Investigating Collaboration in Interdisciplinary Design Teams

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Abstract

As more of the world becomes subject to human intervention, more complex issues become the subject of design. Today, many designers work on complex social and political issues that were traditionally framed as technical problems. Now designers must integrate knowledge from different domains and collaborate with stakeholders to meet people’s needs in a human-centred way. Hence, the design process has had to change and the received view of design is no longer suitable within human-centred design practice. The received view frames designing as a type of problem solving to be done through the formal method of reduction to analyse the problem then construction to synthesise the solution. However, Horst Rittel (1930-1990) claims that this model is not a realistic account of the design process when people are involved. People have different values and worldviews, and therefore, often the issues that concern human-centred design are not self-evident but controversial. Consequently, Rittel maintains that design activity should be modelled as an argumentative process that progressively develops knowledge by surfacing assumptions that underpin the stakeholders’ judgements. This dissertation contributes to the path of research identified by Rittel that investigates the argumentative model of design. I conducted interview research with expert designers and case studies at three design companies to examine how designers and stakeholders interact in their naturalistic environment through the observation of their approaches to collaboration. This dissertation makes an original contribution to knowledge by refining the argumentative model of design and by revealing the influence of informal interactions in supporting collaborative design teams to bring aspects of context to bear upon their reasoning.
Acknowledgments

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Declaration

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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Contents

1. Introduction ..................................................................................................................... 5
   1.1. Research Questions .............................................................................................. 6
   1.2. Justification for the Research ............................................................................. 7
   1.3. Research Framework ........................................................................................... 8
   1.4. Contributions ........................................................................................................ 9
   1.5. Outline of the Report ........................................................................................ 10

2. The Development of Collaborative Design ............................................................ 11
   2.1. Science and Design ............................................................................................ 12
   2.2. Collaborative Design ......................................................................................... 18
   2.3. From Craft Objects to Design Knowledge ................................................... 24
   2.4. Conclusion ........................................................................................................... 28

3. Collaborative Design as Argumentation .................................................................. 29
   3.1. Logic ..................................................................................................................... 30
   3.2. Dialectic ................................................................................................................ 35
   3.3. Rhetoric ................................................................................................................ 42
   3.4. Discussion ............................................................................................................ 53
   3.5. Conclusion ........................................................................................................... 56

4. Research Framework ................................................................................................... 57
   4.1. Design Research Programmes ......................................................................... 58
   4.2. Research Framework ......................................................................................... 66
   4.3. Conclusion ........................................................................................................... 78

5. Interactions in Collaborative Design ........................................................................ 79
   5.1. Mode 1: Appreciating Systems ........................................................................ 80
   5.2. Mode 2: Supporting Active Participation ...................................................... 84
   5.3. Mode 3: Co-experiencing the Context ........................................................... 90
   5.4. Mode 4: Integrating Knowledge with Iterative Prototyping ...................... 94
   5.5. Mode 5: Maintaining the Continuity of the Design Activity ...................... 99
   5.6. Mode 6: Mediating Designing with Artefacts ............................................. 105
   5.7. Mode 7: Building Shared Understanding with Interpretation ............... 111
   5.8. Mode 8: Reflective Dialogue ......................................................................... 118
   5.9. Mode 9: Contributing to Culture ................................................................... 124
List of Figures

Figure 1 The Toulmin Model ................................................................. 44
Figure 2 Complexity of the problem ....................................................... 133
Figure 3 Diversity of expertise ............................................................. 134
Figure 4 Influence of hierarchical control of decision-making ............... 136
Figure 5 Trust in social relationships .................................................... 137
Figure 6 Group cohesion ................................................................. 138
Figure 7 Immersion within the context of the problem ......................... 140
Figure 8 Learning within design activity ............................................. 141
Figure 9 Integration of knowledge ......................................................... 143
Figure 10 Prototype testing ............................................................... 144
Figure 11 Iteration within the design process ..................................... 145
Figure 12 Continuity of flow of design activity .................................. 147
Figure 13 Using analogical reasoning .................................................. 148
Figure 14 Mediation of interactions by artefacts ................................. 150
Figure 15 Synchronisation of knowledge ............................................. 151
Figure 16 Shared understanding of the problem ................................. 152
Figure 17 Conflict due to differences of worldview ......................... 153
Figure 18 Communication ................................................................. 155
Figure 19 Reflection within design activity ....................................... 156
Figure 20 Sharedness of common goals ............................................. 157
Figure 21 Meeting high-level goals and contributing to culture ......... 158
List of Tables

Table 1 The Formality Dimension of Communication................................. 55
Table 2 Respondent Profiles........................................................................ 73
Table 3 Distribution of Words Coding Modes by Case............................... 131
Table 4 Factors Influencing Modes of Interaction........................................ 132
Table 5 Model of Informal Interactions in Collaborative Design Activity....... 160
Design research has made significant advances that have improved our understanding of the nature of design activity. As designers build on existing knowledge to meet current challenges, new avenues for research are revealed. Recently, a number of factors have been identified that suggest that further understanding of the activity of collaborative design work is needed. While design research has been successful in developing systematic design methods for design problems that have been well defined, the design process during the early conceptual design phases remains undefined and open ended. In these circumstances, factors such as organisational culture and effectiveness of group collaboration may affect project success just as much as engineering methods (Catledge & Potts, 1996, p. 182). Although the capacities of some individual designers may be impressive, the scope of knowledge required to grasp all aspects of complex problems is often beyond the cognitive limits of a single person, making it necessary for all stakeholders to participate, communicate, and collaborate (Arias, Eden, Fischer, Gorman, & Scharff, 2000, p. 86; Vande Moere, Dong, & Clayden, 2008, p. 151). Collaboration in teams is often presented as a means to bring as wide a set of perspectives as possible to bear on a problem before major project decisions are made (Geisler & Rogers, 2000, p. 397; Olson, Olson, Carter, & Storrosten, 1992, p. 349). Through integrating the richness of their past experiences and technical knowledge, participants work collectively so that they have enough information to meet the complexity of problems facing society today (Adams, Mann, Jordan, & Daly, 2009; Lewis, 1964; Peng, 1994, p. 19; Smulders, Lousberg, & Dorst, 2008; Sonnenwald, 1996, p. 277).

Interest in collaboration has also been influenced by the emergence of new information communication technologies, large database storage systems, networking software, and
computer-supported cooperative work tools, that can sustain new distributed systems of work and communication (Conklin & Yakemovic, 1991; Geisler & Rogers, 2000; Simoff, 2000; H. H. Tang, Lee, & Gero, 2011; J. C. Tang, 1991). These developments have placed greater emphasis on designing as a social process of interaction, discussion, and negotiation within teams whose members cross departmental and even company boundaries (Brereton, Cannon, Mabogunje, & Leifer, 1996; Dwarakanath & Blessing, 1996; Gunther, Frankenberger, & Auer, 1996; Oak, 2011; Perry & Sanderson, 1998). How project managers synchronise the availability of human and material resources with requirements has also been shifting from linear Tayloristic models towards work processes that are concurrent and multidisciplinary (Geisler & Rogers, 2000; Girard & Robin, 2006). This shift towards collaborative design is needed in response to market conditions that require companies to economically create innovative systems or artefacts with high volume distribution in fast-paced and competitive markets (S. L. Brown & Eisenhardt, 1995; Sonnenwald, 1996). In addition, understanding how working, learning, and innovating are interrelated within the actual work practices of collaborative teams is essential for companies to maintain competitive advantage over the market (J. S. Brown & Duguid, 1991, 2001).

1.1. Research Questions

There has been on-going research within the tradition of design methodology concerning collaborative design activity, however, aspects of this stream of inquiry remain under researched. Protocol analysis—an empirical, observational research method—has been commonly utilised in design methodology to study design activity since the late 1960s, and most prominently in the 1990s (Cross, Christiaans, & Dorst, 1996). While protocol analysis is a very useful research method, it has limitations for studying collaborative design activity due to the reality of the types of problems that can be solved within a laboratory environment within a few hours (Dwarakanath & Blessing, 1996). Recently naturalistic forms of inquiry and ethnographic techniques have emerged as important approaches to studying the complexity of professional collaborative design work in industry (Arias et al., 2000; Bucchiarelli, 1994; Catledge & Potts, 1996; Hughes, Randall, & Shapiro, 1992; Olson et al., 1992; Sonnenwald, 1996; Vinck & Blanco, 2003). Studies such as these provide insight into the complex combinations of interacting activities of people working together, which complements the knowledge developed through other research methods. This study builds on research concerning social processes in design activity through exploring how people
collaborate in interdisciplinary design teams. Specifically, this research project contributes to the research programme identified by Rittel (1984), namely, the “refinement of the argumentative model of the design process and the study of logic of the reasoning of the designer” (pp. 323-324). To address this research programme, I investigated two research questions:

• How do people in collaborative design teams interact?
• What is the significance of informal interactions in collaborative design activity?

1.2. Justification for the Research

Research concerning the nature of collaborative activity has been the concern of various research traditions, for example, knowledge management (Nonaka, 1994; Nonaka & Konno, 1998), situated learning (Lave & Wenger, 1991; Wenger, 1999) and cognitive science (Castellan, 1993; Gernsbacher, Derry, & Schunn, 2005). However, arguably research within the design discipline that examines collaborative design activity as a form of argumentation rather than as a matter of epistemology has been less comprehensive and is comparatively under-researched. This research project is primarily situated within the academic domain of design research and the specific research tradition of design methodology (Cross, 1984, 2000b; Cross & Roy, 1975; Dorst, 2008; Jones, 1980; Jones & Thornley, 1963). The aim of design methodology is to single out the activities and operations performed by designers when they act qua designers, and to analyse those activities so as to be able to state clear definitions of those activities (Gasparski, 1993, p. 171). The premise of this tradition is that we need to understand what designers do to develop support for design activity. Together these two aspects achieve the overall aim of making design more effective and efficient, to enable design practice to develop more successful products (Blessing & Chakrabarti, 2009, p. 5). This involves the formulation and validation of theory and models about design activity and the development and validation of support founded on those theories and models.

This research project makes an original contribution to the domain of design research through generating theory about design activity and to the research tradition of design methodology by identifying factors that influence collaborative design activity that can be subsequently addressed to develop support for the practice of design. Consequently, this research project will presumably be of most relevance to readers interested in studies of
design activity and those readers who seek to develop support to improve design practice and design education.

1.3. Research Framework

The epistemological position that underpins this research is objectivism. The theoretical perspective that I take is post-positivism and the methodology I use is DRM design research methodology. The particular methods used to collect and analyse data are interview, observation, and constant comparative method. The data collection process started with an open sampling approach that sought to maximize variations in respondents’ experiences and perspectives by approaching designers with different disciplinary backgrounds and professional experiences. An expert interview study was conducted consisting of semi-structured in-context interviews with fourteen (n=14) professional designers. The average duration of the interviews was one hour, with their length ranging from 45 minutes to two hours. As key issues arose, further detail of respondents’ understandings was generated through a flexible and unstructured approach utilising probing and follow-up questions. This semi-structured approach was used to create a sense of reciprocity between respondents and the researcher to enable the exploration of the complexity of the topic to be revealed as the interview progressed (Mills, Bonner, & Francis, 2006). The interview transcripts were processed and entered into NVivo computer-assisted qualitative data analysis software. Data collection and analysis proceeded concurrently until theoretical saturation was reached (Hallberg, 2006). Additionally, case studies were conducted at three companies, an industrial design company, an architectural practice, and a design research agency. This stage of the research sought to investigate designers and stakeholders in their naturalistic environment through the observation of their approaches to collaboration in interdisciplinary situations, with the focus on beginning of the planning process where the objectives and aspects of the problem remain undefined. Two hundred hours of participant observation were conducted, as well as thirteen (n=13) semi-structured interviews, document analysis, and participatory design activities.

The dataset was analysed using constant comparative method to generate theory. The constant comparative method is a data analysis technique whereby all codes, categories, and concepts are constantly compared with all other parts of the dataset to explore variations, similarities, and differences (Hallberg, 2006, p. 143). This approach grounds the researcher’s
final theorizing in the respondents’ experiences so that the reader can make the connections between analytical findings and the data from which they were derived.

1.4. Contributions

Since the research questions that drive this project are situated within Rittel’s research programme that investigates the argumentative model of design, the research process began by investigating the philosophical principles of argumentation to reveal the assumptions that underpin Rittel’s second-generation design methods. By considering the theory and philosophy of logic, dialectic, and rhetoric, I reveal that the model of argumentative design endorsed by Rittel is underpinned by the theoretical position that frames argumentation as a dialectical critical discussion (see chapter three). Furthermore, the interpretation of the empirical data I collected discloses that we can probably account for how people in collaborative design teams interact through nine modes: system, participation, co-experience, integration, continuity, mediation, understanding, dialogue, and contribution (see chapter five). Moreover, I found that informal interactions probably play a role in supporting the collaborative design process to bring context to bear upon their reasoning through nine modes of interaction (see chapter six). In addition, the investigation brings new insights about the influence of informal interactions in collaborative design activity and it also refines the argumentative model of design. The refinement of the argumentative model of design conceptualises logical approaches as leading to instrumental design methods, dialectical approaches as leading to understanding the designer as a facilitator who regulates group work, and rhetorical approaches as leading to understanding the designer as a knowledge worker with socially responsible design capabilities.

The investigation contributes by improving our understanding of the factors that underpin collaborative design work that could lead to the development of support for collaborative design work. Furthermore, the research contributes new facts about collaborative design activity that may lead other researchers to develop new experimental techniques that can make more precise predictions about design activity. This study also provides new data that improves our understanding of how collaborative work is actually done in industry today. In addition, this research project is useful to designers because it improves understanding of pre-production design methods to better deal with the complex combinations of interacting activities, behaviours, and relationships of people working together to generate an industrial design product.
1.5. Outline of the Report

The dissertation contains eight chapters. The first chapter introduces the research project, identifies the research questions, establishes the justification for the research, summarises the methodology that frames the research design, and outlines the contributions of the research. The second chapter provides background to the research topic through tracing the historical development of collaboration in design in relation to the transition from positivism to post-positivism in the philosophy of science and the shift in design practice from craft approaches to a knowledge-intensive profession. The third chapter investigates the argumentative model of design through examining the theory and philosophy of argumentation concerning logic, dialectic, and rhetoric, and their corresponding models of design. The fourth chapter describes the framework that underpins the epistemological position, theoretical perspective, methodology, and particular methods used to collect and analyse data: namely objectivism, post-positivism, DRM design research methodology, interview, observation, and constant comparative method. The fifth chapter presents the insights from the interpretation of the fieldwork and integrates those insights with the literature. The sixth chapter analyses the distribution of the insights from the analysis of the fieldwork across the cases and interprets the significance of informal interactions within collaborative design activity. The seventh chapter discusses the contributions and limitations of the model of informal interactions. The eighth chapter outlines the conclusions of the study, considers the limitations of the research approach, and presents trajectories for further research.
The Development of Collaborative Design

This dissertation is concerned with design methodology. Design methodology is a domain of inquiry into the nature of the human-made world. Design methodology is not a single theory or system that encompasses all design disciplines but an ecology of parallel issues in various professions such as engineering design, communication design, industrial design, urban planning, and architecture (Buchanan, 2009, p. 409). During the twentieth century the subjects of design have expanded from crafting objects to addressing complex problems stemming from new technologies and social circumstances. According to Buchanan (2009, p. 409) this changing nature of the subjects of design is reflected for example in the expansion in the meaning of the concept of a “product” from a physical artefact—such as those produced by engineering, industrial design, or architecture—to any result of the thought and action of designers. In this dissertation I follow Buchanan’s (2009) description of the designer as anyone whose “work involved forethought in the conception and planning of any aspect of the human-made world” (pp. 409-410). Buchanan (2009) qualifies this broad description of the designer by identifying four classes of fundamental problems that designers may address in their work, namely:

… communication through signs and symbols; construction and fabrication of artifacts at any scale; deliberation in planning actions, activities, services, and processes; and integration or systematization in encompassing wholes such as social organizations, physical, human, and symbolic environments, and cultures. (p. 410)

These four classes of fundamental problems form the subject matters of design that demarcate the various design professions. However, the subjects of design are not self-
evident but formed by the methods of design. Accordingly design methodologists are not only concerned with the outputs of the work of designers, but also the methods and techniques that designers employ. Consequently, it is reasonable to study not only outputs of design activity but also the methods of thought and action employed in the conception and planning of the human-made world. My main concern within this dissertation is with the philosophical inquiry into the methods of thought and action that disclose the subject matters of design, rather than the particular design professions. The reason for taking this position is that by attending the methods of design, rather than the outputs of design, I can explore and develop new ways of thinking and action that may indicate new potential subjects matters of design methodology.

The historical development of design methodology can be revealed through two channels. First, within philosophy of science concerning the development from positivism to post-positivism and the corresponding investigations of the logic of development of scientific knowledge. Second, in design activity with the change from individual to group work and the movement from craft practice to a knowledge-intensive profession supported by a discipline. These developments reflect ways in which society has changed throughout the 20th century in response to different types of existential pressures such as industrialisation and globalization.

This chapter examines the relationship between the development of the design methods movement and the transition from positivism to post-positivism in philosophy of science. The aim of the chapter is to provide background and a point of departure for the research project rather than systematically review the literature. A more detailed examination of the literature concerning the thought and action of design is provided in chapter three by investigating the theory of argumentation as logic, dialectic, and rhetoric, and their corresponding models of design. In addition, further discussion of the literature is provided in chapter five in an integrated form with the insights from the fieldwork.

2.1. Science and Design

Rapid industrialisation in the early 20th century saw an increasing concern with the scientific production of products. During this period the theoretical articulations of design approached collaborative design activity as a matter of adopting the common language of science. This approach is visible in the intimate relationship between the logical positivist philosophy of
the Vienna Circle and the scientific modernism of the Bauhaus. These two movements radically reshaped science and design in the 20th century.

