics fundamental to all disciplines and orders of design practice. As such, design thinking is as much embedded in design practice concerned with the creation of artefacts as it is with the creation of intangible services and systems. The consistency lies within the foundational attributes of design thinking [Table.1, Fig.22, Fig.23, Fig.24] that allows people to use, adapt and apply design thinking to different disciplines, outside of traditional design practice:

> To be clear, design thinking extends far beyond design as most of us imagine it. Design thinking is not concerned solely, or even primarily, with the look of a product. Rather, it encompasses a whole range of tools and frameworks, may be drawn from other disciplines, that reflect its driving concern with human experience (Gobble, 2014, p.59)

The accessibility of design thinking leads us to question the nature of design practice. Some scholars have argued that design thinking is a new discipline with its own unique approach (Leavy, 2010). However, each order of design practice exhibits many of the common characteristics outlined in Table.1, Fig.22, Fig.23 and Fig.24. The fundamental attributes of design thinking compiled within Table.1 are attributes fundamental across all orders of practice. Thus, this may signify that the concept of design thinking is synonymous with the word *design*. Design practice relies on and matures design thinking in order to solve problems. Design thinking is not a practice that is unique, independent or different to what designers in other sub-disciplines do in their day-to-day work, but has been marketed as such in fields outside of design practice to generate commercial success. Thus, design thinking should be considered as a description of the design approach, with the term emphasizing the mindset that designers across all orders apply to their practice.

8.2 Who is a design thinker?

As design practice expands through the adoption of design thinking, questions arise around who can be considered a design thinker. Design scholars have long argued that design is a characteristic inherent in all human activity (Archer, 1979; Simon, 1996; Saikaly, 2005). This argument has supported statements that generalize design, with propositions that everyone is, or can be, a designer or design thinker. This argument is valid, albeit in a very crude form, as it is crude to say that anyone who picks up an instrument is a musician. A design thinker is an individual who has *tamed* the design approach. This individual carries the design outlook, mindsets and knows when and where to utilize design methods through a designerly process appropriate to the environment they are working within:

> Taking these cues, Buchanan builds a case for design as a new 'liberal art', meaning: 'a discipline of thinking that may be shared to some degree by all men and women in their daily lives and is, in turn mastered by a few people who practice the discipline with distinctive insight.' In other words, an art that is accessible to many but mastered by few. (Graham, 2013, p.vi)

Design thinking is not a practice that is easily mastered. Merit may be founded in talent - as it is possible for a non-designer to quickly adopt and apply a designerly approach. However, just as talent enables mastery of an instrument in a short period of time, the average musician may spend years practising an instrument and still remain mediocre. It is talent, mastery and experience that together classifies a professional from an amateur. Generally speaking, a designer who has spent years refining the design approach in design school and through applying a design approach in practice will be a more advanced design thinker than an individual adopting it for the very first time.

8.2.1 De-centralising design thinking

A design thinker is an individual that embodies and enables the process, mindset and methodology of the designerly approach. Yet, design thinking does not need to emerge through just one individual. Evidence presented in chapter 7. *Cross- Comparison Analysis*, shows that a de-centralisation of design thinking exists in complex practice. It has been observed that as design thinking moves towards higher and more complex and multidisciplinary environments, the role of a lead designer embodying design thinking becomes de-centralised. Instead, design thinking emerges from a group of individuals working with design methods through a design process. Thus, the concept of design thinking embodied in one individual needs to shift, to an understanding that design thinking may be embodied within a collective:

> No design can exist in isolation. It is always related, sometimes in a very complex way, to an entire constellation of influencing situations and attitudes. [...] Earlier generations solved this problem by using many hands and minds over periods of centuries [...]. The 'designer' then was not an individual, but an entire social process of trial, selection and rejection. Today he is still that, though in a somewhat different sense, and we tend to overestimate his significance as an individual. (Nelson, 1957, p.19)

Do all individuals in a multidisciplinary team need to exhibit design thinking characteristics? Not necessarily. For multidisciplinary teams without formal design training, design methods and process play a vital role in enabling and facilitating a design mindset. In an inexperienced design team, design thinking is best introduced via a formal design facilitator. However, it has been highlighted in in chapter 7. *Cross-Comparative Analysis*, that it is the collaborative interactions between the group and design methods and process that enabled design thinking to emerge in complex practice.

Furthermore, the design output, whether a tangible artifact or intangible concept, is also an embodiment of design thinking. The collaborative effort of the design team, guided by a design process, is reflected in the design outcome as a representation and embodiment of collaborative design thinking. Thus, in multidisciplinary design practice, implementation should be the responsibility of each individual within the design team, as each person provides input towards the creation of the outcome. Design thinking is only as good as its solution through implementation, hence a good design team is at the core of a successful outcome.

8.3 Design thinking shapes and is shaped by its environment

Research collected in this dissertation has presented evidence to support the existence of a deep relationship between the mindsets, methods, context and position of design thinking. This relationship showed that whilst design thinking operates within a process framework, it is not static or fixed; the design process adapts to the context and environment it is applied within. Design methods enable design thinking and in turn, facilitate a designerly approach. The relationship between method and mindset is deeply intertwined, with both facets influencing and enabling the other:

> Since the theory provides blueprints to practitioners, a change in the theory is likely to change the empirical world itself. Theory and practice co-evolve. (Von Thienen et al, 2011, p.85)

Analysis on all three case studies revealed that the context of the domain in which a design approach is applied has a direct affect on the behaviour of design thinking. This signifies that fundamental characteristics of design thinking exist across all design practices but additional characteristics may emerge specific to the order and context it is applied within. Designing in the first 'order' of design [see Fig.5] with a focus on artefacts, will require additional methods unique to that order that differ from design that focuses on systems and services. It has been displayed through a cross-comparative analysis on each case study that the environment influences emergent behaviours unique to its order.

In practicing design thinking, few scholars have paid proper attention to the way design methods, context and position enable and enhance design thinking. Since design thinking drives design doing, the relationship between method and mindset cannot be ignored. In addition, the impact of the position of design thinking relative to the environment, of which exerts on the design approach, must also be considered. To summarise, Table.18 exhibits the emergent behaviours found from each case study, and the methods, mindsets and positioning that enable these behaviours to emerge.

CONTEXT	**Third and Fourth Order Complex Environments**				
Emergent Behaviour	*Holistic perspective*	*Vision framing*	*De-centralisation of the designer*	*Disrupting perceptions*	*Design thinking in flux*
Characteristics	1.Divergent thinking 2.Adaptivity 3.Systems thinking	1.Mapping 2.Abduction 3.Empathy	1.Visualisation 2.Passive facilitation 3.Multidisciplinary Collaboration	1.Diversity of perspectives 2.Engagement with stakeholders 3.Demonstrating design process	1. Balancing user and client needs 2. Balancing high level and detailed thinking 3. Balancing adaptivity and structure
POSITION	**Relationship to project ecosystem**				
Case 1: *Periphery*	Direct engagement with project ecosystem fosters holistic perspectives	Emphasis on user during formative phases	Higher engagement with user than client and stakeholders	Less diversity of perspectives and higher emphasis on demonstrating the design process	Consistent balance between competing objectives
Case 2: *internal*	Internal to project ecosystem fosters stronger holistic perspectives	Emphasis on system during formative phases	Higher engagement with client and stakeholders than user	Higher diversity of perspectives but less demonstration of design process	Consistent balance between competing objectives
Case 3: *external*	No direct engagement with project ecosystem disables holistic perspectives	No emphasis on user or system during formative phases. Quick to converge	No engagement with client, stakeholder or user.	High diversity of perspectives but no need to demonstrate design process	No balance between adaptivity and structure. Low level of balance between high level and detailed thinking. No balance between user and client needs
CAUSE	**Underlying Mechanism**				
	Direct interaction with project ecosystem	Direct interaction with project ecosystem	Immediacy through face-to-face collaboration	Close mindedness and fear of unknown	Interaction in formative phases. Desire for equilibrium

Table.18 Summary of emergent behaviours

This analysis enables us to understand how interacting with design methods can enhance or build a design mindset. In addition, it also formulates an understanding on how the environment and position of a design affects the design process, which in turn, shapes design thinking.