Both the Bauhaus masters and the logical positivist philosophers posited foundationalist ontologies of basic forms or primitives upon which their systems rested, and both had methods that involved reduction and construction as a way of identifying their procedure of development (Kukowski, 1992, p. 198). The logical positivists utilised protocol sentences from simple observation reports expressing primitive sense experiences and connectives (such as “if/then,” “or,” “and”), and through the logical construction of combinations of these protocol sentences, sought to ground a scientific philosophy that would “set all reliable knowledge on strong foundations and isolate it from the unreliable” (Galison, 1990, p. 711). According to Galison (1990), the Bauhaus masters attempted “to use scientific principles to combine primitive colour relations and basic geometrical forms” to develop prototypes for mass production that would “eliminate the decorative and create a new anti-aesthetic aesthetic that would prize functionality” (p. 711). Galison (1990) argues “the modernist construction of form out of elemental geometric shapes and colours compares to the verbal development of theories out of logic and elementary bits of perception” (p. 749). As Walter Gropius (Kukowski, 1992) put it:

Artists at the Bauhaus attempted to find an objective common denominator of form—in a way to develop a science of design. Such a foundation of general, super personal formal laws provides an organic and unifying background for various talents. Expression then has reference to the same universally acknowledged basic concepts. (p. 203)

The Bauhaus masters and logical positivists “located a common foe in the ornamental and non-functional, be it in decorative art or metaphysical philosophy” (Galison, 1990, p. 735). And both the designers and philosophers attempted to overcome differences through grounding their approaches within the common language of science (Galison, 1990, p. 749).

2.1.1. Design Methods Movement

The close relationship between positivist science and design continued into the 1950s and early 1960s within the design methods movement (Cross, 1984, 2000b; Cross & Roy, 1975; Dorst, 2008; Jones, 1980; Jones & Thornley, 1963). The design methods movement was based on the idea that the techniques and approaches to problem solving, scientific management, and operational research, which were formulated during World War Two and later refined through large-scale technological projects such as the development of satellites by NASA, might profitably be transferred into civilian domains (Bayazit, 2004; Cross, 2001;
Rittel, 1984). The design methods movement was concerned with developing a form of design science that aimed at incorporating scientific techniques to develop a systematic approach to the management of the design process. Its protagonists attempted to define the rational criteria of optimal decision making, not just the utilization of scientific knowledge in the manufacture of products, but as approaching design as a scientific activity itself (Bayazit, 2004, p. 19; Cross, 2001, p. 53).

The methods of design science used the same two-phase linear method of logical positivism, comprising of first reduction and then construction. In the reduction stage the designer analyses the problem to determine all of its elements and specify all of the requirements that the successful solution must have. Then, in the second stage, the designer synthesises the solution though combining and balancing the requirements against each other, yielding a final plan to be carried into production (Buchanan, 1992, p. 15). This technical-rational design process was continued with the development of computer problem solving programmes. Herbert Simon’s work in artificial intelligence recast design as a goal directed process of searching for satisfactory solutions through Means-Ends Analysis. Simon (1996) proposed that design was as an artificial science that could form a fundamental common ground of intellectual endeavour and communication across the arts, sciences and technology. Simon (1996) argued:

Few engineers and composers… can carry on a mutually rewarding conversation about the content of each other’s professional work. What I am suggesting is that they can carry on such a conversation about design, can begin to perceive the common creative activity in which they are both engaged, can begin to share their experiences of the creative, professional design process. (p. 137)

The technical-rational problem solving model was attractive to design methodologists because of its precision and logical consistency, but it was of little use to design professionals because, in practice, the types of issues that designers often address are controversial rather than self-evident and so resist the reduction-construction method (Buchanan, 1992, p. 15). Consequently, in the late 1960s the recognition that the design science approach was not suitable for meeting many real-world social issues led a number of pioneers of the design methods movement, such as Christopher Alexander and John Chris Jones, to publicly reject its fundamental values and techniques.

Within the same period, there was significant criticism of logical positivism in philosophy of science by philosophers and historians of science such as Karl Popper, Imre Lakatos, Thomas Kuhn, and Paul Feyerbend. The post-positivist philosophy of science that these
philosophers promoted also had significant effect on design methods movement and encouraged rethinking of some of design methodology’s fundamental principles. Two notable streams of thinking that emerged out of the downturn of the design methods movement were Donald Schön’s pragmatist theory of reflective practice and Horst Rittel’s post-positivist second-generation design methods.

2.1.2. Reflective practice

A major challenge to the technical-rational methods of design science was Schön’s pragmatist theory of reflective practice. Schön’s theory emphasised the lived experience of designing rather than the logic of design methods. According to Schön, in actual practice designers did not solve problems in the linear reduction then construction process depicted by positivist design science. Rather, Schön (1995) maintained that, in contrast to the approach of the design methods movement, design practice has as much to do with finding and framing problems as it does with producing solutions. Schön (1995) argued that problem framing is “central to the way professionals deal with uncertainty, instability, uniqueness and value conflict” (p. 50). Therefore, designing is a practice of reflection-in-action between the designer’s intentions and the situation at hand.

Schön (1995) claimed that a practitioner’s ability to reflect-in-action is based on a “repertoire of expectations, images and techniques”, the practice of which overtime becomes “increasingly tacit, spontaneous and automatic” (p. 60). Reflective practice involves applying this tacit repertoire of techniques and knowledge to frame the problem through on-the-spot-experimenting within a single judgmental action. Furthermore, the designer’s effort to frame the problem

… yields new discoveries which calls for new reflection-in-action. The process spirals through stages of appreciation, action, and reappreciation. The unique and uncertain situation comes to be understood through the attempt to change it; and changed through the attempt to understand it. (Schön, 1995, p. 132)

Although Schön did not directly extend his theory of reflective practice to collaborative design activity, he did work with Chris Argyris on organisational learning theory to develop an approach to teamwork in which an individual should display the following aspects of the Model II theory of action (Schön, 1995, p. 231):

- Give and get valid information.
- Seek out and provide others with directly observable data and correct reports, so that valid attributions can be made.
- Create conditions for free and informed choice.
• Try to create, for oneself and for others, awareness of the values at stake in decision, awareness of the limitations of one’s capacities, and awareness of the zones of experience free of defence mechanisms beyond one’s control
• Increase the likelihood of internal commitment to decisions made.
• Try to create conditions, for oneself and for others, in which the individual is committed to an action because it is intrinsically satisfying—not as in the case of Model I, because it is accompanied by external rewards of punishments.

Argyris and Schön’s Model II theory of action emphasises that team members feel more motivated when they make free and informed decisions to participate. Consequently, they are more open to learning, investigating unknowns, disclosing assumptions, and negotiating conflicts (Schön, 1995, p. 232).

Taking a similar position as Simon’s view that design as problem solving can provide common ground between arts, sciences, and technology, Schön (1995, p. 13) argued that reflection-in-action is the fundamental structure of inquiry that underlies the all design professions. Schön’s theory of reflective practice provided a significant alternative to the technical-rational problem solving model. However, while reflective practice has produced a rich programme of design research, and although more recently there has been research on reflective practice in collaborative design teams (Kleinsmann, Deken, Dong, & Lauche, 2011; Kleinsmann, Valkenburg, & Buijs, 2007; Valkenburg & Dorst, 1998), I argue that the core philosophical assumptions of reflective practice imply an archetype of the designer as an individual professional working within their own domain of mastery. In contrast, during a similar period that Schön was working on his theory, Horst Rittel developed an alternative criticism of the technical-rational problem solving model of design that took collaborative work as a fundamental assumption of design activity. Rittel’s theory, which he called the argumentative model of design, proposed that design activity was usefully understood as a counter-play between issues, positions, and arguments that progressively develops knowledge by surfacing the assumptions that underpin stakeholders’ judgements. Rittel’s argumentative model of design was fundamentally concerned with design activity as a collaborative social process of knowledge integration, as opposed to Schön’s theory of reflective practice, which is comparatively more closely focussed on designers’ individual lived experiences.

2.1.3. Second-generation design methods

Influenced by Popper’s (1959, 1965) post-positivist philosophy of science, Rittel proposed the concept of generations of design methods and championed the development of second-
generation design methods (Bayazit, 2004, p. 21; Buchanan, 1992, p. 15; Cross, 1984, p. 304). Rittel rejected the positivism of design science for being too simplistic and incapable of meeting the complex requirements of real-world problems. Moreover, Rittel argued that most design problems are social system problems that are characterised by a fundamental indeterminacy (Buchanan, 1992, p. 15). According to Rittel and Webber (1973):

The search for scientific bases for confronting problems of social policy is bound to fail, because of the nature of these problems. They are “wicked” problems, whereas science has developed to deal with “tame” problems. Policy problems cannot be definitively described. Moreover, in a pluralistic society there is nothing like the undisputable public good; there is no objective definition of equity; policies that respond to social problems cannot be meaningfully correct or false; and it makes no sense to talk about “optimal solutions” to social problems unless severe qualifications are imposed first. Even worse, there are no “solutions” in the sense of definitive and objective answers. (p. 155)

Rittel’s model the design as resolving wicked problems focuses on the beginning of the design process where the objectives and aspects of the problem are discussed and debated. Consequently, this shift in focus to the decision-making process at the beginning of the development process required a different approach that involved organised criticism and argument (Rittel, 1984, p. 320).

One of the foundations of Rittel’s approach is the anti-expert driven assumption of the symmetry of ignorance between all the participants in the planning process. This means that the expertise as well as the ignorance related to a particular problem is distributed over all the participants. No participant is justified in claiming that their expertise is superior to anyone else’s (Rittel, 1984, p. 325). It follows from this assumption that, because the knowledge needed to address a design problem is distributed among many people, therefore, various stakeholders’ participation in the design process should be maximised to activate as much knowledge as possible.

Furthermore, rather than an objective entity, a design problem is an indeterminate network of issues with pros and cons to be approached through an evolutionary process of debate, where statements are made and challenged to expose them to viewpoints from different sides. The point of this argumentative process of systemic inquiry and organised criticism is to increase the probability that nothing essential is left out, and also because the experience of having participated in developing a solution is meaningful to the people who are affected by it (Rittel, 1984, p. 320). Hence, Rittel argues that the knowledge of those who are likely to be affected by the implementation of the design is particularly important. Rittel’s approach recognises that the design process is necessarily collaborative and political rather
than merely technical. This approach requires designers to develop skills in critical thinking and argumentation, and emphasises the need for designers to articulate their knowledge to allow their conjectures to be shared, contrasted, tested, and refuted.

Rittel (1984, pp. 323-324) mapped out three paths for further research of the argumentative approach to designing:

- Refinement of the argumentative model of the design process and the study of logic of the reasoning of the designer in terms of the rules for asking questions, generating information and making decisions.
- Practical procedures for implementing the argumentative model. Such as how to foster the process of group argumentation, how to select the group, and problems of the decision rules.
- The technical manner of supporting the instrumental version of the model through administrative and computer based aids.

To date, research into the second and third paths has been particularly strong. The co-design and participatory design research programmes have developed significant research and techniques for implementing the argumentative model, with emphasis on incorporating users’ input into the design process (Buur, Ankenbrand, & Mitchell, 2013; Buur & Matthews, 2008; Buur & Sitorus, 2007; Sanders, 2002; Sanders & Stappers, 2008). Research within the field of human-computer interaction and design rationale management has contributed significantly to developing technical means of support for the instrumental version of the argumentative model through software for the systematic management of information and computer supported cooperative work (Arias et al., 2000; Dutoit, McCall, Mistrik, & Paech, 2006; Wong & Sriram, 1993). However, I claim that empirical research within the first path, which examines the reasoning processes of designers as argumentation has been less robust and is comparatively under-researched.

### 2.2. Collaborative Design

The description of the development of collaborative design I have presented so far concerns the study of design work primarily located within the tradition of design methodology. According to Cross (1993) design methodology

… includes the study of how designers work and think, the establishment of appropriate structures for the design process, the development and application of new design methods, techniques and procedures, and reflection on the nature and extent of design knowledge and its application to design problems. (p. 21)
Design methodology has a very broad scope if we take the meaning of design to be, as Simon (1996) defines it:

Everyone designs who devises courses of action aimed at changing existing situations into preferred ones. 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. Design, so construed, is the core of all professional training; it is the principal mark that distinguishes the professions from the sciences. Schools of engineering, as well as schools of architecture, business, education, law, and medicine, are all centrally concerned with the process of design. (p. 111)

Following Simon’s (1996) and Cross’s (1993) definitions implies that design methodology would study the behaviour of all of the sciences of the artificial including engineering, medicine, law, management and so on. However, if we take design methodology to be only the concerned with singling out and clearly defining the activities of designers, and if we define those activities as only centred on the individual designer, then the scope is too narrow in the case of collaborative design, since it would exclude, all other potentially significant factors that distinguish collaborative design activities from individual design activities—sociological, environmental, communicative, and organisational factors for example. One consistent theme may be that collaboration and interdisciplinary design work are more socially complex than design work undertaken by individual designers.

Design is important because the scope of the artificial world is rapidly growing and the impact of human endeavour is increasing. If we take designing to mean the planning of the artificial, then designing is intimately linked to these massive changes in the world. Because of the massive scope of the artificial, the cost of failure is very high. Furthermore, the complexity of the types of contexts that designers are working within is growing, and so designers need to work in interdisciplinary teams and collaborate. We need to understand if the context of interdisciplinary collaborative design work involves additional factors that can be supported to make collaborative design more successful. This involves gaining understanding of the significant aspects of how designers collaborate within teams, and in particular, in teams where participants have different backgrounds.

The systematic study of the design process began in the 1950s and 1960s, and in the last twenty years there has been increasing interest in group design work. These studies have drawn on diverse disciplines including engineering design, management, interdisciplinary studies, socio-cultural anthropology, and philosophy of science for example. Aspects that these studies have investigated have included the management of leadership and control of
sub teams of engineers; sociological research to do with power in terms of structure and agency; knowledge management research concerned with organizational learning, tacit and explicit knowledge, and communities of practice; computer supported cooperative work and software for capturing design rationale; psychological research on how teams develop shared mental models; interdisciplinary studies on the integration of different disciplinary approaches. Protocol analysis—an empirical, observational research method—has been commonly utilised in design methodology to study design activity since the late 1960s, and most prominently in the 1990s (Cross et al., 1996). While protocol analysis is a very useful research method, it has limitations for studying collaborative design activity due to the reality of the types of problems that can be solved within a laboratory environment within a few hours. For example, while much of the focus in Cross et al. (1996) is on design activity, including social aspects of group work, the study is set in a completely artificial context.

Three of the studies in Cross et al. (1996) were concerned with the team conversation protocol: Brereton, Cannon, Mabogunje, & Leifer (1996), Dwarakanath & Blessing (1996), and Gunther, Frankenberger, & Auer (1996). Dwarakanath & Blessing (1996) and Gunther et al. (1996) are more similar to each other than to Brereton et al. (1996) since they both use the individual protocol and the group protocol, as well as utilising similar analysis techniques of dividing the transcripts into 15 second slices and classifying each slice into a series of predefined categories to allows for quantitative analysis of the qualitative data. In contrast, Brereton et al. (1996) only focus on the group conversation protocol and utilise a grounded theory analytic approach based on interaction analysis. Gunther et al. (1996) aim to illustrate their method of analysis and so they are not concerned with drawing conclusions about the design process; their focus is methodological, and there is almost no interpretation of the results. The authors do conclude that they were able to capture the course of the design process with their coding system. However, in contrast to Gunther et al. (1996), Brereton et al. (1996) and Dwarakanath & Blessing (1996) are concerned with the content of the designers’ behaviour.

Dwarakanath & Blessing (1996) focus on design as a social process and compare the similarities and differences between the individual designer’s protocol and the group protocol. The study reveals that the group spent more time on issues and arguments than the individual. The individual designer spent more time on alternatives, however, the group created more alternatives, and the group approached that design process differently from the individual. The group explored problems in parallel while the individual was more linear.
While the conclusions presented usefully support the significance of the social nature of group design work, the authors do not develop the implications fully because a significant part of the study is devoted to illustrating the methodological limitation of the data collection process.

Brereton et al. (1996) focus on the activity of the group of designers, and consider in particular how the moment-to-moment activity steers the course of the design work. Their study focuses on the social interaction of the group and how it influenced the content of the final product. The authors characterise the activity as involving negotiation of ideas, this negotiation involves persuasive strategies such as appealing to common sense or higher principles or established experts. Negotiation also involves linguistic approaches including carefully moderating the commitment of the participant to the idea, personalisation of the debate and language. The authors identified opportunist strategies of give and take, and shifting topics to postpone or avoid conflicts. Brereton et al. (1996) also show how story telling and analogy play a role in developing, representing, and communicating design alternatives. The designers’ work depends on negotiation and more subtle social processes. Significantly, Brereton et al. (1996) and Dwarakanath & Blessing (1996) highlight how the social context bears upon the group’s approach to negotiating a successful outcome. The social process of negotiation points to the impact of integration of knowledge in interdisciplinary group work.

Middleton (1967, p. 103) identifies a number of different forms of collaboration in professional design practice including: forms of association between individual people; forms of association between independent firms within a single profession or independent firms in different professions; single practices in which different skills and disciplines are associated; single firms that practice a large measure of devolution, either geographically among their various offices or in the creation of semi-autonomous teams within one office; and offices organized democratically rather than hierarchically, in which decisions are reached through discussion by the group rather than passed down through a chain of command. These different forms of collaboration can be differentiated in terms of their relationship to disciplinary knowledge as multidisciplinary, transdisciplinary, or interdisciplinarity. Multidisciplinary work involves different disciplines approaching a problem in parallel or sequentially without challenging their disciplinary boundaries; transdisciplinary work seeks to unify disciplinary differences in a holistic way; interdisciplinarity works by integrating different disciplinary insights and confronting their differences with the aim to produce a
new understanding that takes those differences into account (Choi & Pak, 2006, p. 359; Repko, 2008, p. 20). However, according to Rogers et al. (2005):

It is also widely believed that ‘true’ interdisciplinarity is very difficult to achieve and, more often than not, remains an elusive goal. In practice, many self-styled interdisciplinary enterprises actually work at the level of being multidisciplinary (or pluridisciplinary): where a group of researchers from different disciplines cooperate by working together on the same problem towards a common goal, but continue to do so using theories, tools, and methods from their own discipline, and occasionally using the output from each other’s work. They remain, however, essentially within the boundaries of their own disciplines both in terms of their working practices and with respect to the outcomes of the work. (p. 266)

Interdisciplinarity is not anti-disciplinarity even though it recognizes the limits of a single discipline’s power to solve complex problems. Because interdisciplinary work integrates different perspectives it is characterized by negotiation and argumentation, and so a strong foundation of disciplinary knowledge is needed in order to support effective communication, sharing, contrasting, and evaluation of insights. Without a strong disciplinary grounding, designers working in interdisciplinary collaborative situations are disadvantaged because their ability to contribute lacks rhetorical strength (Poggenpohl, 2009, p. 13).

Sonnenwald (1993, 1996) conducted empirical research that investigated communication in multidisciplinary design work and focussed on how key actors were able to facilitate work by crossing over boundaries such as disciplinary boundaries or organisational roles and departments. A key assumption of the study was that observing communication reveals the participants’ roles and their normative demands. Utilising a multiple methods approach—including retrospective case study, document analysis, semi-structured interview, participant observation, and survey research—the author conducted a longitudinal study of communication roles within the industrial setting of software design. Sonnenwald’s (1996, p. 288) analysis revealed five different types of boundary spanning roles. These roles were significant for facilitating the interdisciplinary reality of professional software design in industry. Crucially, the study also reveals the significance of both informal and formal communication, and claims that informal communication activities are essential for interdisciplinary boundary spanning. Examples of such informal activities include: simple conversations about the weather and other personal communication; careful self monitoring of communication in terms of using neutral language and carefully chosen facial expression; using analogy to transfer ideas across disciplinary boundaries; extra activities such as providing summaries of the latest knowledge in journals. These different activities are
important because they develop understanding of personal communication and language styles, which are useful later during formal design work. While Sonnenwald (1996) is absolutely clear on the importance of formal activities within design practice, for example having scheduled meetings was important for co-ordinating collaboration, it was the informal activities that allow such formal activities to take place. This conclusion has significant implications for design methodology because traditionally the development of support for designing is most often developed from research of formal design activities such as progress review meetings and client presentations. If Sonnenwald’s (1996) conclusion that formal design activities are affected by informal design activities, then there is an opportunity to develop support for collaborative interdisciplinary designing in informal settings.

McDonnell’s (2009) study of architectural design meetings also indicates the significance of the social process of negotiation in interdisciplinary collaborative design work. The focus of McDonnell’s (2009) study suggests that negotiation drives design decisions during the meeting rather than any process of correspondence between problem requirements and solution attributes. Furthermore, McDonnell (2009) provides support for Rittel’s principle of the symmetry of ignorance by showing that while a priori roles of “expert” “architect” and “non-expert” “stakeholder” play a part, in fact these roles are actually also constantly negotiated during the collaborative conversation, with both designers and users taking on the role of refining the design or exchanging information at different times. According to McDonnell (2009, p. 48), placing too much respect on the designer’s role as an expert can influence non-expert stakeholders to defer their own contributions within a collaborative conversation. McDonnell (2009, p. 44) also reveals an interesting insight that collaboration with users also allows designers to express non-expert notions, which offer a conversational entry point for the user to express their expert knowledge and build greater understanding of the design context. While Rittel’s principle of the symmetry of ignorance is based on the assumption that roles and expertise are based on fixed differences, McDonnell’s study shows that in practice that the roles of expert and non-expert shift, change, and are negotiated during the collaborative design work.

According to McDonnell (2009, p. 36), participants can create shared understanding through communication and conversation as they develop the design. Participants’ ownership within a project accrues through negotiation of design contributions with designers, and agreements over the justification for those design decisions. McDonnell’s (2009, p. 36) study shows that a key practice employed by the designers and users to develop
shared understanding were the intertwining of current situations, analogous situations and different issues. Through using analogy, designers and users are able to overcome disciplinary and knowledge boundaries, and develop a shared understanding that integrates knowledge rather than juxtaposing it. This reveals limitations of theorising collaborative design work in terms of simple correspondences between requirements and features of design solutions because it challenges the idea that requirements pre exist the situation and the collaboration is simply a process of choosing which requirements to attend to. Rather McDonnell’s study shows that requirements themselves are negotiated into being.

Kliensmann & Valkenburg’s (2005) interview study in the automotive industry focuses on the relationship between learning and developing shared understanding in multidisciplinary product development. The authors argue that lacking shared understanding causes a need for additional iterative loops, which ultimately reduces product quality because not all aspects of the problem can be resolved due to resource constraints. The authors maintain that collaboration is not only about accessing information but also about understanding information. Learning opportunities are events that support or constrain shared understanding. The study revealed learning opportunities at actor (direct communication between people), project (barriers or enablers at the projects management level), and company (interfaces between company departments) levels. The authors maintain that addressing learning opportunities at all three levels is the only way to solve such problems. Only addressing barriers between actors is inadequate because it merely seeks to address the symptoms of barriers to shared understanding. The authors recommend that human resources managers should be trained to identify learning opportunities at all three levels and meet problems by integrating issues at all three levels. The article emphasises a link between learning and developing shared understanding. Consequently, support for collaboration should not only address the individual actor level as such interpersonal issues may just be symptoms of issues at other levels of project management or organisational structure.

2.3. From Craft Objects to Design Knowledge

The narrative of the development of design methodology I have presented discloses a period in the history of design where design theory begins to shift its focus from objects to processes and to the transition from a craft to a profession. The object-centred approach grew out of the guild tradition within which design practice transfers a rich stock of tacit
knowledge embodied in the skills and techniques passed down from the master to the apprentice through many years of ritual and imitation. This tradition produced a form of habituated know-how that allowed the individual craftsman to respond intuitively to specific situations. While this form of tacit knowledge remains an aspect of professional practice today, modern education cannot afford the decades of training that are required for traditional guild style craft education (Friedman, 1997). Today, design education is changing from the object-centred master-apprentice model of the guild tradition to the theory driven approach characteristic of a discipline.

Historically, a number of fields such as medicine, engineering, and law, have emerged from craft traditions into disciplines that support professions. However, there are a number of factors in the design profession that resist the transition into a discipline, and consequently the effectiveness of collaborative design practice. Two major paths of resistance come from the profession of design. First, the mistaken idea is that design practice is opposed to the application of systematic methods. Second, the flawed belief that systemic inquiry is at odds with creativity. Poggenpohl (2009, pp. 15-16) drawing on Krippendorff (1995) maintains that these two broad misunderstandings are revealed through the following myths about design practice:

- **Designers are lone craftsmen that create an autobiographical design.** This myth denies the history of design as well as undermining teamwork and collaboration. In addition, challenges that fall outside the craft education paradigm are neglected.
- **Designers are not analytical and aim at holistic responses.** This implies that designers cannot break problems into sub-problems, so tend not to ask interesting questions and are unable to criticize existing research.
- **Designers do not write.** This has the consequence that seminal ideas and prototypes are not recognized, literature on design remains disconnected and that the domain of design knowledge becomes colonized by other disciplines.
- **Designers endlessly search for the “new”.** Without a robust foundation of disciplinary knowledge, ideas are endlessly repeated, the process of knowledge building is not understood, and the accumulation of knowledge is impeded. In addition, science in misunderstood as expounding truth and certainty rather than as an evolutionary process.
- **Designers should be competitive both inside the design profession and outside it.** This misunderstanding resists community building and isolates design from other disciplines.
- **Designers focus on the practice of doing design.** This focus on doing design means that designers tend not to analyse why or how they do what they do.

The object-centred approach of the craft tradition of design is primarily concerned the aesthetic aspects of products, consequently craft designers tend to work towards the end of the development process after many of the key decisions had been made. However, design as
a process is more complex because it requires greater knowledge and depth of expertise than a solo designer can individually possess. This forces designers to move beyond surface concerns with aesthetics and investigate what people actually do, what they value, and how they understand things. Design as a process is a collaborative and human-centred activity that requires designers to work with sociologists, anthropologists, psychologists, engineers, and other stakeholders to understand the interaction between people and their environments. Furthermore, in the human-centred approach, designers must participate in decision-making at the beginning of the development process, where the parameters of design problems are still undefined and collaborate with different stakeholders. Kleinsmann et al. (2011), define collaborative design as a knowledge-integration process “in which actors from different disciplines share their knowledge about both the design process and the design content. They do that to be able to integrate and explore their knowledge in order to achieve the larger common objective: the new product to be designed” (p. 486). This change towards knowledge intensive collaborative work implies that the skills designers need to collaborate effectively with stakeholders are different than those that characterize the object-centred craft tradition.

The role of knowledge within the specific domain of collaborative design activity has been investigated in several streams of design research including for example: Knowledge Management (Friedman, 2001, 2002; Leonard & Sensiper, 1998; Nonaka, 1994; Nonaka & Konno, 1998; Smulders et al., 2008); Organizational Learning and Communities of Practice (Baird, Moore, & Jagodzinski, 2000; Boujut & Laureillard, 2002; J. S. Brown & Duguid, 1991, 1998; Kreiner & Schultz, 1993); Mental Models (Badke-Schaub, Neumann, Lauche, & Mohammed, 2007; Dong, Kleinsmann, & Deken, 2013; Kleinsmann et al., 2007; Langan-Fox, Anglim, & Wilson, 2004); Linguistic and Discourse Analysis (Dong, 2005; McDonnell, 2012; Sonnenwald, 1996; Yang, Dong, & Helander, 2011); Critical Review (Bayazit, 2003; Kreiner & Schultz, 1993; Ostergaard & Summers, 2009; Pahl & Grote, 1996; Poggenpohl, 2004); and Reflective Practice (Kleinsmann et al., 2011; Schön, 1988; Valkenburg & Dorst, 1998). These streams have produced useful research for understanding specific aspects of the role of knowledge within collaborative design activity. Instead of presenting a review of this literature here or as a separate chapter, I have integrated the discussion of this literature with the insights from the fieldwork in chapter five. I argue that integrating the discussion of this literature with the analysis of the fieldwork is more useful than a broad review since it triangulates specific insights from the fieldwork with particular findings.
The necessity of collaboration requires designers to possess the analytical and rhetorical skills that allow them to transform experience into knowledge and understand the events in the complex network of the design process. Skills such as strategic judgement and explanation support knowledge creation by converting knowledge across the epistemological spectrum and ontological scale from individuals, to groups, to organisations, then inter-organisationally, and finally up to the social and cultural knowledge scales (Friedman, 2001, p. 15). According to Friedman (2001, p. 19) having the general principles and specific skills needed to understand and explain the systemic network of the design process and convert knowledge and shift it ontologically, is what distinguishes design professionals prepared to work within the knowledge economy from designers who craft objects.

To do research on the design process means to inquire, not only about what it is, but also how it works and why. While much of designing is a mental activity that occurs in the subconscious, significant aspects involve intentional reasoning that is under conscious intellectual control (Rittel, 1988, p. 2). Therefore, studying the design process means studying the reasoning of designers. According to Mercier and Sperber (2011) most work in the psychology of reasoning is about reasoning understood as

\[\ldots\text{a very special form of inference at the conceptual level, where not only is a new mental representation (or conclusion) consciously produced, but the previously held representations (or premises) that warrant it are also consciously entertained. The premises are seen as providing reasons to accept the conclusion.}\ (p. 57)\]

Furthermore, reasoning appears as a process of argumentation. As Tindale (1999) explains: “‘Argumentation’ is the site of an activity, where reasons are given and appraised, where beliefs are recognized and justified, and where personal development is encouraged” (p. 1). Consequently, studying collaborative design as a knowledge-integration process means to inquire into the participants’ reasoning as it appears as a process of argumentation within design activity.

The shift from understanding design as an object-centred craft to design as a collaborative knowledge-integration activity that appears as a process of argumentation provides good reasons that justify taking Rittel’s argumentative model of design as a point of departure for this research project. However, since there is a deep and rich field of scholarship concerning the theory and philosophy of argumentation, we should not assume that Rittel’s model of argumentation is cogent without first questioning its fundamental assumptions.
2.4. Conclusion

By the beginning of the 1990s the intellectual landscape of the design field had changed significantly from that of the Bauhaus and the design methods movement. The criticisms of the instrumental problem solving approach brought many designers to refocus their attention towards developing ways to meet people’s needs in a human-centred design process that utilised collaborative design and ethnographic techniques to understand what people know, what they value, and how they understand their worlds. Design practice became concerned with designing as a collaborative process that integrates interdisciplinary knowledge rather than the crafting of objects.

This chapter has provided a brief sketch of some of the key moments in the development of the field of design methodology that provide the context for this research project. Establishing the context of the research provides a point of departure from which to investigate the argumentative model of design. In chapter three I examine the assumptions that underpin the argumentative model of design and provide an investigation of the philosophy of argumentation as logic, dialectic, and rhetoric, and their respective models of design as problem solving, second-generation design methods, and fourth order design thinking.
Collaborative Design as Argumentation

Everyone at all familiar with these topics knows that the rhetoric/dialectic/logic trichotomy can be traced at least to Aristotle, as the subjects of his *Rhetoric, Topics,* and *Prior Analytics,* respectively. The *Prior Analytics* supplies the systematic rules by which conclusions may be deduced—that is, necessarily derived—from premises in categorical syllogisms. The *Topics* supplies strategies (to be used in dialogue games) for proving or refuting (either by deductions or by generalizations) propositions about which disagreement is reasonable and there is a prospect of success. The *Rhetoric* supplies advice for persuasive success in speeches in courts of law, in legislative assemblies, and on occasions to celebrate or condemn civic actors or their conduct. These three are no doubt the source of the logic/dialectic/rhetoric trichotomy. (Blair, 2012b, p. 154)

Through critical reading and interpretation, this chapter investigates the theory and philosophy of argumentation and its relationship to design. It investigates theories of argumentation as logic, dialectic, and rhetoric within the philosophical research programme of *informal logic* (Blair, 2012a; Govier, 1999; Perelman & Olbrechts-Tyteca, 1971; Toulmin, 2003; van Eemeren & Grootendorst, 2004; Walton, 1989). First, I consider the aspects of logical systems and reveal how formal demonstration underpins the *problem solving* model of design as exemplified by Herbert Simon’s theory of design as an artificial science (Simon, 1996). I then present Rittel’s critique of logical problem solving theory through his theory of wicked problems. Second, I examine the theory of dialectic within the pragma-dialectical model of argumentation and then I indicate that Rittel’s second-generation design methods take a dialectical approach that structures the communication patterns of stakeholders in the form of a critical discussion. Third, I investigate rhetoric in the theory and philosophy argumentation within Perelman and Olbrechts-Tyteca’s (1971) *The New Rhetoric,* and
Toulmin’s (2003) *The Uses of Argument*. I then examine rhetorical models of design as policy planning (Dunn, 1993; Gasper & George, 1998; Goldstein, 1984; Mason & Mitroff, 1981) and fourth order design thinking (Buchanan, 1985, 1995, 2001; Golsby-Smith, 1996, 2007). This investigation helps to reveal the assumptions that underpin the argumentative model of design and provide the motivation for the research questions that guide the dissertation’s empirical fieldwork.

### 3.1. Logic

According to Perelman and Olbrechts-Tyteca’s (1971) perspective on the philosophy of argumentation, logic consists of a system of necessary propositions whose self-evidence is the sign of its reasonableness. Moreover, logic is opposed to deliberation and argumentation, which concerns the domains of the credible, the probable, and the plausible. Within a logical system, agreement is inevitable because disagreement is error. Logic cannot be concerned with opinions, it must produce a system of necessary propositions, concerning which agreement is inevitable, and every rational being must submit to it. According to Toulmin (2003) “anyone who understands them [logical systems] must acknowledge their legitimacy” (p. 120). Furthermore, according to Perelman and Olbrechts-Tyteca (1971) “Self-evidence is conceived both as a force to which every normal mind must yield and as a sign of the truth of that which imposes itself because it is self-evident” (p. 3). Logic is rational and therefore disagreement is a sign of irrationalism. According to Descartes (1911)

> Whenever two men come to opposite decisions about some matter, one of them must certainly be wrong, and apparently there is not one of them that knows; for if the reasoning of one was sound and clear he would be able to lay it before the other as finally to succeed in convincing *his* understanding also. (emphasis in the original, p. 3)

As we can see from the quote above, the method of formal demonstration in logic is anti-argumentative. The correct decision is obtained by demonstrating the validity of the expressions. The validity of the expressions is established by deduction from axioms and rules of transformation. Toulmin (2003, pp. 5-6) argues that logic is concerned with techniques of inferring, that is, the rules of the performance of inference, and so the logician’s focus is on the formal relations between propositions. Consequently, Toulmin (2003) claims that “to ask whether an argument is valid is to ask whether it has the right form, and the study of form is best undertaken in a self-consciously mathematical manner” (p. 6). The formal logic of mathematics concerns the geometrical method of demonstration that establishes a proof that is the reduction to the self-evident.
The reasonableness of a logic system is not related to evidence. Where the first elements come from that became the axioms selected by the logician—whether they are impersonal truths, divine thoughts, or results of experiments—is not part of the logician’s concern (Perelman & Olbrechts-Tyteca, 1971, p. 14). Within formal demonstration, the meaning of the elements or their conformity with facts is irrelevant. The logician is free to create the system of symbols and combinations of symbols as they please. They decide what are the axioms that are considered without proof as valid, and the rules of transformation that make it possible to deduce, from the valid expressions, other expressions of equal validity in the system. The only aspect that is important, and the aspect that gives demonstration its force, is choosing axioms and rules in a way that avoids ambiguity and doubt. It is essential, without hesitation, even mechanically, to be able to establish whether a sequence of symbols is valid because it is an axiom or an expression deducible from the axioms (Perelman & Olbrechts-Tyteca, 1971, p. 13).