> It is argued that the difficulties of articulating the meaning of design thinking can have consequences for researchers studying the concept. The lack of consensus on the concept also might lead to managers to implement it without taking account of the particular context, and relying on generic and idealistic descriptions of what design thinking means and the value it can provide. (Carlgren, 2013, p. 55)

Further research should elaborate on preliminary efforts outlined in this dissertation, to provide deeper analysis on the connection between design method, mindset, position and environment. This observation needs further research evidence carried out on cases from each order of design practice. This is relevant both for identifying whether environments pertaining to orders of practice enable emergent behaviours and characteristics unique to that order.

8.3.1 Impact on four orders of design

What impact does the evolution of design practice, enabled through new contexts and environments, have on the four orders of design? Buchanan notes, the expansion and evolution of design practice is the natural progress of design thinking:

> The practice of design is expanding, but it still means "human making". The meaning of the word design has broadened, because we're now able to design a wide variety of products, e.g. products that are tangible and products that are intangible. The biggest change in design practice has been the change from artefacts and communication into a new world of actions, activities, and processes. (Buchanan, 2013)

As design evolves towards higher orders of practice, each order contains design disciplines of the orders that precede it. For example, a service design project pertaining to third order of practice may require artefacts and communications from first and second orders for the service design to be successfully implemented. This was evident in both case 1 and 2:

> To me the fourth order of design is the design of the environments and systems within which all the other orders of design exist. Understanding how these systems work, what core ideas hold them together, what ideas and values – that's a fourth order problem. Both the third and the fourth order are emerging now very strongly. (Buchanan, 2013)

Even though details of processes and methods may change slightly depending on scale, context and complexity, the fundamental characteristics are present in all orders and should be classified as part of the foundation and definition of design thinking and design practice. Evolving with practice, design thinking must retain foundational characteristics at its core that allows for clear identification.

8.4 Implementation of design thinking in complex environments

> Design Thinking seems on its way to become the state-of-the-art innovation method. And yet, we understand only little about what really matters for it to be successful. (Von Thienen, Noweski, Meinel & Rauth, 2011, p.82)

Implementation poses one of the largest challenges for design thinking. Design thinking has proven itself as a process that empowers innovative thinking and working, yet its broader value and impact is only visible through implementation. Design innovation should not be measured solely on the amount of creative ideas that are generated, but instead, measured on the innovative ideas that are able to be successfully implemented and adopted by its audience. Much of the discussion around design thinking assumes that if a design process is used for project development then implementation will naturally follow and outcomes will be a success. Implementation is often an afterthought and a phase that is often managed not by the design team but by the client. This creates a disconnect between the practice of design and the practicalities of implementation. Implementation is one of the most undervalued phases of the design process. Many references on design thinking discuss the process and mindset and add little towards how both of these aspects integrate and affect implementation. Many of the most common design thinking models have no implementation phase included as part of the process [Fig.25]

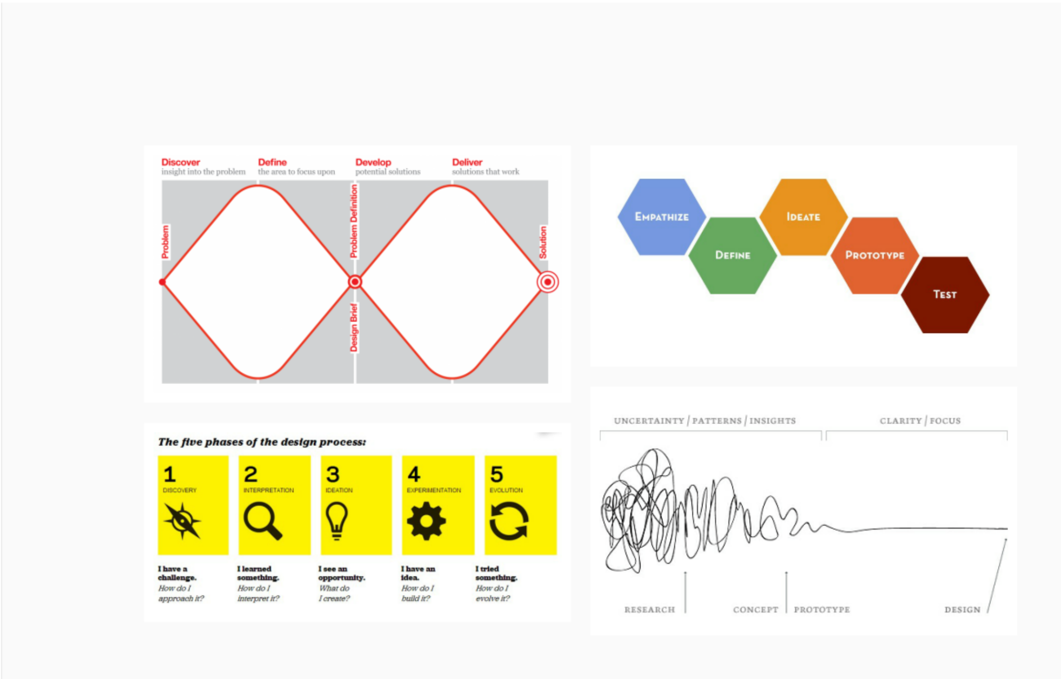

Fig.25 Common design thinking processes. Top left: Design Council's double diamond (2014), top right: Stanford D.School bootcamp (2011). Bottom left: IDEO Design thinking process for educators (2011). Bottom right: Damien Newman design squiggle (ca. 2004).

The absence of implementation in design process models may be attributed to its long history that has centered on artefacts and tangible solutions. With design artifacts, such as a product or logo, the implementation is relatively straightforward and evaluation is clear and accessible to the client. As design practice has evolved towards service, systemic and socially responsible design, outcomes are embedded within ecosystems and metrics for evaluation are difficult to define: "Right now, because implementation is so difficult and expensive, it seems like commercial products are the only ones that offer clear built-in incentives for participation" (Design and Social Impact, 2013, p.24). Thus, implementation requires a broader strategic, systemic and holistic perspective, incorporating both the operations of the business and the object of design that will be embedded within the project ecosystem. It is in part for this reason that design management has emerged as a sub-discipline of design and design thinking:

> Design can be managed and utilized on three different levels: operational, tactical, and strategic (Borja de Mozota 2003, Joziasse 2000, Best 2006, Kootstra 2006). These resonate with the three levels of strategy within companies: corporate strategy, business strategy and operational strategy (Joziasse 2000). And design contributes to all these levels. (Äijälä & Karjalainen, 2012, p.26)

For complex design practice - that is, projects situated within third and fourth orders of design- strategy, implementation and evaluation are crucial to success. Strategic design is most often associated with higher orders of design thinking, thus, strategic design may be used as a synonym or description of design thinking practice in third and fourth order environments (Tonkinwise, 2010, p.386; Farrell & Hooker, 2013). Design thinking in complex environments requires additional methods to integrate designed solutions within the context of the complex ecosystem it is designing for. Systemic design thinking may be an additional perspective and/or method that is required to compliment design practice in complex environments, as was observed in case 1 and 2:

> Preparing designers for participation in policy planning will be a challenge for design education. Meeting the challenge will require new understanding, an extended range of design tools, and concerted support from the design professions to demonstrate the value of design thinking to decision making at the highest levels. (Owen, 2005, p.16)

The need for additional design tools and training for complex practice has recently been addressed through newly established avenues of research, practice and education. The *Symposium of Relating Systems Thinking to Design*, established in 2012 (Systemic Design, n.d, "RSD Symposia"), and *Transition Design* course established in 2014 offered at Carnegie Mellon University (Carnegie Mellon Design, n.d, "About our research"), are two primary examples of the awareness and need for design research and education for practice in third and fourth order environments. Furthermore, both of these initiatives indicate that design practice is evolving towards establishing formal expertise in higher orders of practice; the design of ecosystems that focus on the intersection of systems, society and technology that constitute complex environments.