In formal demonstration, interpretation of the meaning of the elements can be left to those that will apply it. If the demonstration is questioned, it is sufficient for the logician to indicate the process by which the final expression of the deductive system was obtained. As soon as the logician concerns themself with the meaning the elements in the system, or their application to particular situations, then the context and social conditions cannot be neglected. They then enter the domain of the controversial and of argumentation.

Toulmin (2003, pp. 168-169) claims that utterances and rational judgement are made in particular times and situations and so they should be understood within this context. Consequently, aspects of argumentation such as cogency, strength, and evidential support resist idealisation. For example, when we make predictions we can only know whether or not we are mistaken when the event itself arrives. Between the time of the prediction and the event new evidence may become available that leads us to modify the prediction, or new expertise may be obtained that questions the relevance of the evidence on the issues in question and so the prediction may be withdrawn (Toulmin, 2003, p. 169). When the logical relations are assumed to be timeless then there is no room for progressive appraisal. Predictive arguments can only be timeless if we remove them from their context.

Toulmin (2003) claims that while the simplicity of logical arguments is attractive, we should not treat logical arguments as a universal model and then demand that all other forms of argument should conform to its standards (p. 133). Rather than being paradigmatic, Toulmin (2003, p. 134) claims that logical arguments are a special case, and while the
elegance and simplicity of logic is appealing, there is no reason that predictive, aesthetic, or ethical arguments should conform to the model of logical (i.e. geometrical) demonstration. Toulmin (2003) states:

A geometrical argument serves us when the problem facing us is geometrical; a moral argument when the problem is moral; an argument with a predictive conclusion when a prediction is what we need to produce; and so on. Since we are unable to prevent life from posing us problems of all these different kinds, there is one sense in which the differences between different fields of argument are of course irreducible—something with which we must just come to terms. There is simply no point in demanding that a predictive argument (say) should be presented in analytic form. (p. 168)

Consequently, Toulmin (2003, p. 174) describes his main contribution as identifying that there is a divergence between how arguments are used in logic and in practice, and that this divergence is due the mistaken adoption of logical demonstration as a universal paradigm of reasonableness.

3.1.1. Logic and Argumentative Design

The approach to design as logic is shown in the problem solving model of design as exemplified by Herbert Simon’s theory of design as an artificial science (Simon, 1996). In the problem solving approach, problems are assumed to be fixed and unchanging over time, and therefore the solution can be demonstrated by showing that the features of the solution can be inferred from the requirements. Newell and Simon (1972) developed problem solving theory by first creating a computer programme in 1955-56 called Logic Theorist (LT) to prove theorems in formal logic. According to Gedenryd (1998):

The task of LT was to find a proof for a given theorem in formal logic, given the axioms to be used for the proof. For a program to be able to do this, everything needed first had to be encoded appropriately and given to it. Besides axioms and theorem, also the available rules of logic, their proper application, and how they are combined into deductive sequences, had to be encoded into the program in an appropriate form. Then, using various methods, the program was to assemble valid combinations of steps into a sequence leading from axioms to proof. (p. 51)

This research domain later came to be called Artificial Intelligence and the computer programme became General Problem Solver and later the method of Means-Ends Analysis. The model of reasoning in design activity presented in problem solving theory is based the clear separation of problem and solution, and the approach was successful in solving formalised symbolic problems such as the Towers of Hanoi puzzle or games of chess. The theory of designing as problem solving has been tenacious and influential, however, it became subject to strong criticism because of the difficulty of separating problem definition
from problem solving within real-world design situations (Gedenryd, 1998, p. 69). This critique of logical problem solving was illustrated by Rittel’s theory of *wicked problems*. According to Rittel (1972a; Rittel & Webber, 1973), design issues cannot be resolved using the logical problem solving approach because design issues are wicked problems that have different properties from the type problems that can be solved using logical problem solving theory. Rittel and Webber (1973, pp. 160-167) describe ten properties of wicked problems:

1. **Wicked problems cannot be exhaustively formulated.** Because the search for information must begin with a solution already in mind, and any proposed solution prompts further questions. Therefore, designers should propose many different solutions to provoke more questions and information searches.

2. **Wicked problems have no stopping rule,** since a better solution is always possible. Therefore designers should try to aim go beyond the given requirements.

3. **Solutions to wicked problems are good or bad not correct or false,** since many parties with different worldviews are entitled to judge solutions. Therefore designers should maximise the scope of different judgements and worldviews.

4. **Wicked problems have no immediate or ultimate test,** since all the consequences of implemented designs cannot be known ahead of time. Therefore designers should both commit to acceptable designs and be aware that every design has the possibility to fail.

5. **Every attempt at solving a wicked problem counts,** since every implemented solution generates irreversible consequences and may create further needs. Therefore all implemented designs are final designs.

6. **Any approach to solving a wicked problem is permissible,** since it is a matter of judgement whether to implement a particular solution or keep looking for better solutions. Therefore, it is always possible to invent new ways to solve wicked problems.

7. **Every wicked problem is unique,** since a previous solution cannot always be implemented in a similar context. Therefore designers should keep an open mind even when tackling similar problems.

8. **Every wicked problem is a symptom of another wicked problem,** since you can never be sure you are attending to a problem at the right interpretative level. Therefore designers should get different interpretations of the level of the problem.

9. **Wicked problems can be explained in numerous different ways,** since there can be no correct or logical explanation of a problem and since the explanation or worldview chosen influences the solution direction taken. Therefore designers should get many different explanations of a problem from many different worldviews.

10. **Designers have no right to be wrong.** Since the aim of design is to change the world of peoples lives. Therefore designers must take responsibility for their solutions.

Rittel (1988, p. 2) states that much of the mental activity of design is subconscious but, because aspects of design are intentional and purposive, then that activity is under intellectual control and relies on reasoning. Furthermore, while there is “logic” to the patterns of designers’ reasoning, Rittel (1988) claims that it not a type of formal logic but rather orderly deliberation and argumentation where the designer “tries to explain or justify what he is proposing, speculating about future consequences of his plan, deciding the appropriate
course of action” (p. 2). Rittel claims that the argumentative model of design is not a model of formal logic because the issues that concern design are not self-evident but controversial, and therefore, their reasonableness is established by judgment rather than demonstration. According to Rittel (1984), the emphasis of the argumentative model of design is on

... those parts of the argumentative process that precede formal decision. Argumentation stops once a formal decision is reached. One of the arts of the second generation is actually the postponement of the formal decision in order to enhance the process of forming judgments. In the ideal case rules of formal decision-making wouldn’t be necessary at all, because people would become unanimous in the course of discussion. Formal decision has always meant curtailing debate, and therefore the formation of judgments. (p. 324)

Rittel (1971, pp. 18-19) claims that because the planning process is argumentative and plans controversial, each position one takes, and each issue to be considered, can be further contested so that more fundamental assessment and deliberation is needed. Accordingly, where to stop and settle the investigation of the problem at hand, is a matter of judgement rather than logical demonstration. Issues are controversial because they have changing frames of reference and require interpretation. Consequently, issues cannot be falsified because assumptions and ideologies affect how they are framed, and therefore, understanding and critical thinking are required to cope with the demands of judgement and commitment.

Rittel and Webber (1973, p. 6) argue that most important design issues are complex open societal problems that, in contrast to the problems of the natural sciences, rely on political judgment for resolution. Rittel (1969, p. 6) claims that political decision making deals with problems that have continuously changing frames of reference and therefore natural science based approaches cannot be used since they are developed for describing particular aspects in standardised ways. Every science deals with only a partial reality and the reliability of knowledge is only applicable to this narrow scope—specialisation is a trade-off between reliability of knowledge and narrowing the scope of its validity. A particular model cannot describe all relevant factors that affect political decision problems; there are always typical and unique factors. Furthermore, different theories will become possible and relevant depending upon one’s interpretation of the situation. Consequently, the argumentative model of design entails political decision-making rather than the formal logic of scientific problem solving.
3.1.2. Conclusion

From the brief examination of the assumptions of logical demonstration presented here, we must reject logic as the archetype that underpins Rittel’s argumentative model of design because, ultimately, logic is anti-argumentative. And so, to investigate the Rittel’s argumentative model of the design process further we must look beyond the logical method of formal demonstration, and examine dialectic and rhetoric. In the next section I will investigate the contemporary view of dialectic as developed by van Eemeren and Grootendorst (2004) in their theory of *pragma-dialectics*. This notion of dialectic concerns argumentation as a form of critical discussion and so should be distinguished from dialectical theories of history and sociology such as those found in Hegel or Marx for example.

3.2. Dialectic

Dialectic concerns arguments that are probably true rather logical systems of necessary propositions. In their theory of pragma-dialectics, van Eemeren and Grootendorst (2004) distinguish between “geometrical philosophers who want to demonstrate how something is and the anthropological and critical philosophers who prefer to discuss matters” (p. 14). The geometrical view of reasonableness refers to the anti-argumentative logical method of formal demonstration, and the anthropological and critical views refer to rhetoric and dialectic. The anthropological view takes reasonableness as culture-bound and so relative. The critical view is a sceptical position that relies on explicit argumentation to question differences of opinion to arrive at a mutually acceptable resolution (van Eemeren & Grootendorst, 2004, p. 16). The anthropological and critical views take the position that there is more than one perspective regarding a standpoint defended by argumentation. However, according to van Eemeren and Grootendorst (2004, p. 20) the anthropologico-relativistic philosophical view takes an epistemo-rhetorical theoretical position and is concerned with knowledge and beliefs. While, in contrast, pragma-dialectics follows Popper’s critical rationalist philosophy of science and therefore takes a pragma-dialectical theoretical position that presents a normative model of critical discussion (van Eemeren & Grootendorst, 2004, p. 16). Van Eemeren and Grootendorst (2004) describe a critical discussion as

\[\text{… an exchange of views in which the parties involved in a difference of opinion systematically try to determine whether the standpoint or standpoints at issue are defensible in the light of critical doubt or objections. (p. 52)}\]
The pragma-dialectical approach is primarily concerned with investigating “how arguers resolve a difference of opinion by removing all doubt from the standpoint that is defended” (van Eemeren & Grootendorst, 2004, p. 30). The pragma-dialectical model of a critical discussion is dialectical because it is based around the perspective of two parties trying to resolve a difference of opinion by methodical exchange of discussion moves, and it is pragmatic because “these discussion moves are described as speech acts that are performed in a specific situation and context” (van Eemeren & Grootendorst, 2004, pp. 21-22). A dialectical argument involves one party aiming to convince another party of a standpoint, and the other party refuting it. Arguments occur within communication to achieve the specific goal of justifying or refuting a proposition, that is, to defend a standpoint to convince another of its acceptability (van Eemeren & Grootendorst, 2004, p. 3). Van Eemeren and Grootendorst (2004) define argumentation as follows:

Argumentation is a verbal, social, and rational activity aimed at convincing a reasonable critic of the acceptability of a standpoint by putting forward a constellation of propositions justifying or refuting the proposition expressed in the standpoint. (p. 1)

Van Eemeren and Grootendorst (2004) state that the pragma-dialectical critical discussion aims to convince while the epistemo-rhetorical approach aims to persuade. Van Eemeren and Grootendorst distinguish between persuasion and conviction and claim that:

While persuasion implies the immediate effect that the audience reacts to the argumentation in the desired way, conviction can only be reached after some further rejection on the part of the person who is to become convinced. Before proceeding to consider exactly how convincing the argumentation is, that person has to understand that argumentation has been advanced and exactly what it involves. Rhetorical devices often owe their success precisely to the fact that they are not recognized as such. (van Eemeren & Grootendorst, 2004, p. 30)

Resolving a difference of opinion is not the same as settling a dispute, it is the joint conclusion of the acceptability of standpoints. Van Eemeren and Grootendorst (2004, p. 58) state that an argument can be settled when the parties mutually agree that the difference of opinion has ended, for example, through the outcome of a vote or arbitration. Settlement does not necessarily mean that the difference of opinion has been resolved, as van Eemeren and Grootendorst (2004) state:

A difference of opinion is only resolved if a joint conclusion is reached on the acceptability of the standpoints at issue on the basis of a regulated and unimpaired exchange of arguments and criticism. (p. 58)

Van Eemeren and Grootendorst (2004) claim that to justifiably evaluate arguments, a theory of argument requires a normative dimension. Pragma-dialectics has a normative dimension
because it aims to resolve differences of opinion to reasonably weigh up the arguments for and against the standpoints at issue. Therefore, van Eemeren and Grootendorst (2004) state “This means that the set of theoretical instruments that we need has to contain rules and procedures that indicate which moves are admissible in a critical discussion” (p. 50). The normative model uses “instruments in link theory to practice, they have heuristic, analytic, critical functions for the analysis and evaluation of argumentation” (van Eemeren & Grootendorst, 2004, p. 19). The normative dimension of van Eemeren and Grootendorst’s pragma-dialectical approach involves reconstructing argumentative discourse or testing to reveal the extent to which the specimen corresponds with the ideal model of critical discussion (van Eemeren & Grootendorst, 2004, p. 23). Reconstruction involves transforming the discourse or text to reveal the conclusion, claim, or standpoint of the argumentation (van Eemeren & Grootendorst, 2004, p. 28).

There are four phases to the ideal model of pragma-dialectical critical discussion. The confrontation stage is when a standpoint is doubted, meaning, there is a difference of opinion. Then in the opening stage the parties try to find common ground from which the argument can proceed. Then the parties advance their arguments for their standpoints. Then, in the concluding stage, the parties attempt to resolve the difference of opinion:

The difference of opinion can only be considered to be resolved if the parties are, concerning each component of the difference of opinion, in agreement that the protagonist’s standpoint is acceptable and the antagonist’s doubt must be retracted, or that the standpoint of the protagonist must be retracted. (van Eemeren & Grootendorst, 2004, pp. 60-61)

The pragma-dialectical model of argumentation is useful for understanding the theory of argumentation that underpins Rittel’s argumentative model of design because it shows that Rittel’s second-generation design methods take a dialectical approach that utilises normative tools for structuring the communication patterns of stakeholders. Rittel and his contemporaries developed normative tools for structuring design work that have become more commonly referred to as design rationale management systems (Dutoit et al., 2006).

3.2.1. Rittel’s Dialectical Model of Design Argumentation

Rittel describes design as a counter-play between issues, positions, and arguments. According to Rittel and Nobel (1988, p. 2), models of designing that separate the activity into a sequence of stages, such as analysis > synthesis > evaluation, are not realistic accounts the design process. Therefore, Rittel and Nobel (1988, p. 2) claim that design activity should be taken to be a
process of argumentation. The process is a discourse, driven by dispute and disagreement, where participants with differing worldviews construct arguments for or against positions on an issue (Kunz & Rittel, 1970, pp. 1-2). Answers to issues that have been resolved can themselves be questioned and so become issues for further argumentation:

[The designer] debates with him-self or with others; issues come up, competing positions are developed in response to them, and a search is made for their respective pros and cons; ultimately he makes up his mind in favor of some position, frequently after thorough modification of the positions. In this model of design as argumentation, the various issues are interconnected in intricate ways; usually several of them are ‘open’ simultaneously, others are ‘postponed’ or ‘reopened’ (Rittel, 1988, p. 3).

The counter-play between issues, positions, and arguments progressively develops knowledge by surfacing assumptions that underpin the participants’ judgements, which consequently enlarges the group’s understanding of the scope of positions towards an issue.

Because a statement within the discourse about an answer to an issue is also a formulation of a solution, the argumentative process proceeds as the alternative formulation of judgments and search for ideas (Rittel, 1988, p. 5). As the search for the plan progresses, the understanding of the situation changes as new facts and values come up depending on solutions offered. There is no logical order to the trajectory of the process, no rules prescribing steps to take, therefore Rittel (1988, p. 5) argues that designers have great epistemic freedom to proceed in a manner according to their judgement. Similar to the pragma-dialectical theory, the aim of the argumentative process is to convince rather than persuade:

It is on the conviction rather than the persuasion processes that planning methods can and should be based. The reason is that the desired form of planning should try as little as possible to persuade and condition those involved but to have as many comprehension processes as possible to reach a state of knowledge through an ‘aha’ effect. (Rittel, 1972b, p. 3)

However, unlike the pragma-dialectical theory of critical discussion, Rittel claims that the aim of the argumentative model of design is not to settle disagreement or achieve consensus of conflicting positions once and for all, because conflict prevents the system from “freezing” and “stagnating”. Rather, the aim is to stimulate discussion and argument so that it might increase the likelihood that some overlooked piece of information is not left out (Rittel & Nobel, 1988). Consequently, Rittel (2010, p. 97) suggests that the best solution in these circumstances is not a true or false solution, but one that best fits the pattern of the participants’ conflicting positions.

According to Rittel (1972a, p. 8) design methods that claim to objectively determine the best of a set of alternative solutions or represent the positions of all affected parties must fail
because it matters who is involved in the process. Something is scientifically objective if the operation leading to a statement does not depend on who makes the statement. But in planning arguments, statements cannot be objective in the scientific sense because it matters who carries out the process and who is involved, since there are always political and ethical assumptions underpinning arguments for solutions (Rittel, 1984, pp. 319-320). If logical design methods are used to stimulate an evolving discourse among participants, then they are useful because they can become the focus of organised debate and discussion. Furthermore, just looking at the output of a planning process does not identify the particular deontic statements that underpinned the arguments for a solution, since implicit political and ethical attitudes colour the development of proposed solutions (Rittel, 1972a, pp. 7-8). Therefore discussion is needed to surface these deontic assumptions and make the reasoning process transparent.