8.4.1 Positioning:

However, along with the need for systemic and holistic design methods in complex design practice, the effect of positioning needs to be considered in light of implementation. The position of design relative to the problem or organizational ecosystem directly affects implementation. Thus, considering the effect of positioning is important when understanding the barriers and enablers for design implementation. Driving the commercialization of design thinking is an expectation of successful implementation of innovative solutions. Implementation may be affected by the position and relationship between design thinking, the project order and ecosystem.

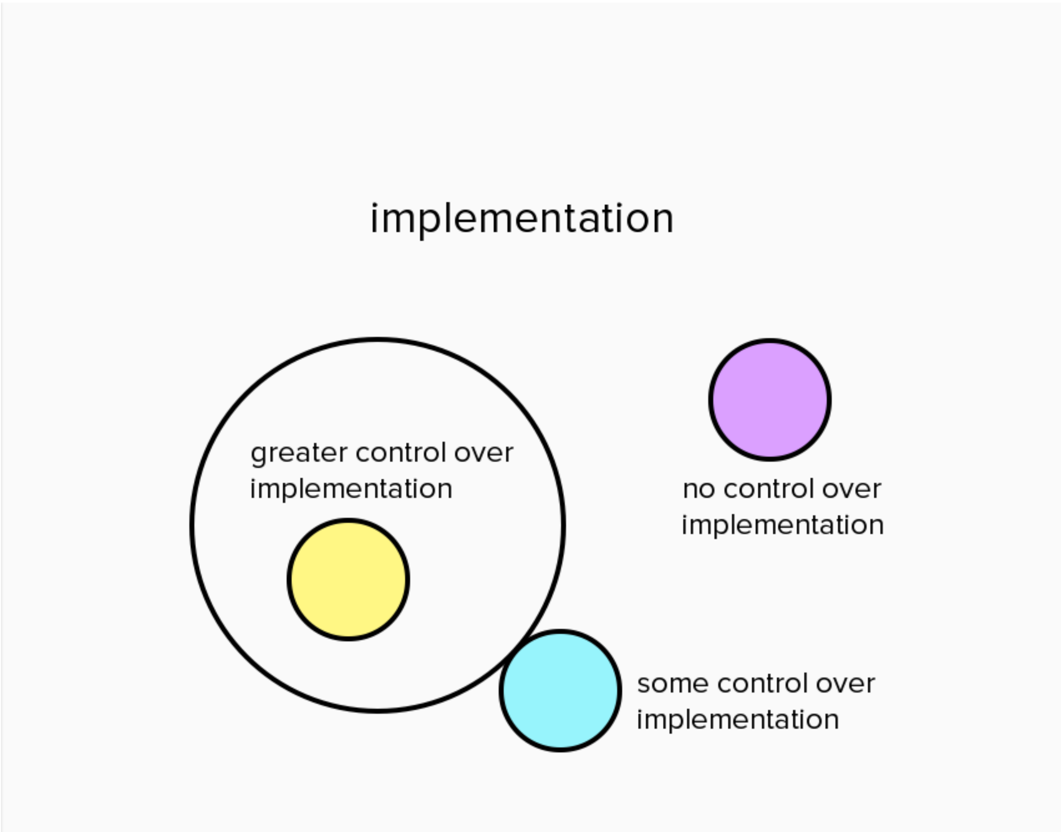

Fig.26 Effect of positioning in implementation for each case study

Discussed in chapter 7. *Cross- comparison analysis*, Case 1 operated as a design agency external to the client organisation and on the periphery of the project and client ecosystem. The design team in case 1 had an objective advantage with the ability to observe internal operations of the client organization from a fresh perspective. However, design teams operating on the periphery of the project organization and ecosystem may have less impact during implementation than design teams operating internally to the project ecosystem. This is due to a common design scenario that was exemplified in case 1; the client organization is forced to decide whether they wish to continue with the services of the external design team beyond just design development. For design teams operating on the periphery, there is less control over implementation as the client must decide if they wish to continue paying for their services throughout implementation. Barriers for successful implementation for design operating on the periphery of the project ecosystem include: time, resourcing, money and confidence from the client that they are able to implement the design solution independent of the design team. In case 1, the client decided not to establish ongoing assistance from the design consultancy and implemented the design solution independently.

Design practice positioned on the periphery of the project ecosystem as in case 1, or externally as in case 3, places higher risk on implementation. The operations of the design team, remote from the client and project environment, can create a sense of detachment between the design solution and the project ecosystem. Furthermore, for complex design practice, an external position exposes that "designers feel more comfortable in designing a product, service or experience as they do in understanding the complexities of the business. Therefore, designers will need to be educated as much as business as part of this new economy" (Bucolo, 2015). For case 3, the process and responsibility behind implementation is left to the client and out of the hands of the design team. Designing in this external, remote and open source position indicate that solutions are often left unimplemented or fail to be executed in their entirety (Durst, 2012). Design practice that is internal and embedded within the project and organizational ecosystem may have a greater sensitivity and understanding of the operations of its ecosystem and thus may design solutions that are more appropriate for implementation.

This strategic planning for design implementation requires additional time, money and resources and is often not a feasible option for clients outsourcing design expertise. Furthermore, this position also raises questions over who is responsible for when failures upon implementation. It is difficult to determine if it was poor design or poor implementation management that resulted in unsuccessful solutions when design solutions are handed over to the client for implementation. Often it is during implementation where most design problems surface:

> One of the central aspects of this kind of failure is the fact that some designers never learn that they have actually failed to meet client needs, customer needs, or end-user needs. This is because designers often end their involvement with the project before the failures arise and the clients of most failures do not return to the original designer for repair work. (Friedman, 2003, p.514)

The advantage of design positioned internally to the project ecosystem is that it affords a greater understanding of the operations of the project. The design team in case 2 were able to design and implement solutions that were more effectively and seamlessly integrated within the organization, largely in part because the team were embedded within the project system. Yet, implementation in case 2 was not handled solely by the design team. Design solutions were passed to a business line where a business and marketing team organise the release and implementation of the design solution. However, the hurdle for design positioned internal to the project ecosystem, is for design teams to maintain user-centered sensitivity whilst balancing systemic and business objectives.

8.5 Design thinking and its return to its genesis

It has been proposed in the first chapter of this thesis that the practice and term, *design*, is synonymous with, embodies and enables *design thinking*. The exception, however, is when using the term *design thinking* emphasis is placed on the unique mindset and approach behind design practice. The evolution of design thinking, highlighted in chapter 2. *Literature Review*, began during the design methods movement. This movement aimed to establish a science of design, and in doing so, discussed and emphasised complex strategic and systemic problems. Rittel and Webber's paper, *Dilemmas in a General Theory of Planning*, considered as one of the most influential texts which has helped to develop and define design thinking and practice, is one example of how discussions during this period focused on what we would identify today as higher orders of design practice. Yet, service, strategic and systemic design practice that

pertains to third and fourth order environments has only recently been acknowledged and developed into a discipline that is accepted as part of design practice.
The backlash of the first generation design movement saw design practitioners reject discussions of a higher and more intangible strategic design practice as it was associated with an attempt to “scientise” the art and craft of design and design thinking. Thus, from this point, developments in design theory and practice focused on the reflective nature of design that was often emphasized as a process between the designer and the designed artifact:

> Zurlo (1999) acknowledges that design has become strategic because of one main factor: the product is no longer understood just as an object. The product has evolved into a product system. It is a complex artifact in itself and it is flexible and interactive. (Garcia, 2012, p.158)

Exploration of new design methods and methodologies naturally followed this period and new design environments and industries emerged. As practice evolved, the design naturally progressed towards higher orders and more complex environments which has led us today to what was discussed during the early establishment of design practice. It has taken 30 years for design professionals to formally acknowledge the importance of design in complex environments. However, the evolution of design thinking identified in chapter 2. *Literature Review*, was a necessary process for design thinking in order to mature and grow towards confidently handling complex design problems.

8.6 Conclusion

This discussion chapter has addressed four main topics central to the development and establishment of design thinking. First, the question of *what is design thinking?* was addressed. In this discussion, a consensus towards a definition of design thinking was identified through a randomly selected literature review. Second, *who is a design thinker?* was discussed, proposing that a design thinker may not necessarily be a trained designer. Third, a discussion on the effect that environment has on design thinking was presented. Through evidence collected in this thesis, it was suggested that design thinking is enabled as much from the interaction with methods as it is through collaboration and context. Problems surrounding implementation of design thinking in complex environments followed. This discussion surfaced issues around the evaluation of design solutions and the impact that positioning has on implementation. Finally, to close this chapter, a discussion of the evolution of design thinking was reintroduced with a brief discussion on the return to higher orders of design practice and thinking that had initiated the design methods movement.

More empirical research is required to assess the barriers, enablers and effects that positioning has on design process and implementation. The longevity of design thinking, particularly for complex environments, will rely on not just the creation of innovative ideas, but "ensuring that key ideas maintain their integrity during that process. Designers must be involved over the duration of change processes, providing constant expertise and feedback to identify, test, and deliver durable solutions" (Boyer, et. al., 2010)". In contrast, "We found, for example, opposite beliefs regarding the question whether design work should be outsourced or not. According to some experts, design teams need to work outside of common business contexts to avoid being "captured" in their routines" (Von Thienen, Noweski, Meinel & Rauth, 2014, p.83). This supports the importance of positioning and interaction with the design environment than operating remotely from it. The focus of design thinking thus far has emphasised the innovative power for ideation inherent in a design thinking process, including the idea of experiencing this process and building a design culture. The focus of design thinking literature must shift from documenting the innovative ideation inherent in a design thinking approach, to extending the design process by developing practical and strategic methods so that innovative ideas generated can be successfully realized and implemented in continuation with a design thinking approach.

9.

Conclusion

This dissertation has sought to refine, extend and clarify the theory and practice of design thinking. In doing so, this dissertation has focused specifically on design thinking in complex environments. It has addressed three questions: *1. What is the behavior of design thinking in complex environments? 2. Does the location of design relative to the project environment affect the design process in complex environments*? and *3. What are the underlying mechanisms that enable or disable designerly behaviours to emerge in complex environments?* Through detailed analysis of three representative case studies of design thinking in complex environments, this thesis has challenged pre-existing ideas about the behavior and application of design thinking in third and fourth order environments.

9.1 Contribution to research

This dissertation began by tracing out a broad history and development of design thinking theory and practice that has contributed to our understanding of design thinking to date. This history was discussed in chapter 1. *Literature Review*. This chapter identified a chronological evolution of design thinking theory and practice traced through the writings of seminal design practitioners and academics from within the design field, whilst identifying common and conflicting characteristics of design thinking. The literature review established that design thinking is embedded within, and emerged from, the design industry and identified a clear gap in the literature for further empirical and theoretical discussion on design thinking in complex, third and fourth order (Buchanan, 1992) environments. The literature review provided insight into how historical design developments have contributed to our current definition and understanding of design thinking. This chapter served to clarify and define design thinking, in order to establish a foundation for the research investigation into design thinking practice in complex environments.

Chapter 2. *Research Framework,* provided an opportunity to revise common theoretical approaches to design research. In this chapter, critical realism was presented and argued as an appropriate theoretical perspective for understanding the emerging practice of design in complex environments. Furthermore, a framework for critical realist analysis was created, which had not been previously developed or adapted for research into design practice. As such, the methodology chapter set out to construct a clear critical realist process of analysis for future design researchers. This process involved establishing critical realism as an epistemology, before conducting grounded theory analysis, to then draw causal conclusions via the critical realist process of retroduction. The critical realist perspective was used for data collection and analysis for each case study, as well as for cross-comparative analysis, to reach underlying mechanisms of emergent design behaviours in complex environments. This perspective helped shift the analysis from thick descriptions towards establishing theoretical foundations for design in complex environments.

Each case study presented in this dissertation contributed to knowledge on design thinking in complex environments. Case studies were chosen according to a defined set of criteria outlined in Chapter 3. *Research Framework*, that was guided by frameworks on design practice by Buchanan (1992) and on complexity of problem spaces discussed by Flach (2011). Furthermore, cases were chosen to reflect various positions of design thinking relative to the project and client ecosystem; extending on theory presented by Junginger (2009;2012).

Case study 1 focused on design thinking adopted within a service and strategic design agency. This case followed the agency as they worked on a service and strategic design project for a large telecommunications client. This case represented design thinking positioned on the periphery of the client environment. This case study revealed that design positioned on the periphery of the project ecosystem has a greater emphasis on the user than the client and organizational ecosystem (See 7.2.2 and 7.2.3). In addition, this study showed how design thinking on the periphery may be less collaborative between the client and the design team, yet requires greater demonstration of design in order to disrupt client perceptions and culture (See 7.2.4).

Case 2 presented design thinking that was positioned as an internal resource to the project ecosystem and client organization. This case followed the Australian Taxation Office as they applied a design thinking approach to solve taxation policy related problems. This study revealed that design thinking is an emergent behavior from a multidisciplinary team of collaborators, and showed how design methods facilitate and enable design thinking (See 5.3.4 and 5.3.6). Furthermore, it demonstrated that engaging with the design process and methodology can enable design thinking without the need for a leading design expert (See 7.2.3.1). As such, it showed that design thinking in this case study was an emergent behavior of a group of inexperienced individuals and was not directed by a design expert (See 5.3.5).

Finally, Case 3 focused on design thinking applied in a new and innovative context- an online open source platform (OpenIDEO). The position of design thinking in this platform means participants do not have a direct relationship with the project and client ecosystem. Design thinking in an online open source environment is thus positioned as a de-centralised approach. Case study 3 identified the limitations of applying design thinking to an online, open source and remote internet platform. The remote open-source platform of OpenIDEO revealed that design activity from members is not fully representative of a holistic design thinking approach. It was suggested that the external position of design thinking, detached from direct interaction with the project and/or client ecosystem, disables a number of designerly mindsets and behaviours observed in the previous two case studies (See chapter 7. *Cross-comparison analysis*).

From the raw data presented in each case study, a cross-comparison analysis was conducted in chapter 7. *Cross- comparison analysis.* This chapter identified common themes and categories across each case that may signify emergent characteristics of design thinking in complex environments. Six emergent characteristics surfaced from the cross-comparative analysis: 1. Holistic perspectives, 2. Vision framing, 3. De-centralisation of the designer, 4. Perspective shifting, 5. Embodiments of design thinking and 6. Designers in flux. These themes were identified through comparison between the context, process and position of design thinking in each case.

This cross-comparison chapter achieved three things: 1. it addressed the research question and objectives outlined in the literature review, 2. presented findings that were evident in each case study, supporting the justification of emergent behaviours which may be contextual to the order design thinking is applied and 3. it identified underlying causal mechanisms driving each emergent behavior that provide the foundation for a theory on design thinking in complex environments.

Finally, chapter 8. *Discussion*, synthesizes knowledge obtained for this dissertation and provides a broader analysis, discussion and interpretation of design thinking in complex environments. This chapter contributes to the broader discussion on design thinking practice; proposing clarifications for the ambiguity surrounding design thinking.

9.3 Limitations

The methods adopted for this dissertation each withhold bias and limitations. First, the use of case study research presents a limitation in the way data is collected and analysed. Researchers adopting a mixed data collection design may forget to acknowledge their reflective position, particularly when utilising quantitative data. Critical realists remind mixed method researchers that the use of statistical evidence is not to 'claim' universal theory but should be used to compliment causal analysis to strengthen the reliability and validity of theory (Downward et. al, 2002, p.491).