Rittel (1980, pp. 4-5) claims that the answers to planning questions are controversial rather than obvious because they depend on the worldviews of the participants. Worldviews are subjective, while obvious answers depend on objective questions. Since answers to planning questions are controversial and subjective, the methods of science developed for objective issues are not applicable. Rather, participants construct a network of arguments for and against an issue, and each participant gradually forms judgments about which arguments to adopt. Consequently, there are no true of false solutions but more or less cogent arguments for particular plans, and the decision to adopt a plan is determined by the organisation: individual decision, vote by majority rule, and so on.

Rittel (1972b, p. 1) describes the planning process as an information process. However, rather than considering information in a narrow sense as “the-facts-of-the-matter” or as the substratum that allows one to choose among words when communicating, Rittel (1972b, p. 2) takes the position that information is a process of changing someone’s knowledge: either informing someone or disinforming them. The processes of informing or disinforming produces and manipulates six types of knowledge (Rittel, 1972b, p. 3): factual knowledge about what is the case; deontic knowledge about what should become the case; explanatory knowledge about why what is or should be the case is as it is or as it should be; instrumental knowledge concerning ways to change what is the case; conceptual knowledge about the meaning of words and forms of communication that we use to make ourselves understood; modal knowledge that describes the degree of possibility or necessity of ways to change what is the case. Rittel (1972b) describes how designers manipulate these types of knowledge as
follows:

He starts with a discrepancy between factual and deontic knowledge, seeks out explanations why things are so and how they should be, and these explanations give him hints about the instrumental knowledge he needs to overcome this discrepancy. And now and again or constantly he must ask himself what he is in fact doing, what he in fact means by productivity, or neighbourhood, or an operating town? He then produces conceptual knowledge that he exchanges with others. (p. 3)

The design process can be understood as the production of these elements of knowledge that are specific for a given design issue or for the context of a given design issue. The elements of the process are issues, that come from controversial statements relating to particular situations and are given in the form of questions (Kunz & Rittel, 1970, p. 2). Kunz and Rittel (1970, p. 3) identify six types of issues that correspond to the six knowledge types:

- Factual issues: “Is X the case?”
- Deontic issues: “Shall X become the case?”
- Explanatory issues: “Is X the reason for Y?”
- Instrumental issues: “Is X the appropriate means to accomplish Y in this situation?”
- Conceptual issues: “What does X mean?”
- Modal issues: “What is the degree of possibility of X?”

Like the pragma-dialectical model, the design discourse is reconstructed, and each participant’s position towards each issue is recorded in a database. Rittel advocates that tools, which he calls social technologies, can be used to reconstruct arguments and support his model of the argumentative process. Rittel (1988, p. 2) claims that these tools can support the participants to make their argumentative process more transparent, that is, allow the participants and the public to trace and scrutinise the procedure of decision-making. Furthermore, transparency supports the group to comprehend and debate connections, conjunctions, and relations between the current problem and other problems. In addition, social technologies support objectification of the argumentation through articulate communication that supports shared understanding and learning (Rittel, 1972a, p. 8). The aim of supporting objectification of argumentation is not to produce agreement but to forget less, to stimulate doubt, to identify where there is disagreement, and control the delegation of judgement (Rittel, 1972a, p. 8). Rittel (1984, p. 320) claims that even though traditional design methods can be used within the argumentative process of forming and deliberating the pros and cons of positions, the argumentative approach is not just a different attitude to using traditional design methods or a different arrangement of their application.
Various computer-supported tools have been developed to support planning teams to structure their communication as an argument. Such tools are commonly termed design rationale management systems, examples include Rittel’s original IBIS (Issue-Based Information System) (Cao & Protzen, 1999; Conklin & Yakemovic, 1991; Kunz & Rittel, 1970), and APIS (Argumentative Planning Information System) (Rittel, 1980), and other systems such as PHI (Procedural Hierarch of Issues) (McCallion & Britton, 1991), QOC (Questions, Options, Criteria), and DRL (Decision Representation Language). However, these tools have not been as influential as Rittel’s theories (Dutoit et al., 2006, p. 20). Horner and Atwood (2006, pp. 78-85) identify four categories of fundamental barriers that obstruct effective use of design rationale management systems: cognitive limitations that render design rationale management incomplete; capture limitations where design rationale fails to capture design decisions made in informal situations; retrieval limitations where the content of the rationale captured is not relevant for subsequent decision making; and usage limitations where users do not know how to apply design rationale to current design problems. These limitations may in part be due to the dialectical form of Rittel’s normative model. Rittel assumes that design is a debate between individuals and so the interaction of the six types of knowledge is restricted to the combination of explicit knowledge. Consequently design rationale management systems based on Rittel’s model may not fully support the knowledge creation cycle (Nonaka & Takeuchi, 1995).

3.2.2. Conclusion

Rittel’s normative social technologies have had some influence within design professions, such as software design, that mostly deal with mostly explicit knowledge and technical problems. However, in more human-centred design fields such as industrial design, service design, or strategic design, Rittel’s argumentative model has mostly captured designers’ attention as a means to describe designing as a form of problem solving that deals with wicked problems as described in Rittel and Webber’s (1973) influential article Dilemmas in a General Theory of Planning. However, in my view, restricting one’s understanding of Rittel’s theory of design to the description of wicked problems misses the key insight that, in fact, the infamous ten properties of wicked problems follow as a consequence of framing design as a form of argumentation involving critical thinking and judgment rather than a set of properties of a subcategory of the theory of problem solving.
To further investigate the significance of judgment in argumentative design and understand some of the limitations of Rittel’s dialectical approach, we will next consider the type of arguments found in the philosophy of rhetoric and rhetorical models of design.

3.3. Rhetoric

As we have seen in the previous section, the pragma-dialectical theoretical position is characterised by the model of argumentation as a critical discussion. In contrast, the anthropologico-relativistic philosophical view takes an epistemo-rhetorical theoretical position that is concerned with knowledge and beliefs (van Eemeren & Grootendorst, 2004, p. 20). Furthermore, the pragma-dialectical critical discussion aims to convince, however, the epistemo-rhetorical argument aims to persuade. In addition, the pragma-dialectical position utilises a normative model of a critical discussion for evaluating arguments, but in the epistemo-rhetorical position “argumentation must be in agreement with the standards applying in the socio-cultural community where the argumentation takes place” (van Eemeren & Grootendorst, 2004, p. 18). Accordingly, while logical demonstration shows necessary connections between self-evident truths, and dialectic provides rules for resolving differences of opinion within critical discussion, in contrast, rhetoric sets out to increase intensity of adherence to theses by establishing a sense of communion around particular values held by the audience and the speaker.

Perhaps the most significant contemporary texts concerning rhetoric in the theory and philosophy of augmentation are Perelman and Olbrechts-Tyteca’s (1971) *The New Rhetoric*, and Toulmin’s (2003) *The Uses of Argument*. Both texts were originally published in 1958, only a few years before Rittel delivered his seminar series at the College of Environmental Design at the University of California, Berkeley, in 1964, in which he begins to articulate his argumentative model of design. In the next section I will address Toulmin’s (2003) *The Uses of Argument*, and in the following section Perelman and Olbrechts-Tyteca’s (1971) *The New Rhetoric*.

3.3.1. Toulmin’s Defeasible Arguments

Toulmin (2003) claims that focusing on the formal relations of logic loses the link between argumentation and practical life. Like Perelman and Olbrechts-Tyteca’s (1971) *The New Rhetoric*, Toulmin (2003) claims that practical argumentation needs a model of reasonableness other than that of demonstration. Toulmin (2003, p. 2) states that his motivation is to
consider “general, philosophical questions about the practical assessment of arguments” rather than work on the problems of technical logic. However, rather than develop Aristotle’s Rhetoric like Perelman and Olbrechts-Tyteca (1971), Toulmin (2003, p. 7) proposes to draw on jurisprudence as a new analogy for argumentation. Toulmin (2003) states that in jurisprudence, arguments are comparable to lawsuits and that “a main task of jurisprudence is to characterise the essentials of the legal process” (p. 7). Toulmin (2003) conceives of the aim of his project as a parallel: his aim is “to characterise what may be called ‘the rational process’, the procedures and categories by using which claims-in-general can be argued for and settled” (p. 7). Consequently, Toulmin is concerned with defeasible arguments, that is, arguments that stand up to criticism rather than arguments that are logically valid. As Toulmin (2003) asserts:

A sound argument, a well-grounded or firmly-backed claim, is one which will stand up to criticism, one for which a case can be presented coming up to the standard required if it is to deserve a favourable verdict. (p. 8)

Toulmin (2003) is primarily concerned with “justificatory arguments brought forward in support of assertions, in the structures they may be expected to have, the merits they can claim and the ways in which we set about grading, assessing and criticising them” (p. 12). Rather than the classical structure of minor premise, major premise, and conclusion, Toulmin proposes that an argument should offer the following elements:

- **A claim** that what you want your audience to believe
- **Grounds** that provides the evidence or reasons why they should believe it
- **A warrant** that explains why the evidence is relevant to the claim
- **Backing**, the body of accepted knowledge of a field that provides the foundations that authorize the reliability of the warrant
- **Qualifications** that make the claim and evidence more precise
- **Rebuttal**, counter arguments etc.

Figure 1 illustrates how the elements are arranged in a general model. Toulmin (2003) recognises that there are many types of arguments, however, he introduces the technical term *field* to account for arguments that have the same scheme. Toulmin (2003) states that two arguments can be considered to be from the same field when the “backing or the conclusions of each of the two arguments... are of the same logical type” (p. 14). Furthermore, Toulmin (2003) affirms that there are elements of arguments that are field-invariant and elements that are field-dependent. According to Toulmin (2003):

... for instance, not only that the sorts of grounds to which we point in support of conclusions in different fields are different, but also that the ways in which these grounds
bear on the conclusions—the ways in which they are capable of supporting conclusions—may also vary as between fields. (p. 39)

Toulmin’s important contribution is his notion of the warrant. Toulmin (2003, p. 90) distinguishes between the claim, whose merit is being established, and the grounds, facts, evidence, or data appealed to as a foundation for the claim. According to Toulmin (2003) warrants are propositions that show that the step to the claim from the data is appropriate and legitimate (e.g. Given grounds G, one may take it that claim C). Toulmin (2003) asserts that the difference between data and warrants is that data are referred to explicitly, while warrants are very often referred to implicitly:

Some warrants authorise us to accept a claim unequivocally, given the appropriate data—these warrants entitle us in suitable cases to qualify our conclusion with the adverb ‘necessarily’; others authorise us to make the step from data to conclusion either tentatively, or else subject to conditions, exceptions, or qualifications in these cases other modal qualifiers, such as ‘probably’ and ‘presumably’, are in place. It may not be sufficient, therefore, simply to specify our data, warrant and claim: we may need to add some explicit reference to the degree of force that our data confer on our claim in virtue of our warrant. In a word, we may have to put in a qualifier. (p. 93)

In Toulmin’s model, every part of an argument serves to support claims. Claims are statements that aim to persuade someone to change their minds about something or to undertake a course of action. Furthermore, because most people resist changing their minds,
especially about things they feel are important, we need to provide supporting evidence and also expand our argument with two more elements: warrants and backing. Including these three parts will increase the soundness of an argument.

The warrant of an argument is its general principle, an assumption, or premise that links the claim and its supporting evidence into a logically related pair. A warrant shows that the evidence is relevant to the claim, however, a warrant is not self-validating and another element—backing—is needed to show that the warrant is reliable and relevant. Backing is the body of accepted knowledge of a field or the values of a social group that provide the foundations that authorise the reliability of the warrant. It is the broad body of knowledge, experience, or set of cultural values that is presupposed by anyone who accepts a particular warrant. Once we have demonstrated that all the elements of the argument are present and connected we have formulated a sound argument. However, we can ask further questions about the strength of those connections.

Because the connections between the grounds, warrants and backing are not absolutely irrefutable, we have to provide qualifications for our claims. When we provide qualifications, we limit the certainty of our conclusions, stipulate conditions in which our claim holds, and address readers’ potential objections. Whenever we make a claim that is true only under certain conditions or when the link between the claim and the evidence is only probably true, we owe it to our readers and ourselves to qualify our arguments appropriately. Good reasons and thoughtful qualifications convince our readers that we are trustworthy, because we acknowledge the obstacles that interrupt the connection between our evidence and claim.

Toulmin’s model is useful because it provides a tool for retrospective and prospective argument assessment through supporting critical thinking. Critical thinking is the act of being prepared to scrutinise the knowledge and values that we assume to be true without question. The first step towards developing critical thinking skills is to understand the general structure of arguments. Because then we can test whether an argument is sound—meaning whether all the required elements and their connections have been accounted for. We might think that, on the surface, our argument is straightforward. However it is often the case that the people we are trying to persuade do not share the same accepted knowledge or cultural values that we take for granted. And this can lead to misunderstanding and the breakdown in teamwork.

In the next section I will describe the influence of the Toulmin model in social policy design, and then, in the following section, the influence of the rhetorical turn in
argumentation on the facilitated conversation technique of Buchanan’s fourth order approach to design thinking.

3.3.2. Toulmin Arguments in Planning and Policy

Like Rittel’s approach, Dunn (1993, p. 260) claims that social policy reforms deal with ill-structured problems, which unlike physical theories, cannot be falsified with experimental data because social theories are infused with the assumptions, frames of reference, and ideologies of stakeholders. Consequently, the main concern in generating policy is defining problems rather than determining effective reform. Therefore, Dunn (1993, p. 260) claims that the primary threats to validity of social policy are not first-order threats to validity but second-order threats that question how the problem is defined. Second-order threats provide meta-criteria against which the formulation of the problem—as opposed to the parts and relations that constitute the problem—may be questioned. Moreover first-order errors support choosing between alternative causal inferences, while second-order errors concern differentiating appropriate worldviews or problem definitions (Dunn, 1993, p. 261).

Dunn’s approach is similar to Rittel’s argumentative model of design, since his concern is not with the validity of causality within particular solutions statements, but with encouraging debate between participants through surfacing the assumptions and worldviews that underpin particular solutions. Dunn (1993, p. 270) claims that Toulmin’s model of argumentation provides a procedure for both retrospective and prospective argument assessment, because, when argumentation models are used to support a planning process it can help participants to surface assumptions and reflect on their contributions. According to Dunn (1993, p. 262) the assessment standards of policy reforms should not be restricted to those of natural science, since then policy is difficult to use in practice, because the success of policy reforms is ethical as well as factual, and policy knowledge standards must address both values and not only rules for making valid causal inferences. Consequently, policy reforms should be considered as arguments, since it breaks down the sharp distinction between science and practical knowledge, and opens policy design to broader standards for assessing and challenging knowledge claims (Dunn, 1993, p. 261).

While the structure of Toulmin arguments is field-invariant, the substance of the elements and standards for assessing their strength vary according to the particular field’s history and social function (Goldstein, 1984, p. 301). Goldstein (1984, p. 301) claims that planning arguments are distinguished by the nature of their audience and a relatively
heterogeneity of planning argument schemes. Similarly, Stumpf and McDonnell (2002, p. 10) claim that design teams’ shared values and beliefs create a context of acceptability from which argumentation schemes are deployed. Furthermore, the shared context of argumentation connects designers to their community and culture as they collaborate in a team (Stumpf & McDonnell, p. 9). Stumpf and McDonnell (2002, p. 14) use the elements of rhetoric to support a new approach to the analysis of Schön’s theory of reflective practice within the experimental learning in design teams. Stumpf and McDonnell (2002, p. 15) use rhetoric to view the design process as a form persuasive social interaction. Since rhetoric depends on the shared understanding of what is acceptable as a valid statement to a particular audience then, Stumpf and McDonnell (2002, p. 15) claim, Schön’s concept of a frame can be reconsidered from a rhetorical perspective.

Dunn (1993, p. 265) claims that planning arguments are a type of substantive argument, which takes the position that there are rational grounds to recognising the validity of some types of claims as persuasive in particular social contexts, even though they are not organised in deductive systems. Furthermore, the reasoning processes that underpin the knowledge claims made by these non-deductive but rational argumentation schemes can be revealed via the Toulmin model of substantive argument (Dunn, 1993, p. 269). Dunn (1993, p. 269) claims that the Toulmin model has a critical function because practitioners frequently suppress implicit worldviews and frames of reference because they see outcomes as speaking for themselves as a demonstration of causal patterns.

3.3.3. The New Rhetoric

Aristotle’s Rhetoric influences Perelman and Olbrechts-Tyteca’s study of argumentation but they do not take this point of departure to focus on the style communication. Rather Perelman and Olbrechts-Tyteca’s (1971, p. 6) theory of argumentation concerns discourse in all forms not only speech. Furthermore, Perelman and Olbrechts-Tyteca (1971) rebel against the conception of rhetoric as

... the art of good speaking and good writing, as an art of expressing thought, a purely formal art... We refuse to separate the form of a discourse from its substance, to study stylistic structures and figures independently of the purpose they must achieve in the argumentation. (p. 142)

In particular, Perelman and Olbrechts-Tyteca’s (1971) study of argumentation is significantly influenced by a form of rhetoric called epideictic discourse. In epideictic discourse the aim of the
argumentation is not only intellectual but also aimed at the performance of action. As Perelman and Olbrechts-Tyteca (1971) describe:

[Epideictic discourse] is not designed to promote the speaker, but for the creation of a certain disposition in those who hear it… seen in this way all argumentation is conceived only in terms of the action for which it paves the way or which it actually brings about. (p. 154)

According to Perelman and Olbrechts-Tyteca (1971), since arguments are not demonstrations, then arguments should take psychological and social conditions into account. Because Perelman and Olbrechts-Tyteca’s (1971) claim implies that argumentation is more than just simply speaking, then there must be an audience that listens as well, and so argumentation presupposes a community. However, while Perelman and Olbrechts-Tyteca (1971) maintain that argumentation is relative to the audience it is aimed at persuading, this audience may, in some circumstances, be a universal audience. In this sense, Perelman and Olbrechts-Tyteca’s (1971) theory of argumentation is not limited to the caricature of an orator giving a speech in the town square, but is an attempt to describe argumentation techniques that people use in practice to win the approval of others for their standpoints to set in motion intended actions. Furthermore, the norm of reasonableness in evaluating argumentation that follows from Perelman and Olbrechts-Tyteca’s (1971) theory lies with the audience. The argumentation is considered cogent if it succeeds in influencing the audience for which it is intended.