Additionally, the temptation to abstract data 'as is' and fail to reflectively acknowledge ones position in qualitative, but particularly quantitative approaches, leads to a lack of proper comparative analysis that is required for both critical realism and grounded theory. Failure to consistently and critically re-conceptualise ones own theory developed between either qualitative or quantitative data sources (whilst acknowledging the limitations of each) will inhibit proper analysis of underlying causal mechanisms in order to generate grounded theory. This results in 'thick' descriptions of data; a consequence that must be avoided for both critical realism and grounded methodology research. To reduce this limitation, a cross-comparison chapter was introduced with purpose to move beyond "thick" descriptions of data presented in each case study, to a deeper causal and reflective analysis that proposes underlying mechanisms driving emergent insights.

Furthermore, each case study in this thesis presents a different design thinking project in complex environments, and only three cases are presented that exemplify design thinking in complex environments. This may limit the ability to extrapolate insights beyond the cases being studied. However, the triangulation of insights across each case study, coupled with design literature, ensures that emergent categorical insights common to each case corroborate or conflict with existing studies and research, providing necessary rigor to the positions presented in this thesis. Furthermore, the purpose of a critical realist approach is to extend beyond individual case research to identify underlying mechanisms of emergent core categories which may become identifiable in design projects operating within complex environments beyond the scope of this thesis.

9.4 Further research

Many topics addressed within this thesis may be utilized for, and require, further research. Broadly, more empirical research is needed that investigates how design thinking is applied in complex environments. As complex design practice is an emerging area of design, more design research is needed to understand, document and analyse this topic. In addition, further empirical evidence is needed that focuses on investigating and comparing the unique, emergent behaviours of design thinking in different orders of design practice. This evidence will add further support to the proposition presented in this thesis: that design process and thinking in each order will surface methods and/or mindsets required to design in that order of context. Further investigations into these questions will build knowledge on the effects and influence that positioning, context and environment play on the design process, whilst also understanding the root causes which enable emergent behaviours to occur.

Fundamentally, further consolidation is needed to support the presence of fundamental design thinking characteristics that exist in each form of design practice. Further research is required to understand if all, or part, of the design thinking characteristics outlined in this thesis apply across every sub-discipline of design practice. Finally, more research should be documented on the use of critical realism in design research. This thesis hopes to have made a methodological contribution by clarifying a framework for analysis for design researchers wishing to investigate design thinking in complex environments, through a critical realist theoretical perspective.

9.5 Final comments

Design thinking has gained popularity over the past decade for its promise of innovation and creativity. Numerous authors have attempted to define and refine design thinking, with most claiming that design thinking has no common consensus within the design community. This research has examined key design literature and has demonstrated that a consensus does exist amongst many definitions of design thinking. This consensus has been outlined and argued as a foundation for which to identify design thinking practice in each of Buchanan's orders of design practice.

This thesis has focused on the examination of three cases of design thinking in complex, third and fourth order environments. In this analysis, this research has discovered that design thinking characteristics in this growing context of practice are consistent with foundational characteristics highlighted in the literature review. In addition, emergent behaviours unique to the order in which design thinking is applied have surfaced through analysis on each case study. This dissertation has extended on descriptions of design thinking to identify and propose potential underlying mechanisms driving emergent behaviours of dwesign activity in complex, third and fourth order environments. This dissertation is useful for design researchers, practitioners and students of design thinking for it solidifies a clear history and definition of design thinking, highlights potential behaviours unique to third and fourth order design practice, and guides knowledge on how to manage, research and apply design thinking in complex environments.

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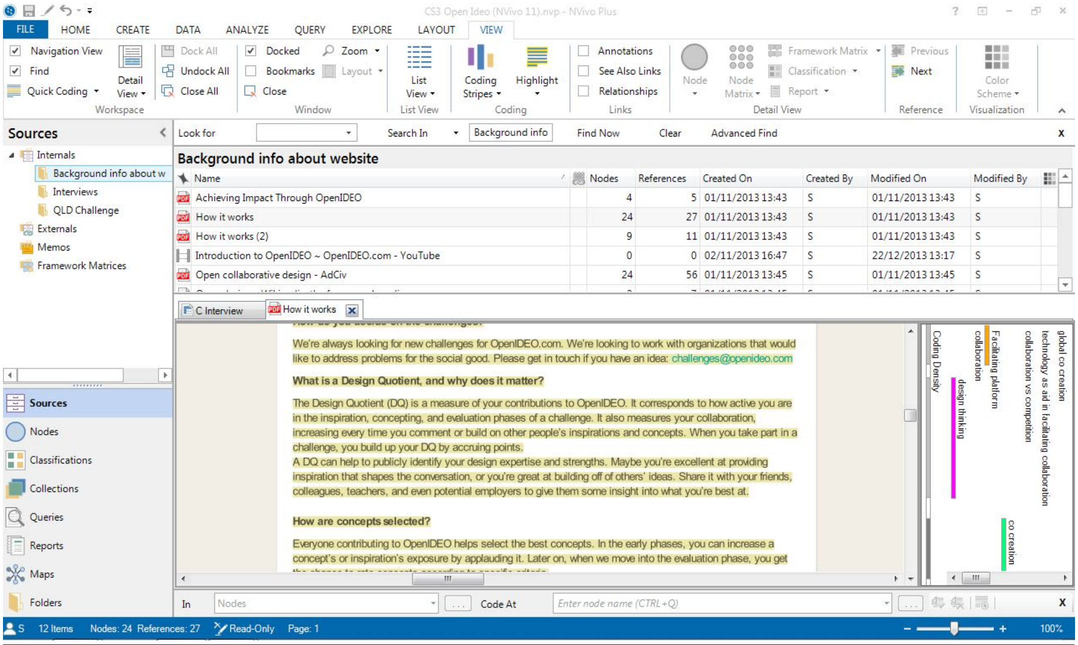
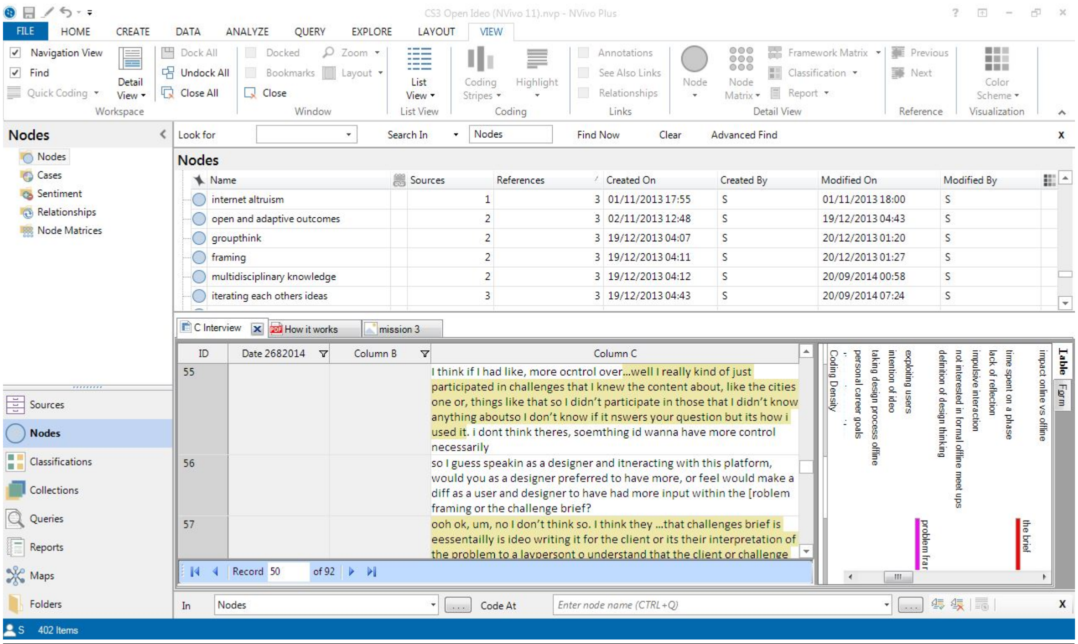
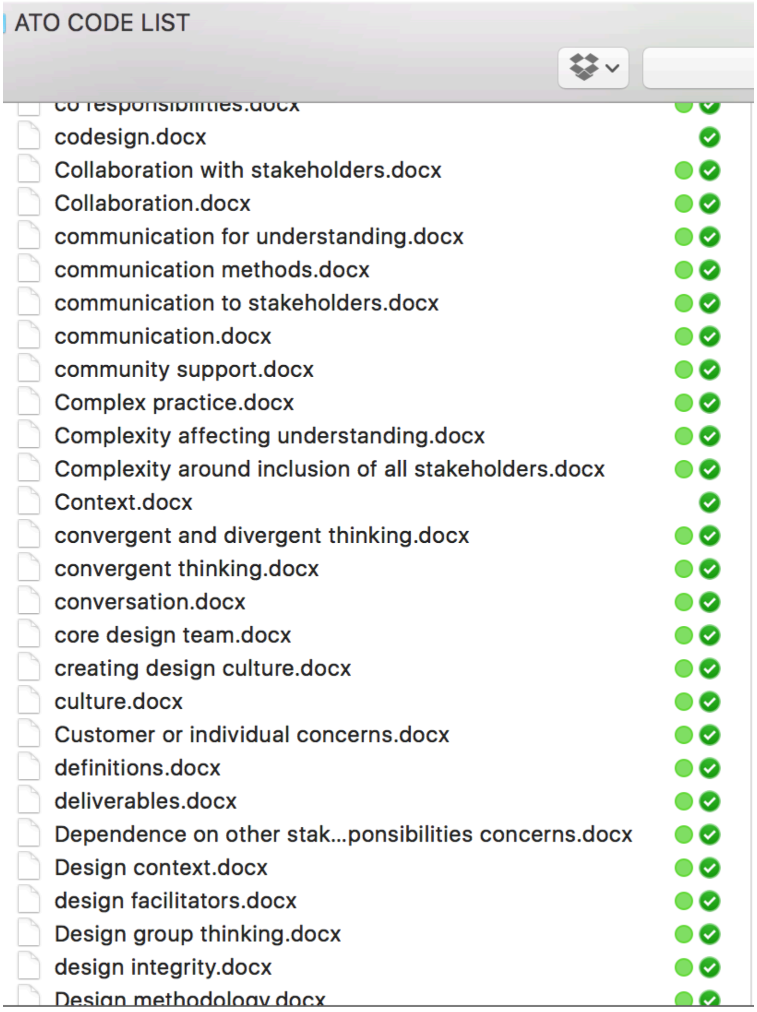
Appendix

A: Example of Nvivo case study (3) coding

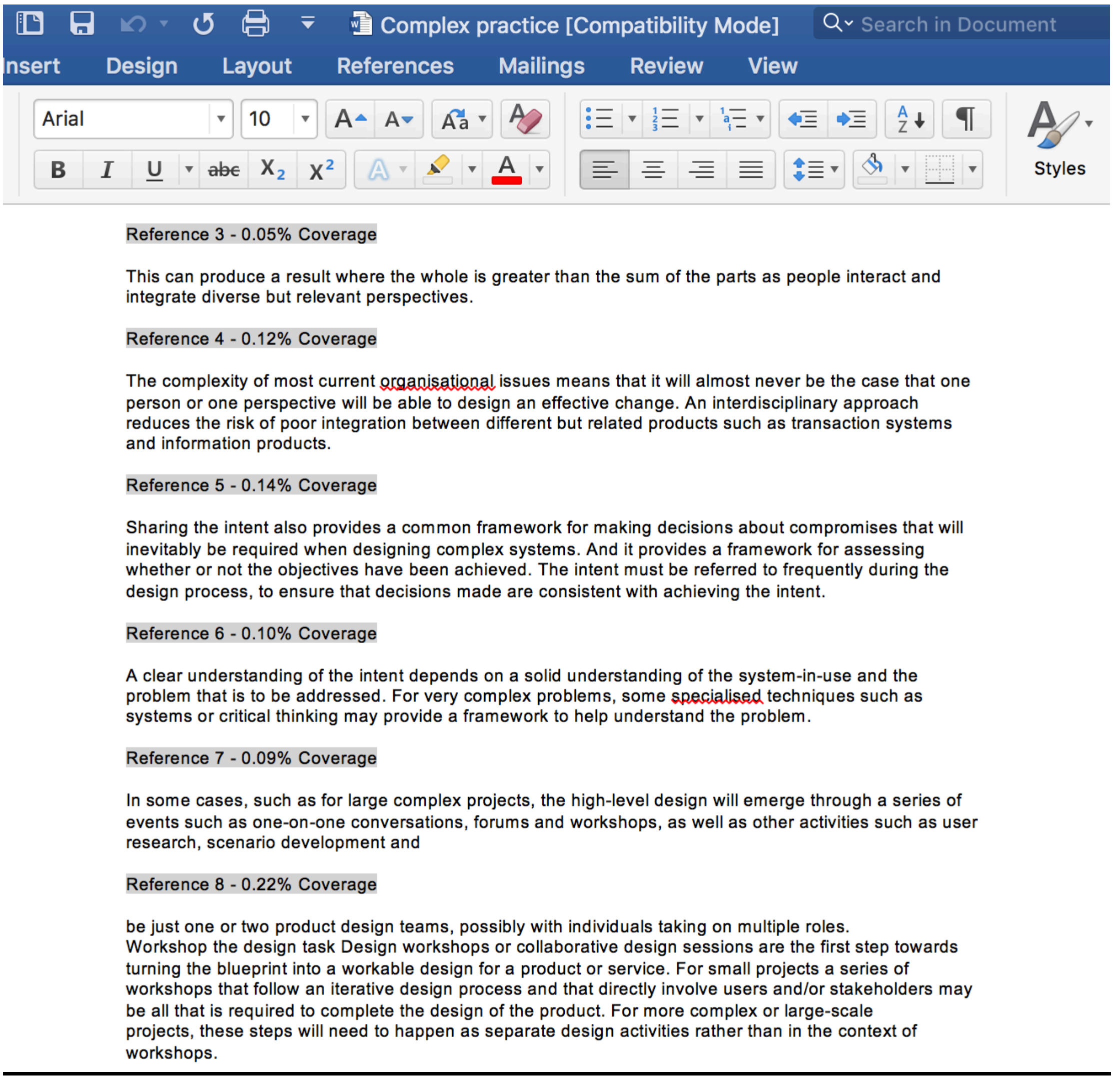




B: Example of exported word document of codes from Nvivo for grouping in Mural.ly (Appendix C.)



Example of a list of Codes as Microsoft Word documents, exported from Nvivo on one single case study (ATO)



Reference 3 - 0.05% Coverage

This can produce a result where the whole is greater than the sum of the parts as people interact and integrate diverse but relevant perspectives.

Reference 4 - 0.12% Coverage

The complexity of most current organisational issues means that it will almost never be the case that one person or one perspective will be able to design an effective change. An interdisciplinary approach reduces the risk of poor integration between different but related products such as transaction systems and information products.

Reference 5 - 0.14% Coverage

Sharing the intent also provides a common framework for making decisions about compromises that will inevitably be required when designing complex systems. And it provides a framework for assessing whether or not the objectives have been achieved. The intent must be referred to frequently during the design process, to ensure that decisions made are consistent with achieving the intent.

Reference 6 - 0.10% Coverage

A clear understanding of the intent depends on a solid understanding of the system-in-use and the problem that is to be addressed. For very complex problems, some specialised techniques such as systems or critical thinking may provide a framework to help understand the problem.