Perelman and Olbrechts-Tyteca (1971, p. 37) also maintain that persuasion of an audience should not be obtained by them yielding to the strength of the speakers dialectical superiority in a debate as in van Eemeren and Grootendorst’s pragma-dialectical approach, but rather in the honest search for the best solution to a controversial problem. As Perelman and Olbrechts-Tyteca (1971) explain:

In a debate each interlocutor only advances those arguments that are favourable to his own thesis, and his sole concern is refuting those arguments that are unfavourable to him. The man with settled position is thus one-sided, and because of his bias and the consequent restriction of his effort to those pertinent arguments which are favourable to him, the others remain frozen… discussion is the sincere quest for truth, whereas the protagonists of debate are chiefly concerned with the triumph of their own viewpoint. (p. 38)

According to Perelman and Olbrechts-Tyteca (1971), before an argument begins there must be agreement on the premises. Premises may be facts or values. Facts need to be agreed upon to be self-evident, they stop being facts as soon as they are the conclusions of argumentation. Values connect particular groups to the idea of multiplicity of groups. The speaker appeals to
values to induce the hearer to make certain choices rather than others, and to justify those choices so they may be accepted and approved by others. Values that claim universality are only so when they are general, as soon as they are made specific then they become relative only to particular audiences. Generalized values are like facts to the extent that when they are precisely formulated they conform to particular groups.

According to Perelman and Olbrechts-Tyteca (1971) argumentation compels us to consider not only the choice of premises but also the interpretation of the meaning given to them. Facts are elements that are provisionally or conventionally considered to be univocal and undisputed. When there are incompatible interpretations of the facts, then the issue of interpretation is important, but when one interpretation is adequate, the issue of interpretation falls into the background (Perelman & Olbrechts-Tyteca, 1971, pp. 20-21). However, interpretation not is merely the choice between seemingly incompatible interpretations, since we can interpret something as a symbol, or act, or a means, for example, then also the choice of the level upon which the interpretation will be conducted is significant, and while these levels may not be incompatible, the choice to bring one interpretation to the foreground may force another to the background. Furthermore, because it is rare in non-formalised language that a speech appears absolutely clear to everybody, then the choice of bringing one interpretation to the foreground may indicate a particular system of beliefs (Perelman & Olbrechts-Tyteca, 1971, p. 23). Consequently, Perelman and Olbrechts-Tyteca (1971) claim, that clarity is only assured by voluntary limitation of the context in which the interpretation should be made, and thus, “The necessity for interpretation is the rule, while elimination of all interpretation, is part of an exceptional and artificial situation” (p. 126). Perelman and Olbrechts-Tyteca’s (1971) new rhetoric suggests an alternative theory of argumentation in contrast to logical demonstration or resolving a dialectical debate, rather argumentation can be considered as an activity that aims to provoke action by forming a community through identification. In other words, rhetoric aims increase intensity of adherence to theses by establishing a sense of communion around particular values held by the audience and the speaker to introduce action and change.

3.3.4. Rhetoric of Design

Richard Buchanan has established the most substantial research programme investigating the rhetorical model of design to date (Buchanan, 1985, 1992, 1995, 2001). Buchanan (1985, p. 5) claims that the objects that designers create influence people in a similar way that speakers
persuade an audience. Both speech and design aim to persuade “the audience with the reasons for adopting a new attitude or taking a new course of action” and so both are rhetorical arts with the aims of “shaping society, changing the course of individuals and communities, and setting patterns for new action” (Buchanan, 1985, p. 5). Buchanan (1985, pp. 5-8) claims that design is more intelligible when viewed as a form of rhetoric rather than as a technology or science, because when design is viewed as an art of rhetoric, the significance of ethics and values is less hidden from view. According to Buchanan (1992):

Most people continue to think of technology as a product rather than its form as a discipline of systematic thinking… Every liberal art had its own technologia or systematic discipline… Design also has a technologia, and it is manifested in the plan for every new product. The plan is an argument, reflecting the deliberations of designers and their efforts to integrate knowledge in new ways, suited to specific circumstances and needs… The power of design as deliberation and argument lies in overcoming the limitations of mere verbal or symbolic argument… Argument in design thinking moves toward the concrete interplay and interconnection of signs, things, actions, and thoughts. Every designer’s sketch, blueprint, flow chart, graph, three-dimensional model, or other proposal is an example of such argumentation. (p. 19)

Buchanan, (1998) claims that the “human values concerning what is good, useful, just, and pleasurable” have now lost any fixed meaning and have become “essentially contested” in our contemporary society (p. 11). Because design is concerned with conceiving and expressing values, which are now contested, then technological thinking is no longer reliable and new ways of addressing problems is needed—namely a rhetoric of design.

Buchanan (2001, pp. 195-196) discusses the classical themes of rhetoric—logos or usefulness, pathos or usability, and ethos or desirability—as features of designed objects and design practice. First, logos is technological reasoning that designers use to provide intelligible structure to their designs such that a product is useful in performance and capable of doing its work (Buchanan, 2001, p. 195). Second, pathos is suitability or fit of the product to the intended user or community. Third, ethos is the expression of the “voice” of the product, such that it is aesthetically desirable and that people may identify with it. According to Buchanan (1985, pp. 8-9) artefacts demonstrate designers’ persuasive communication with a user that the design is technically useful and humanly important. Because designing is a form of persuasive communication with a user about technology and human values, then designing can be considered as a form of argument that is guided by rhetoric.

In Buchanan’s view of design as rhetoric, persuasive communication comes first and then designed objects. He writes in a footnote (Buchanan, 1985, p. 21) that this is similar to the arrangement of the seven liberal arts of scholastic pedagogy. The seven liberal arts were
divided into the *trivium* and the *quadrivium*. The trivium was made up of grammar, logic and rhetoric; they formed the preparatory work for the quadrivium: arithmetic, geometry, music, and astronomy. The quadrivium concerns these four arts as related to number (arithmetic), space (geometry), time (music), and space-time (astronomy). According to Kline (1954)

From the time of Pythagoras, the study of music was regarded as mathematical in nature and grouped with mathematics. This association was formalized in the curriculum of the medieval system of education wherein arithmetic, geometry, spherics (astronomy), and music comprised the famous quadrivium. The four subjects were linked further by being described as pure, stationary, moving, and applied number, respectively. (p. 287)

Buchanan (1985, p. 21) uses the quadrivium to distinguish between different *orders of design*: graphic design (arithmetic), engineering/industrial design (space), architecture (time), and urban planning (space-time). Later, in his *Wicked Problems and Design Thinking*, Buchanan (1992, pp. 9-10) uses different examples of the four orders: symbolic and visual communication, material objects, activities and organised services, and complex systems or environments for living, working, playing and learning. More recently, Buchanan (2001, pp. 201-202) gives slightly different examples: symbols, things, actions, and systems. The four orders of design thinking represent rhetorical arts for dealing with successively larger and more integrated problems.

**3.3.5. Facilitated conversation and fourth order design thinking**

Buchanan (1998, p. 14) traces the “rediscovery” of the arts of rhetoric and dialectic in organisations to the systems thinking approach to quality control in the mid-20th century, for example in the work of W. Edwards Deming. According to Buchanan (1998, p. 14) the significance of the quality management movement was in supporting managers and workers to discuss the quality of work processes, rather than being a centred on the application of statistical measures of quality. Moreover, in this circumstance, dialectic was decoupled from ideology and was used as a creative art for collectively building knowledge and understanding. According to Buchanan (1998):

> Dialectic is, in fact, a powerful tool for collective deliberation about circumstances and ends, where a clarification and exploration of values and principles may be an essential condition for productive action. (p. 15)

Rather than being driven by conflict, Buchanan (2001, p. 202) claims that dialectic, when rediscovered, is a form of cooperation and collaboration that he terms fourth order design. According to Buchanan (2001, p. 202) when designers facilitate this collective form of dialectic they aim to express the organising principle that operates behind systems and
environments. This organising principle is not given as a fact but is a thesis that is constructed by the communication of the stakeholders.

Similarly, Golsby-Smith (2007, pp. 24-25) claims that a management strategy should be considered as a type of argumentation not the outcome of logical analysis, because analysis is concerned with accounting for what already exists and so it cannot determine alternative futures because futures do not yet exist. And since argumentation is concerned with facilitating exploration of alternative futures, then, designers should use the tools of rhetoric rather than logic to explore shared experiences, identify emerging themes, and connect them to applications (Golsby-Smith, 1996, p. 18). Golsby-Smith (1996, p. 19) criticises the received view of systems analysis because it reduces people to input/output factors. Instead Golsby-Smith (1996) claims that systems can be characterised as a “set of conversations around a shared purpose” (p. 19). According to Golsby-Smith (1996, p. 19) the concept of a conversation preserves the role of purpose but does not reduce it to the notion of outputs, because conversation explores themes and sets boundaries. Therefore the purpose of a conversation is relational. Consequently, Golsby-Smith (1996, p. 19) argues that facilitating conversation is a key art within fourth order design. According to Golsby-Smith (1996):

[Conversation] skills are used in a live drama; in that you take the topic to a group of people rather than away to work on alone in the safety of the designer's cloister. You submit the topic to a group of people who care about it, but whom probably do not all agree on their positions. Then you unfold the argument in real time with no predictability of outcomes. (p. 19)

Buchanan's forth order design thinking could be considered a dialectical approach since conversation is a key aspect, but since its main concern is finding shared identity and producing action rather than resolving conflict through debate, then, I argue, it is more closely aligned with rhetoric than dialectic. Fourth order design thinking is rhetorical because the objective is to bring the group into identification with certain values to produce action not for one party to convince another party of their standpoint as in a debate.

3.3.6. Conclusion

The investigation of rhetorical models of argumentation and design given in this section provide several useful insights concerning the potential roles of action, audience, and interpretation in argumentation. We have seen that rhetoric is not only concerned with intellectual inquiry but also the performance of action. Also, rhetorical arguments work through establishing the relevance of grounds to claims, and as such, they presuppose an
audience with various worldviews within a context characterised by various facts and values. Accordingly, dealing with values involves interpretation to create knowledge and understanding within the community through the creation of shared identity.

3.4. Discussion

This dissertation inquires into the nature of the human-made world. It takes design methodology as its concern, specifically the philosophical inquiry into the methods of thinking and action that produce the subject matters of design. In chapter two I highlighted some of the major developments in design methodology over the course of the twentieth century, and I suggested that design methodology has expanded its focus from the techniques that individual craftsmen employ to produce objects to also including approaches to integrating knowledge in interdisciplinary teams. An important theory of design that takes knowledge as its focus is Simon’s theory of problem solving but this theory has also received strong criticism, for example with Schön’s theory of reflective-practice and Rittel’s argumentative model of design. Reflection and argumentation present useful theories of knowledge in design, but since Rittel’s model is more explicitly concerned with group work than Schön’s, then Rittel model presents a potentially more promising point of departure to investigate collaboration in interdisciplinary design teams. However, to proceed in the careful and critical manner appropriate for scholarly research, first we needed to understand the form of argumentation that underpins Rittel’s model.

In this chapter I have explored the philosophical assumptions that underpin logical, dialectical, and rhetorical argumentation and I considered corresponding examples of models of design thinking and action. First, we saw that the logical model of design aims to demonstrate the most optimal sequence of transformations that will change a problem state into a solution state. The focus is on rationally demonstrating that the product of the sequence of transformations is valid due to the form of its proof. Second, from the perspective of dialectic, problems are not self-evident facts but controversial social issues that cannot be abstracted from their context. The way the issue is framed always reflects particular stakeholders’ worldviews, and so, designing should maximize the participation of all those who are affected by the issue to address the conflicting worldviews of the participants. The focus is on providing a procedure to reveal the value judgments that underpin different participants’ proposals, to support critical discussion to resolve the difference of opinion. Third, the rhetorical model of design concerns the process to achieve the purposes of the
design activity within a given context. The process involves, not only propositions or explicit statements, but all available means of persuasion within a situation. The rhetorical process focuses on the communicative context and the meaningful interactions between the design team and stakeholders to support joint commitment to practical and ethical action.

This investigation of the theory and philosophy of argumentation indicates that Rittel's model of design is underpinned by a dialectical type of argumentation in the form of a critical discussion. Rittel's model portrays design activity as an exchange of speech where one party tries to convince the other of their position on an issue. The design rationale management tools he outlined perform the normative and critical dimension of the dialectical aspects of Rittel's model. In Rittel's dialectical theory, collaboration in design activity is addressed by regulating the procedure within which the participants interact rather than by developing methods for logically justifying the validity of a solution to a problem or articulating the substantive content of rhetorical process of the participants' interactions. Furthermore, Rittel states that his model does not oppose logical design methods; in fact they may contribute essential aspects within the argumentative procedure:

... in the course of dealing with an issue many of the tools of the first generation [i.e. logical design methods] may become tools, used to support or attack any of the positions taken. You might make a cost-benefit study as an argument against someone else's deontic statements, or you might use an operations research model in order to support a prediction or argue against somebody's prediction. However, I wouldn't say that the methods are the same just in a different arrangement and with a different attitude, but there are some methods particular to the second generation [i.e. dialectical design methods], and these are in particular the rules for structuring arguments, and that these are new, and not in the group of methods developed in the first generation. (Rittel, 1984, p. 321)

By revealing that dialectic underpins Rittel's argumentative model of design, we can better understand what is at stake in Rittel's model within a general theory of argumentation. A particular strength of Rittel's model is that it points to new subjects of design methodology. Rittel's insight is to expand the scope of design methods from justifying the validity of a proposal to taking the procedure of participation within teamwork itself as a focus of design thinking and action. However, I argue that since Rittel's model describes a procedure rather than a process, it does not fully account for the substance of collaborative design activity. To more deeply investigate the substantive process of collaboration in interdisciplinary design teams means also taking the aspects of rhetorical argumentation into account. As we have seen, rhetoric, like dialectic, is concerned with forming judgments about controversial issues, but unlike dialectic its concern is not with formulating rules to regulate the collaborative
procedure, rather its approach is concerned with the process of collaboration in terms of the substance of the participants’ interactions within a particular communicative context.

3.4.1 Informal Interactions

My concern in this investigation is with the process of collaborative design, and I hypothesize that to investigate the process means to investigate the substantive content of participants’ interactions within their communicative context. However, it follows that, since substantive interactions are context dependent, they are difficult to fully specify in advance. In this sense, I suggest that those interactions that can be specified and scheduled are formal interactions, and those the concern substantive interactions that are context dependent are informal interactions. Design methods developed from formal situations are different from methods developed from informal situations, and the formal should not be applied to the informal. In the past, studies concerning the design process have investigated the design process in formal contexts (meetings, brainstorming sessions, concept evaluation sessions) often in laboratory settings and focussing on relatively simple design problems rather than wicked problems. Where these studies have formed the basis for developing support for design activity, the support that is developed is appropriate for those formal contexts rather than informal situations. Most existing design methods, where they were based on research at all, were based on research that investigated formal situations, and this shows that development of support for informal aspects of the design process is under-researched. The distinction between formal interactions and informal interactions parallels the continuum of difference between formal communication and informal communication as illustrated in Table 1.

Table 1

The Formality Dimension of Communication

<table>
<thead>
<tr>
<th>Formal Communication</th>
<th>Informal Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheduled in advance</td>
<td>Unscheduled</td>
</tr>
<tr>
<td>Arranged participants</td>
<td>Random participants</td>
</tr>
<tr>
<td>Participants in role</td>
<td>Participants out of role</td>
</tr>
<tr>
<td>Pre-set agenda</td>
<td>Unarranged agenda</td>
</tr>
<tr>
<td>One-way</td>
<td>Interactive</td>
</tr>
<tr>
<td>Impoverished content</td>
<td>Rich content</td>
</tr>
<tr>
<td>Formal language &amp; speech register</td>
<td>Informal language &amp; speech register</td>
</tr>
</tbody>
</table>
According to Kraut et al. (1990):

At the heart of what we term informal communication is its ad lib nature. Conversations take place at the time, with the participants, and about the topics at hand. None of these characteristics - timing, participants, or agenda - is scheduled in advance. Moreover, during its course the communication changes to take into account the participants' current interests and understandings. In this sense, informal communication is truly interactive, with all participants in the communication being able to respond to what they perceive to be the current state of affairs, including the communication up until that point and their perception of the other participants' reactions to it. Through this feedback mechanism, informal communication can be more effective than formal channels, as participants in the conversations elaborate or modify what they have to say in order to deal with someone else's objections or misunderstandings. (pp. 148-149)

Since there is overlap and integration between dialectic and rhetoric, I will use the term formal to refer to those aspects that concern demonstration and logical design methods and informal to refer to those aspects of collaborative design activity that involve the dialectical discussion and rhetorical interactions that concern the substantive meaningful content of the design process. Consequently, this research project aims to investigate collaboration in interdisciplinary design teams by addressing two research questions. The primary research question is What is the significance of informal interactions in collaborative design activity? However, to address this research question I will first need to address the broader secondary question How do people in collaborative design teams interact?

### 3.5. Conclusion

In this chapter I examined the philosophy of argumentation as logic, dialectic, and rhetoric, and their respective models of collaborative design as problem solving, second-generation design methods, and fourth order design thinking, to reveal the assumptions that underpin the argumentative model of design. I identified the dialectical basis of Rittel's second-generation design methods and discussed some of the limitations. I then identified the research questions that motivate the fieldwork portion of this study.