Reference 7 - 0.09% Coverage

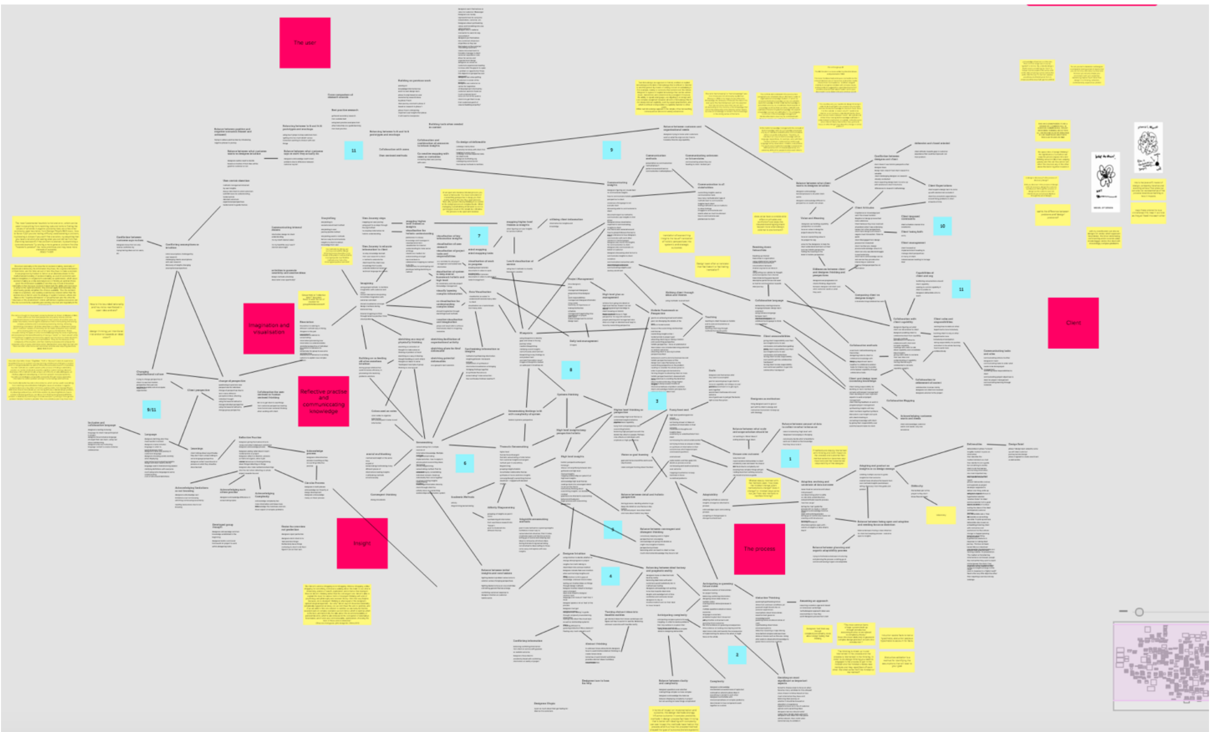
In some cases, such as for large complex projects, the high-level design will emerge through a series of events such as one-on-one conversations, forums and workshops, as well as other activities such as user research, scenario development and

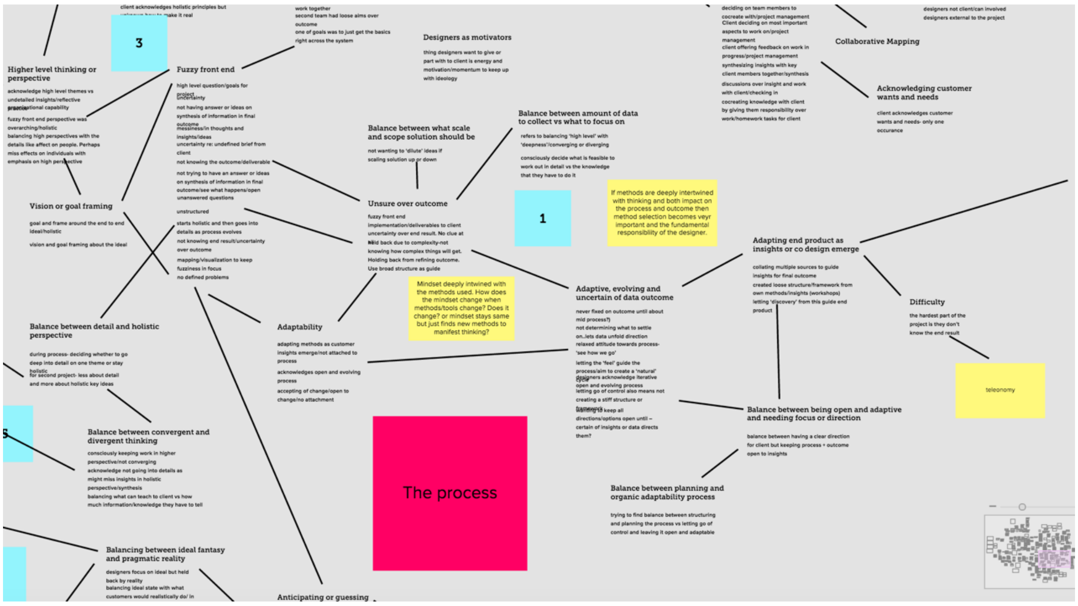
Reference 8 - 0.22% Coverage

be just one or two product design teams, possibly with individuals taking on multiple roles. Workshop the design task Design workshops or collaborative design sessions are the first step towards turning the blueprint into a workable design for a product or service. For small projects a series of workshops that follow an iterative design process and that directly involve users and/or stakeholders may be all that is required to complete the design of the product. For more complex or large-scale projects, these steps will need to happen as separate design activities rather than in the context of workshops.

Example of a single code Word doc, with references documented to that code for a specific case (ATO)

<u>C:</u> Example of Mural.ly affinity diagramming (grouping) of codes exported from Nvivo





Example taken from Case study 1 grouping

D: Samples of interview questions

Lets start with you. What is your background and experience with policy design?

Could you explain what co design means in the ATO?

Lets now look at the design process at the ATO. Can you describe, in some detail, how the co-design process is employed and where your role fits in the overarching design thinking process in the ATO (does it come in at a particular stage? Or operate throughout?)

Could you outline the main roles and responsibilities of individuals in this process?

What is your involvement in the overall design process? (what stage do you enter into the process?)

What stage of the process does co-designing the solution take place? Does co-design refer to collaborating with users or internal departments, or both?

At what stage does user research begin? Do you co create much of the final outcome with the customer/user?

What do you do when collaborating/brainstorming? Could you describe a typical collaborative brainstorming or prototyping session?

At what stage in the process did the solution become apparent?

Does the solution go through many rounds of iteration (or change over time?)

How many rounds of user testing do you usually conduct? (use super case as example)

---about the co design reports---

Regarding the co design report on the super online platform, who does this report get sent to?

Do you feel that a design (thinking) process has significant impact on the outcomes that are generated? Why/why not?

Do you evaluate the impact that the design process has on the outcome, and when implemented?

Sample of ATO (case study 2) interview questions

1. Tell me a little bit about yourself. What is your background? (education/work experience)

2. Could you describe what you think design thinking is/or about?

3. Do you have much experience with design thinking? (if yes, what kind?)

4. How long have/were you involved with OpenIDEO, what was your role (if you were assigned one)

5. Did you ever take your contributions 'offline'; i.e did you ever physically map/prototype/sketch your ideas while you were contributing to project challenges?

6. Did you submit any winning concepts? What were they?

7. What phases of the project process did you feel you had most involvement in? (Why?)

8. If you had winning concepts, were you involved in any way with implementing the winning idea? (Were you contacted by OpenIDEO at all regarding this?)

9. What phases do you feel you would like to have more involvement in as a user (if at all), and why?

10. Do you as a user feel that you have much influence over the project/process and outcome of concepts on OpenIDEO?

11. What motivates you to contribute? What would demotivate you?

12. Do you feel a design process works in a collaborative, open source online environment such as OpenIDEO? Why or why not?

Sample of OpenIdeo (case study 3) interview questions

Ethical clearances

SUHREC Project 2011/249 Ethics Clearance Inbox x

Kaye Goldenberg <KGOLDENBERG@groupwise.swin.edu.au> 11/11/11
to Daniel, Rachel

To: Dr Daniel Huppatz, Design/ Ms Stefanie Carla Di Russo
[BC: Ms Stefanie Carla Di Russo]

CC: Ms Rachel Mosel, Research Admin. Co-ordinator, Design

Dear Dr Huppatz,

SUHREC Project 2011/249 Analysing the application of design thinking process methods to resolve sustainable project problems
Dr Daniel Huppatz, Design/ Ms Stefanie Carla Di Russo
Approved Duration: 11/11/2011 To 11/07/2012 [Adjusted]

I refer to the ethical review of the above project protocol undertaken on behalf of Swinburne's Human Research Ethics Committee (SUHREC) by SUHREC Subcommittee (SHESC4) at a meeting held on 14 October 2011. Your response to the review as e-mailed on 7 November was reviewed by a SHESC4 delegate.

I am pleased to advise that, as submitted to date, the project has approval to proceed in line with standard on-going ethics clearance conditions here outlined.

- All human research activity undertaken under Swinburne auspices must conform to Swinburne and external regulatory standards, including the National Statement on Ethical Conduct in Human Research and with respect to secure data use, retention and disposal.

- The named Swinburne Chief Investigator/Supervisor remains responsible for any personnel appointed to or associated with the project being made aware of ethics clearance conditions, including research and consent procedures or instruments approved. Any change in chief investigator/supervisor requires timely notification and SUHREC endorsement.

- The above project has been approved as submitted for ethical review by or on behalf of SUHREC. Amendments to approved procedures or instruments ordinarily require prior ethical appraisal/ clearance. SUHREC must be notified immediately or as soon as possible thereafter of (a) any serious or unexpected adverse effects on participants and any redress measures; (b) proposed changes in protocols; and (c) unforeseen events which might affect continued ethical acceptability of the project.

- At a minimum, an annual report on the progress of the project is required as well as at the conclusion (or abandonment) of the project.

- A duly authorised external or internal audit of the project may be undertaken at any time.

Please contact me if you have any queries about on-going ethics clearance. The SUHREC project number should be quoted in communication. Chief Investigators/Supervisors and Student Researchers should retain a copy of this e-mail as part of project record-keeping.

Best wishes for the project.

Yours sincerely

Kaye Goldenberg
Secretary, SHESC4
****

Kaye Goldenberg
Administrative Officer (Research Ethics)
Swinburne Research (H68)
Swinburne University of Technology
P O Box 218
HAWTHORN VIC 3122
Tel +61 3 9214 8468

From: Keith Wilkins on behalf of RES Ethics
Sent: Monday, 6 January 2014 5:03 PM
To: Stefanie Di Russo; Daniel Huppatz
Cc: RES Ethics
Subject: SUHREC Project 2011/249 Ethics Clearance for Modifications/Extensions (1)

To: Dr Daniel Huppatz/Ms Stefanie Carla Di Russo, Design

Dear Daniel and Stefanie

SUHREC Project 2011/249 Understanding the application of design thinking in complex multidisciplinary practice
Dr Daniel Huppatz, Design; Ms Stefanie Carla Di Russo
Approved Duration Extended to 31/12/2014 [Extension/Modified Title: January 2014.]

I refer to your request to extend ethics clearance for the above project and to cover a change in project title. Your request, as emailed on 19 and 24 December 2013, which included a completed modification request form was put to a SUHREC delegate for consideration.

I am pleased to advise that, as modified to date, the project has approval to continue to end of 2014. Previously communicated conditions for on-going ethics clearance (reprinted below) still hold.

Please contact the Research Ethics Office if you have any queries about on-going ethics clearance citing the SUHREC project number. A copy of the clearance email should be retained as part of project record-keeping.

Best wishes for the continuing project.

Yours sincerely

Keith

Keith Wilkins
Secretary, SUHREC & Research Ethics Officer
Swinburne Research (H68)
Swinburne University of Technology
P O Box 218
HAWTHORN VIC 3122
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Dear Daniel and Stefanie

SUHREC Project 2013/286 Understanding the impact of design thinking in complex multidisciplinary practise
Dr Daniel Huppatz, Ms Stefanie Carla Di Russo; FHAD
Approved Duration: 20/02/2014 to 31/08/2014 [Adjusted]

I refer to above project revised protocol, as emailed by you on 28 January 2014, which was reviewed by delegates of a Sub-committee (SHESC3) of Swinburne's Human Research Ethics Committee (SUHREC). Collated feedback from the reviewers was sent to you on 17 and 19 February 2014. Your responses to the feedback, as emailed today with attached revised consent instruments, accord with the feedback.

I am pleased to advise that, as submitted to date, the project may proceed in line with standard on-going ethics clearance conditions here outlined.

- All human research activity undertaken under Swinburne auspices must conform to Swinburne and external regulatory standards, including the current *National Statement on Ethical Conduct in Human Research* and with respect to secure data use, retention and disposal.

- The named Swinburne Chief Investigator/Supervisor remains responsible for any personnel appointed to or associated with the project being made aware of ethics clearance conditions, including research and consent procedures or instruments approved. Any change in chief investigator/supervisor requires timely notification and SUHREC endorsement.

- The above project has been approved as submitted for ethical review by or on behalf of SUHREC. Amendments to approved procedures or instruments ordinarily require prior ethical appraisal/clearance. SUHREC must be notified immediately or as soon as possible thereafter of (a) any serious or unexpected adverse effects on participants any redress measures; (b) proposed changes in protocols; and (c) unforeseen events which might affect continued ethical acceptability of the project.

- At a minimum, an annual report on the progress of the project is required as well as at the conclusion (or abandonment) of the project. Information on project monitoring, self-audits and progress reports can be found at: http://www.research.swinburne.edu.au/ethics/human/monitoringReportingChanges/

- A duly authorised external or internal audit of the project may be undertaken at any time.

Please contact the Research Ethics Office if you have any queries about on-going ethics clearance. The SUHREC project number should be quoted in communication. Researchers should retain a copy of this email as part of project recordkeeping.

Best wishes for the project.

Yours sincerely

Keith for
Secretary, SHESC3

From: Astrid Nordmann
Sent: Thursday, 19 June 2014 2:28 PM
To: Daniel Huppatz; Stefanie Di Russo
Cc: RES Ethics
Subject: SHR Project 2014/107 - Ethics clearance

To: Dr Daniel Huppatz, Ms Stefanie Di Russo - FHAD

SHR Project 2014/107 Understanding the impact of design thinking in complex multidisciplinary environments
Dr Daniel Huppatz, Stefanie Di Russo, FHAD
Approved duration from 19-06-2014 to 30-06-2015 [adjusted]

I refer to the ethical review of the above project protocol by a Subcommittee (SHESC1) of Swinburne's Human Research Ethics Committee (SUHREC). Your responses to the review, as per the emails sent on the 2nd, 18th and 19th June 2014, were put to the Subcommittee delegate for consideration.

I am pleased to advise that, as submitted to date, the project may proceed in line with standard on-going ethics clearance conditions here outlined.

- All human research activity undertaken under Swinburne auspices must conform to Swinburne and external regulatory standards, including the current *National Statement on Ethical Conduct in Human Research* and with respect to secure data use, retention and disposal.

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- A duly authorised external or internal audit of the project may be undertaken at any time.

Please contact the Research Ethics Office if you have any queries about on-going ethics clearance. The SHR project number should be quoted in communication. Researchers should retain a copy of this email as part of project recordkeeping.

Best wishes for the project.

Yours sincerely,
Astrid Nordmann
SHESC1 Secretary