The following chapter describes the framework that underpins the epistemology, theoretical perspective, methodology, and particular methods used to collect and analyse data: namely objectivism, post-positivism, DRM design research methodology, interview, observation, and constant comparative method.
This research project is situated within the discipline of design and the research tradition of design methodology (Cross, 1984; Dorst, 2008). The aim of design methodology is to single out the activities and operations performed by designers when they act qua designers and state clear definitions of those activities (Gasparski, 1993, p. 171). The premise of this tradition is that we need to understand what designers do to develop support for design activity. Together these two aspects achieve the aim “to make design more effective and efficient in order to enable design practice to develop more successful products” (Blessing & Chakrabarti, 2009, p. 5).

Research in design methodology has frequently utilised laboratory-based observation and protocol analysis techniques to study design activity (Cross et al., 1996). While protocol analysis is a valuable research method, it has limitations for studying collaborative design activity due to the realism of the types of problems that can be solved within a laboratory environment within a few hours. Recently, ethnographic techniques have emerged as practical approaches to studying the complexity of professional collaborative design work in industry (Arias et al., 2000; Bucciarelli, 1994; Catledge & Potts, 1996; Hughes et al., 1992; Olson et al., 1992; Sonnenwald, 1996; Vinck & Blanco, 2003). Studies such as these provide insight into the complex combinations of interacting activities of people working together, which complements the knowledge developed through other research methods.

Traditionally, accounts of design activity have been based on two different types of studies: descriptive studies and prescriptive studies. Accounts of design activity constructed from descriptive studies are based on descriptions of what designers do. For example, how designers act and perform, but also their attitudes and cognition, their characteristics such as
their level of expertise, the artefacts they use, and the social and physical environments they work in. Prescriptive studies of design activity present cases for what designers should do. Historically, the first prescriptive studies tended to be derived from reasoning from first principles or from individual professional experience. Descriptive studies aim to develop knowledge about design activity; prescriptive studies aim to develop knowledge for design activity. Because descriptive studies and prescriptive studies have different aims they use different procedures, strategies, and criteria to develop knowledge. But since there are many different approaches to doing design research, a framework is needed to make appropriate decisions that link particular procedures, strategies, and criteria to particular aims. This chapter describes the framework that underpins the epistemology, theoretical perspective, methodology of this research project, and details the particular methods used to collect and analyse data.

4.1. Design Research Programmes

There are many different ways in which the relationship between aims and knowledge is raised in the design research literature and many useful answers have been given. However, the significance of these answers can be difficult to establish because their terms of reference are often unclear. A framework that organises the epistemological aspects of design research approaches is needed to make meaningful distinctions between the different positions. A large number of different terms have been used to refer to the research process in the field of design, and these terms are often used synonymously as methodologies, approaches, perspectives, or philosophies, as if they are all comparable (Niedderer & Roworth-Stokes, 2007, p. 7). To make meaningful distinctions between the different positions and make their respective epistemological assumptions explicit, a structured knowledge framework is needed. Michael Crotty (1998) in his book *The Foundations of Social Research: Meaning and Perspective in the Research Process*, frames the research process as composed of four basic elements: epistemology, theoretical perspective, methodology, and methods. These elements provide a structure to understand the research process and give a ground from which to identify the assumptions about the world that are embedded within the methods used to do research. Crotty (1998, p. 5) defines the meaning of each element as follows:

- **Epistemology**: the theory of knowledge that defines what kind of knowledge is possible and legitimate.
Theoretical perspective: the philosophical stance informing the methodology and thus providing a context for the process and grounding its logic and criteria.

Methodology: the strategy, plan of action, process or design lying behind the choice and use of particular methods and linking the choice and use of methods to the desired outcomes.

Methods: the techniques or procedures used to gather and analyse data related to a research question or hypothesis.

According to Crotty (1998, p. 5), the hierarchical nature of the structure determines that the assumptions embedded in the primary element inform each subsequent element. For example, research conducted using the data collection method of participant observation is one of many methods embedded within the methodology of ethnography, which itself has been adapted by symbolic interactionism, which is one of many theoretical perspectives which exemplify a constructionist epistemology. It follows then that in this example, the assumptions about how we know what we know that are embodied by the theory of knowledge within constructionist epistemology are also embodied within the findings developed from data collected through the method of participant observation. Crotty’s framework usefully connects the theory of research to the practice of research, places the opposition of quantitative and qualitative procedures at the level of methods, reveals the assumptions that underpin particular research models, and identifies the limits of their generalizations.

Crotty’s framework situates theoretical perspectives, methodologies, and methods within objectivist, constructionist, or subjectivist epistemology. An exhaustive discussion of the differences and implications of each of these three epistemological stances is beyond the scope of this research project, however, it is useful for our purposes to outline the most important aspects. Crotty (1998, p. 7) states:

- Objectivist epistemology holds that a meaningful reality exists independently of consciousness and experience, that entities carry intrinsic meaning within them as objects, and that we can discover this “objective truth” if we carefully go about it in right way.
- Constructionist epistemology rejects the view that there is objective truth waiting to be discovered. Rather truth and meaning are constructed out of the engagement of our minds with the world. The constructionist stance maintains that different people may construct meaning in different ways, even in relation to the same phenomenon, such as between those in different eras or cultures.
- Subjectivist epistemology maintains that meaning is imposed by people’s minds without the contribution of the object. This implies that what is perceived is what is real, and that there is no underlying true reality that exists independently of perception.
However, while Crotty’s knowledge framework appears to suggest clearly defined distinctions between the three epistemological positions, it is important to recognize that within each position there are stronger and weaker versions. For instance, phenomenological research is categorized as constructionist; however, phenomenological research can encompass approaches that range from thoroughly objectivist to thoroughly subjectivist epistemology. Consequently, it is important to note that each epistemological position represents a spectrum of similar approaches rather than a discrete, homogenous class.

There are a large number of research methods and corresponding epistemological commitments available to researchers in design, and many of the most significant articles in the literature seek to outline various models for the different possibilities. Some try to present total pictures of the breadth of design research: all take particular epistemological stances. In the following sections I examine three examples of approaches to design research to illustrate objectivist, constructionist, and subjectivist epistemological approaches to design research. The analysis of the authors’ work I present is meant to illustrate the aspects of the particular epistemological position rather than provide a comprehensive account of the depth and breadth of the authors’ work.

4.1.1. Objectivism

Friedman’s (2003) argument for theory construction in design research takes knowledge to be the core of research. For Friedman (2003, p. 512), knowledge is articulated through systematic inquiry organised in theory and research provides the collection of methods that allows us to construct theories. Friedman (2003) states:

Critical thinking and systemic inquiry form the foundation of theory. Research offers us the tools that allow critical thinking and systemic inquiry to bring answers out of the field of action. It is theory and the models that theory provides through which we link what we know to what we do. (p. 512)

According to Friedman (2003, p. 513), a theory in its most basic form is a model that describes how something works by showing the relationship between its elements. Theories develop in a pattern of increasing sophistication in terms of their degree of systematization and level of generalization. Drawing on Parsons and Shils (1962), Friedman (2003) outlines a hierarchy of theoretical types that moves from

… ad hoc classification systems (in which categories are used to summarize empirical observations), to taxonomies (in which the relationships between the categories can be described), to conceptual frameworks (in which propositions summarize explanations and
predictions), to theoretical systems (in which laws are contained within axiomatic or formal theories). (p. 518)

Friedman (2003, p. 520) argues that the bases of theory construction in all disciplines are empirical facts and explicit articulate statements, because those who cannot observe facts cannot theorize them, and explicit articulation allows us to compare, share, and reflect on the theories we develop. Comprehensive and parsimonious theory allows us to frame and organise our observations to develop generalizable answers that can be used by human beings in other times and places (Friedman, 2003, p. 213). Friedman (2003, p. 521) maintains that theory is a tool that allows us to question what we see and what we do, and to make the changes we need to reach our goals.

I argue that the approach to design research that Friedman presents is underpinned by a moderate version of objectivist epistemology. For example, Friedman’s method of construction of theoretical models based on empirical facts with the aim of prediction and explanation separates the activities of the researcher from facts that they observe. Separating knowledge from the researcher indicates that Friedman’s approach to theory construction should be positioned towards the objectivist end of the epistemological spectrum. However, Friedman’s emphasis on the necessity of critical thinking leaves room for the role of interpretation in building knowledge, therefore, I claim that his theoretical perspective is closer to post-positivism than positivism, and should be considered a version of objectivism that is more closely positioned towards the constructionist end of the objectivist epistemological spectrum.

4.1.2. Constructionism

Cross (1999), building on Archer’s (1995) definition of research as “systematic enquiry whose goal is communicable knowledge” (p. 6), defines design research as the “development, articulation and communication of design knowledge” (p. 5). According to Cross (1999), design knowledge is found in people, processes, and products. Furthermore, design knowledge corresponds to three design domains:

- **Design epistemology**: The study of designerly ways of knowing. Cross maintains that design is a natural human ability that includes both vernacular design as well as professional design. Design knowledge of how people design can include both empirical studies of design behaviour, theoretical deliberation on how people learn and develop design ability, and also how to teach it.
• *Design praxiology*: The study of practices and processes of design. Cross defines design processes as tactics or strategies. Design knowledge in this domain involves the process of design, development, and application of techniques.

• *Design phenomenology*: The study of the form and configuration of artefacts. This domain studies the implicit knowledge embodied in precedents and exemplars of profession and vernacular design. This form of design knowledge also concerns relation between products and context in terms of semantics, ergonomics, and environment.

Cross maintains that the domain of design knowledge that will be most helpful to design practice and design education is the study of *designerly ways of knowing*. Cross (2001, p. 54) defines this knowledge domain within the theory of reflective practice developed by Schön (1983). Accordingly, Cross’s approach to researching designerly ways of knowing encompasses procedures and techniques that gain understanding through making and reflecting upon the making of artefacts, and through using and reflecting upon the use of those artefacts.

As we saw in chapter two, Schön describes reflective practice as a reflective conversation with the situation, that is, the interaction between the designer’s intentions and the context at hand through the process of on-the-spot-experimenting within individual *design worlds*. According to Schön (1988):

> The idea of design worlds is inconsistent with an *objectivist* point of view, according to which things are what they are independent of our ways of seeing them. On this view, it is difficult to explain how different designers see things differently, have trouble talking with each other about them, and take radically different approaches to design. But design worlds are consistent with a *constructionist* perspective like Goodman’s where miscommunication, novelty, and diversity of approach are exactly what we would expect. From a constructionist perspective, the seeming objectivity of a consensual design world is not a given but an achievement, a product of the work of communicative inquiry. (p. 183)

Because Cross’s method of researching designerly ways of knowing is underpinned by Schön’s account of reflective practice, therefore the “knowing” this procedure produces is developed from the engagement of the designer's mind and the world. Therefore, I argue that we should consider Cross’s study of designerly ways of knowing within the constructionist epistemological spectrum. However, Cross also argues that design practice on its own does not constitute research unless it also involves reflection on the work and communication of results. With this qualification in mind, we should position Cross’s approach towards the objectivist end of the spectrum of constructionist design research approaches.
4.1.3. Subjectivism

Following the philosophy and sociology of science of Paul Feyerbend and Harry Collins, Frayling (1993, p. 3) defends the criticism of the stereotype of scientific research as positivist or critical rationalist. Instead, he maintains that the practice of doing science does not resemble its white coated laboratory stereotype and in fact “involves irrationality, craftsman’s knowledge rather than propositional knowledge” and a “significant measure of subjectivity” (Frayling, 1993, p. 3). Consequently, he argues that there is a lot of common ground between scientific research and the work of artists, craftspeople and designers. Frayling (1993) defines research with a small r, from the Oxford English Dictionary as “the act of searching, closely or carefully, for or after a specified thing or person” and elaborates, “it isn’t about professionalism, or rules, or guidelines, or laboratories” (p. 1). In contrast, he associates research with a big R with the professionalization of research in the university sector and chemistry industry. He maintains that examples of the cognitive tradition of research with a small r can be found in the last four hundred years of art practice and gives the examples of Leonardo’s drawings of anatomy, George Stubbs’ paintings of animal anatomy, John Constable’s painting of cloud formations, Pablo Picasso’s use of reference materials and memories in the painting Les Demoiselles d’Avignon, op artists’ explorations of perception, “computer artists” and “artists as semiologists” (1993, p. 3). Frayling (1993, p. 5) describes three types of research with a small r:

- **Research into art and design:** Historical research, aesthetic or perceptual research, and research into social, economic, political etc. theoretical perspectives on art and design.
- **Research through art and design:** Materials research, development research and action research. This type of research involves a studio project, a diary and a report, where the “diary tells, in a step-by-step way, of a practical experiment in the studios, and the resulting report aims to contextualise it” (Frayling, 1993, p. 5).
- **Research for art and design:** “Research where the end product is an artefact—where the thinking is, so to speak, embodied in the artefact, where the goal is not primarily communicable knowledge in the sense of verbal communication, but in the sense of visual or iconic or imagistic communication.” (Frayling, 1993, p. 5).

By associating design with personal, tacit, non-verbal, embodied, craftsman’s knowledge and works of fine art, Frayling clearly rejects objectivity of knowledge and defends the place of personal knowledge within design research. Because Frayling’s approach accommodates artistic procedures through which the researcher embodies their feelings and ideas within artefacts, meaning is imposed by the artist’s mind rather than, for example discovering facts
within the environment, therefore we can position Frayling’s approach to research towards the subjectivist end of the epistemological spectrum.

4.1.4. Implications

The significance of acknowledging the differences between the aspects of these epistemologies is twofold. First, it connects the theory of research to the practice of research and reveals the limits of truth claims in terms of objectivity, validity, and generalizability. Second, Crotty’s model emphasizes the necessity of remaining epistemologically consistent. Objectivist research must distinguish scientifically established objective facts from people’s everyday subjective meanings. Consistently constructionist research must place all meanings, scientific and non-scientific on an equal basis—they are all constructions, and none is truly objective or generalizable. The further one moves towards subjectivism, the greater the limits of the objectivity, validity, and generalizability of one’s claims (Seale, 1999, p. 469). Epistemological awareness requires that at each point in the research process we recognize that we make a variety of assumptions about human knowledge, the realities encountered in the human world, and the interpretability of our findings.

I argue that the three models of design research presented also contain implicit characterisations of the nature of design activity. Frayling’s model assumes the designer is an individual craftsman. For Cross, the designer is a reflective practitioner who attempts to understand the meaning of their design work. Friedman’s designer is a professional knowledge worker who addresses problems in a variety of domains. The three models characterise designing as craftwork, reflective practice, or knowledge creation. The craftsman’s approach concerns directly making objects; reflective practice focuses on designing as a learning process; knowledge creation is a strategic approach to theory construction.

As we saw in chapter two, the object-centred approach grows out of the guild tradition, which builds knowledge through the transfer of a rich stock of tacit knowledge embodied in the skills and techniques passed down from the master to the apprentice through many years of ritual and imitation. This tradition produces a form of habituated know-how that allows the individual craftsman to respond intuitively to specific situations. Furthermore, recent ethnographic research into modern design practice has revealed that designers do not work as lone creative geniuses, more often designers work collaboratively in interdisciplinary teams (Arias et al., 2000; Bucciarelli, 1994; Chiu, 2002; Guinan, 1986; Lauche, 2005; Minneman,
This change in design practice implies that it is likely that the object-centred approach to design assumed in Frayling’s subjectivist model of design research may no longer fully represent the reality of professional design practice.

Furthermore, focusing on craft objects and personal expression short-circuits the knowledge building cycle between research and practice. Unless research develops knowledge that can be tested, applied, and reflected on by other people in other times and places, it creates a gulf between research and practice, and reduces design to concerns with surface aesthetics. Subjectivist design research is based on the mistaken idea that design practice is opposed to the application of systematic methods and the erroneous belief that systemic inquiry is at odds with creativity. These factors contribute to limiting design practice to unique cases and the simple repetition of past knowledge. To move beyond ad hoc approaches to collaborative problem solving, research and theory is needed that develop broad explanatory principles that can meet complex, large-scale needs in comprehensive, sustainable, cost-effective, predictable, and measurable ways (Archer, 1984, p. 347).

4.1.5. Progressive Research Programmes

Epistemological positions reveal assumptions in terms of powers of generalization, but also locate the research in either isolationist or situated relationships with other disciplines (Biggs & Buchler, 2008, p. 6). The isolationist position claims that design research is somehow special and should be granted special criteria and regulations. In contrast, the situated position maintains that because design is positioned in a comparative competitive environment, it must place itself in relation with its peers by finding commonalities with the academic community as a whole. Presumably, by arguing that craftwork is research, Frayling (1993, p. 5) separates design research from established paradigms of research, and therefore, his model of research takes the isolationist position. Cross’s emphasis on individual reflective practice would also appear to place his model of design research within the isolationist position; however, Cross (2001, p. 55) explicitly acknowledges that the design discipline must embed itself within the intellectual tradition of the university and demonstrate standards and criteria match those of the other disciplines. This model takes the situated position. Friedman’s (2003, p. 520) model of theory construction based on explicit statements as the basis of research in all disciplines clearly aligns his approach with the situated position.
University disciplines support professions by providing analytical tools to question assumptions and by developing generalized explanations, principals, and theories that can be put to use by people in other times and places. Disciplines work by building knowledge within the domains of their inquiry by scaffolding new knowledge on previous knowledge though criticism, application, and reflection. This process requires a cycle between tacit and explicit knowledge (Friedman, 2001; 2003, p. 520; Nonaka, 1994; Nonaka & Konno, 1998; Wenger, 1999). Because tacit knowledge is embodied in craft practices and habitual behavioural patterns, it must be converted into articulate statements to allow the construction of theories that can be shared, contrasted, tested, and reflected upon. Generating empirical evidence and developing generalizable answers allows designers to address timely problems rather than repeat past mistakes (Poggenpohl, 2009, p. 14). Building a rich stock disciplinary knowledge is essential to design because it forms the foundation from which collaboration can proceed.

In the next section I describe the details of the framework that underpins the research design of this investigation, and justify the data collection and analysis methods used to conduct the fieldwork and interpret the findings.

4.2. Research Framework

While there are many different possible research approaches—each with their corresponding epistemological assumptions—the specific questions, aims, and objectives of the research project entail that particular research designs may be more appropriate than others. In Crotty’s scheme, methods are chosen within a methodology, which is chosen according to a theoretical perspective and before that an epistemology. But this implies that researchers choose an epistemology first, which in fact, in the actual everyday practice of research, may not always be the case. Rather methods might be chosen that “feel” appropriate or generate “useful” results, and the methodology, theoretical perspective, and epistemology may emerge as the research develops. However, with this qualification in mind, utilising Crotty’s knowledge framework, and foregrounding the discussion of the approach to this research, we can outline the research design of this project as follows:

- **Epistemology:** Objectivism
- **Theoretical perspective:** Post-positivism
- **Methodology:** DRM design research methodology
- **Methods:** Interview, observation, constant comparative method
4.2.1. Epistemology: Objectivism

The epistemology that underpins this research project is objectivism. According to Crotty (1998) “objectivist epistemology holds that a meaningful reality exists independently of consciousness and experience, that entities carry intrinsic meaning within them as objects and that we can discover this objective truth if we carefully go about it in right way” (p. 7). In this view, research uncovers facts that tell us about what sorts of mechanisms and processes exist in the world, and the relations between them (Gaspar, 1990, pp. 292-293). Furthermore, causal relations between facts are irreducible features of the world that we can learn about through empirical research.

Explanation is the search for systematic factors operating in the world. A theory illustrates the relationship between factors and predicts what happens when they interact. Accurate prediction is convincing evidence in favour of a theory. The choice between competing theories can be based on their explanatory power. When a theory introduced to explain one phenomenon, explains another independent phenomenon that is evidence that it is an accurate description of the world. The best explanation of a theory’s success is that the mechanisms and events that it postulates actually exist or closely resemble what actually exists.

4.2.2. Theoretical Perspective: Post-positivism

The theoretical perspective of this investigation is post-positivism. Popper, the founder of post-positivism, supported Hume’s argument that the justification of scientific theories cannot be verified by any finite accumulation of observational evidence, instead Popper argued that scientific theories can be observationally falsified and that empirical falsification is the criterion of demarcation of scientific theories (Suppe, 1974, p. 167). Popper also rejected the logical positivist approach to scientific knowledge because, in his view, the formulation of logical artificial language systems has no bearing on what actually happens in the practice of science, and therefore, it misses the central problem of the philosophy of science: the growth of scientific knowledge (Suppe, 1974, p. 167).

Popper argued for an evolutionary theory of the growth of scientific knowledge based on a process of conjecture and refutation. In Popper’s view, science starts with problems rather than with observations, because it is only within the context of grappling with a problem that the scientist makes observations in the first place. The purpose of observation and experiment is to test the extent to which a theory functions as a satisfactory solution to a
given problem (Thornton, 2009). According to Popper, scientific discovery is guided by theory, rather than theories being discoveries due to observation. Since theories can only be falsified and not confirmed, Popper argued that science should aim to subject as wide a variety of theories as possible to empirical falsification. Indeed it is this proliferation of theories which is responsible for the growth of scientific knowledge, and therefore, science should not be dogmatically tied to single theories but ought to be an open research community (Suppe, 1974, p. 170).

While Popper is considered a founder of post-positivism, the theoretical perspective of this research project draws on the post-positivist methodology of scientific research programmes developed by Popper’s student Imre Lakatos (1973; 1970). In Lakatos’s version of post-positivism, progressive research programmes build knowledge through the prediction of novel facts rather than by Popper’s theory of refutation by crucial experiments. Lakatos (1973) states:

The hallmark of empirical progress is not trivial verifications: Popper is right that there are millions of them. It is no success for Newtonian theory that stones, when dropped, fall towards the earth, no matter how often this is repeated… [But] so-called ‘refutations’ are not the hallmark of empirical failure, as Popper has preached, since all programmes grow in a permanent ocean of anomalies. What really count are dramatic, unexpected, stunning predictions: a few of them are enough to tilt the balance; where theory lags behind the facts, we are dealing with miserable degenerating research programmes. (para. 24)

I argue that the research tradition of design methodology should be conceptualised as a research programme in the Lakatosian sense. I agree with Lakatos’s position that the growth of scientific knowledge is not driven at the level of individual theories but rather at the level of research programmes. Moreover, I argue that Lakatos’s identification of progressive research programmes as those that construct theories that predict novel facts, is most closely aligned with Friedman’s epistemological position and his approach to theory construction in design research. Friedman (2003) states:

Systematic or scientific knowledge arises from the theories that allow us to question and learn from the world around us… To serve successfully demands an ability to cause change toward desired goals. This, in turn, involves the ability to discern desirable goals and to create predictable—or reasonable—changes to reach them. Theory is a tool that allows us to conceptualize and realize this aspect of design. (p. 521)

However, design methodology is still an emerging research programme compared to those in other disciplines. Furthermore, there is a gap within the field of design between the discipline of design and the profession of design. In science, the discipline and the profession are more closely aligned. Because much of the work in the design profession is still object-centred,
theory construction is needed to support designers to contrast, test, consider, share, and reflect on the theories they develop. Lakatos (1973) echoes this situation when he states:

One must treat budding programmes leniently: programmes may take decades before they get off the ground and become empirically progressive. Criticism is not a Popperian quick kill, by refutation. Important criticism is always constructive: there is no refutation without a better theory. (para. 26)

Because design methodology is still an emerging field, closer consideration of the knowledge creation cycle between the discipline and the profession is needed. Accordingly, Friedman (2001) argues:

The goal is a full knowledge creation cycle that builds the field and all that practice in it. Practice tends to embody knowledge. Research tends to articulate knowledge. The knowledge creation cycle generates new knowledge through theorizing and reflection both. (p. 23)

I address this knowledge creation cycle between the discipline of design and the profession of design through accomplishing this research using Blessing and Chakrabarti’s (2009) DRM Design Research Methodology. DRM design research methodology incorporates two aspects of the knowledge creation cycle needed for the development of a progressive design research programme: first, the formulation and validation of theory and models about design activity; second, the development and validation of support founded on those theories and models.

4.2.3. Methodology: DRM Design Research Methodology

DRM design research methodology is a research methodology developed by Blessing and Chakrabarti (2009) that is specifically tailored to design research. This methodology incorporates two types of studies; descriptive studies that develop understanding about design activity, and prescriptive studies that develop support for design activity. This involves the formulation and validation of theory and models about design activity and the development and validation of support founded on those theories and models. Because DRM design research methodology connects particular descriptive studies to particular prescriptive studies it engages a full knowledge creation cycle.

DRM design research methodology has four stages: Research clarification (RC), descriptive study 1 (DS-1), prescriptive study (PS), and descriptive study 2 (DS-2). The research clarification (RC) stage involves an initial literature search to formulate a realistic research goal. In the descriptive study 1 (DS-1) stage the researcher conducts empirical research to understand the influencing factors and to accurately describe the existing situation. In the prescriptive study (PS) the researcher uses their increased understanding of
the existing situation to elaborate a description of a desired situation. They identify which factors are most likely to lead to changing the existing situation into the desired situation and develop initial support to do this. The initial support is evaluated and then an actual support is developed. The descriptive study 2 (DS-2) involves the evaluation of the effectiveness of the actual support. It is important to note that the four stages of DRM design research methodology should not be interpreted as a fixed, rigid, linear sequence; rather they form a plan that underpins a research process that, in reality, involves many iterations and parallel execution of stages.

The stages of DRM design research methodology presented in the outline above are all essentially comprehensive; however, specific research projects may not undertake each stage in depth depending on time and resources available. In different cases, a stage may be review-based, comprehensive, or initial. Review-based means only a review of the literature is required. A comprehensive study involves a literature review and an empirical study. An initial study addresses the first few steps of a stage to indicate avenues for further research. Within these limits there are 7 variations of DRM design research methodology. The variation of DRM design research methodology undertaken in this dissertation is type 2: a review-based research clarification stage, a comprehensive descriptive study 1 stage, and an initial prescriptive study stage. According to Blessing and Chakrabarti (2009, p. 19), due to the time and resources required for all stages to be completed in depth, type 2 or type 3 DRM studies are the most common for doctoral research.

We have considered the theoretical framework that informs this research in the previous section, namely objectivism, post-positivism, and DRM design research methodology. Now I will detail the methods through which evidence was gathered.

4.2.4. Methods

Qualitative research is often used to explore new areas and is therefore widely used in design research. However, basing a claim on qualitative data only has a pitfall similar to naive psychology; the wrongful assumption that results can be generalized over a larger group of people. Often qualitative research is done with a small sample of people, because often the size of the sample is determined to be enough once particular topics or themes start to repeat themselves. After all, often the aim of qualitative research is simply to explore new information and identify factors of interest. Accordingly, there is a relatively large chance for sampling error to occur—the sample is not representative of the population. This chance of
sampling error is especially of concern when dealing with complex human behaviour and when the aim is to use acquired knowledge and implement it into designs to be used by people.

Quantitative research, on the other hand, tries to resolve the problem of sampling error through choosing large enough samples and choosing them wisely. Therefore, results based on quantitative are more safely generalized. However, quantitative research aims to test hypotheses derived from theory and fundamental knowledge and are often very singular—testing one independent and one dependent variable only—and the theory or knowledge needed to construct relevant hypotheses within the design discipline often does not exist. Hence, both qualitative and quantitative research approaches have their positive contributions to design knowledge: qualitative research identifies factors relevant to specific contexts and quantitative research makes it possible to create design claims with a understanding of their certainty.

However, both approaches also have potential pitfalls. Basing design claims on qualitative data may not address the actual needs of users and quantitative research cannot be performed where there is a lack of specific fundamental knowledge relevant to the area of design to base hypotheses on. Accordingly, methodologies that focus only on qualitative research, such as interviews and focus groups, or quantitative research, such as questionnaires and experiments do not suffice. This conclusion is consistent with Norman’s (2010) assertion that new research approaches should be developed within the design discipline that aim to answer the specific research questions that concern designers. Consequently, I claim that a mixed method research design can provide a comprehensive way for designers to do research relevant to their discipline.

Mixed method research refers to the use of both qualitative research and quantitative research within one research design to answer the same research question. Different approaches within mixed method research can be distinguished based on either priority or implementation of data collection (Creswell, 2003; Lopez-Fernandez & Molina-Azorin, 2011; Morgan, 1998; Morse, 1991; Onwuegbuzie, Johnson, & Collins, 2011; Tashakkori & Teddlie, 1998). In essence, priority can be given to either qualitative or quantitative research or equal weight can be placed on both within the research design. Implementation of data collection refers to the choice to either collect or interpret qualitative and quantitative data concurrently or sequentially. The major mixed method designs derived from combinations of these two
factors are: triangulation, embedded, explanatory, and exploratory (Creswell, Plano Clark, Gutmann, & Hanson, 2003).

Triangulation occurs when both qualitative data and quantitative data are interpreted simultaneously to provide more reliable results. Embedded research seeks to clarify the results obtained with one type of research with the other type of research. This can happen either sequentially or concurrently and the choice of which one is used to clarify the other depends on the research question. In an explanatory design a quantitative research phase is followed by a qualitative phase whereby the qualitative results explain the quantitative results. The quantitative phase informs the questions or sampling of the qualitative phase (Creswell, 2003; Creswell et al., 2003). Exploratory designs start with qualitative research and those findings are subsequently validated by quantitative results. Typically, the factors or outcomes identified in the qualitative phase are applied to a larger and more diverse sample in the quantitative phase (Creswell et al., 2003). This latter approach is often employed in relatively unstudied areas (Borrego, Douglas, & Amelink, 2009).

4.2.4.1. Data collection
Sanders (2002) maintains that researchers can access people’s experiences from three different temporal perspectives: their memories, their current experiences, and their ideal experiences. These types of experiences are revealed by listening to people express what they say and think through words; by watching what people do and seeing what they use; and by accessing what people know, feel, and dream through empathic techniques. These three types of experience can be summarised as being expressed through what people say, do, and make.

Each of the three modes of expression outlined offer a different perspective on the phenomenon being investigated and each mode of expression is approached using different research methods. This project utilises interviews to access designers past experiences of collaboration, and observation to account for what designers do while undertaking collaborative work. I interviewed professional designers about collaborative design and conducted three case studies that investigated interdisciplinary collaboration in industrial design, architecture, and design research. Table 2 provides general overview of the respondents’ profiles, including their pseudonym, professional discipline, and expertise level.
Table 2

Respondent Profiles

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Professional Discipline</th>
<th>Expertise Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andrew</td>
<td>Software Design</td>
<td>Expert</td>
</tr>
<tr>
<td>Fiona</td>
<td>Design Research</td>
<td>Competent</td>
</tr>
<tr>
<td>Helen</td>
<td>Exhibition Design</td>
<td>Competent</td>
</tr>
<tr>
<td>Jeff</td>
<td>Design Research</td>
<td>Competent</td>
</tr>
<tr>
<td>Mark</td>
<td>Industrial Design</td>
<td>Expert</td>
</tr>
<tr>
<td>Dennis</td>
<td>Industrial Design</td>
<td>Expert</td>
</tr>
<tr>
<td>Lucy</td>
<td>Graphic Design</td>
<td>Competent</td>
</tr>
<tr>
<td>Anthony</td>
<td>Industrial Design</td>
<td>Expert</td>
</tr>
<tr>
<td>Vincent</td>
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<td>Competent</td>
</tr>
<tr>
<td>Nathan</td>
<td>Design Thinking</td>
<td>Expert</td>
</tr>
<tr>
<td>Sonja</td>
<td>Illustration</td>
<td>Competent</td>
</tr>
<tr>
<td>Stephen</td>
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<td>Competent</td>
</tr>
<tr>
<td>Wendy</td>
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<td>Competent</td>
</tr>
<tr>
<td>Paul</td>
<td>Motion Graphics</td>
<td>Expert</td>
</tr>
<tr>
<td>Chris</td>
<td>Industrial Design</td>
<td>Expert</td>
</tr>
<tr>
<td>Max</td>
<td>Industrial Design</td>
<td>Expert</td>
</tr>
<tr>
<td>James</td>
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<td>Expert</td>
</tr>
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<td>William</td>
<td>Industrial Design</td>
<td>Competent</td>
</tr>
<tr>
<td>Dave</td>
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<td>Expert</td>
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<td>Peter</td>
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<td>Chloe</td>
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</tr>
<tr>
<td>Tim</td>
<td>Design Research</td>
<td>Expert</td>
</tr>
</tbody>
</table>

Table 2 Respondent Profiles

4.2.4.2. Interview

The data collection process started with an interview study that involved interviewing professional designers. I used an open sampling approach to maximize variations in respondents’ experiences and perspectives by approaching designers with different disciplinary backgrounds and professional experiences. Over a three-month period, I conducted semi-structured in-context interviews with fourteen (n=14) experienced professional designers. The average duration of the interviews was one hour, with their length ranging from 45 minutes to two hours. I structured the interviews around a common set of questions concerning sensitising concepts regarding interdisciplinary collaborative design work (see the appendix for a copy of the interview protocol). As key issues arose during the interview, I generated further detail of respondents’ understandings through a
flexible and unstructured approach utilising probing and follow-up questions. I used this semi-structured approach to create a sense of reciprocity and to explore the complexity of the topic as the interview progressed (Mills et al., 2006, p. 9). I recorded the interviews using a digital recording device, and took notes during the interviews. I transcribed the interviews as soon as possible after I recorded them and wrote memos of my immediate impressions, ideas, and theoretical reflections. The fourteen interviews from the initial interview study are grouped together as Case 4: Interview Study. In addition, I used the same interview technique within the case study fieldwork to collect a further thirteen (n=13) interviews. Therefore, the interview dataset consists of twenty-seven (n=27) interviews.

Since the objectives of the study concern the informal aspects of the argumentative model of design, I used the interview method to ask the respondents to describe and reflect upon their professional work experiences rather than test the quantitative frequency or rate of individuals’ interactions. Since the argumentative model of design involves informal interactions that are, for example, substantive rather than analytic, relational rather than isolated, and contextually situated rather than idealised, then I needed to use an interview approach that investigated the designers’ worlds, their experiences and their stories, the way that they organised themselves, their individual and collective relationships, and the social and physical environment that they created for themselves. This approach was necessary to account for the naturally occurring activity of collaborative design work in a way that reflects the ways that knowledgeable insiders perceive their local meaningful context.

Since interview is a data collection method that accesses personal accounts of how particular respondents see the world, it is useful because it allows the researcher to see the world through that participant’s eyes and so gain deep understanding of their point of view. However, since interview data consists of respondents’ reflections on their past experiences, this means that the dataset may contain the unsubstantiated stories people tell about their practice, which could include quite substantial leaps in interpretation of their real practice, as well as repetition of existing theories about what they do. Therefore, to ground the respondents’ stories from the interviews in specific observable situations, I conducted ethnographic case studies of actual collaborative design practice in industry. Using interviews and observation allowed me to support the coherence and depth of the data collection through triangulating the insights across the data collection methods.
4.2.4.3. Ethnographic case study

Ethnographic methods were used to collect and analyse data within three case studies of professional design work in industry. According to Robson (1993), a case study is “a strategy for doing research that involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence” (p. 146). Because interdisciplinary collaboration is inherently complex due to the interaction of different people from different traditions and specialties, case study is an ideal technique because it offers an approach to gathering data without over simplifying the complexity of the situation.

The case studies investigated designers from three different professions in their everyday environment through the observation of their approaches to collaboration. The observations focused on the initial stages of the design process. I made the fact that I was an observer clear to the groups from the start. I observed and tracked the participants’ activities by recording field notes, collecting visual material, participating in design activities, and asking questions to explain various aspects of the activity as it unfolded. Furthermore, I conducted semi-structured in-context interviews with the participants (n=13) from the case studies utilising the same interviewing method as the interviews in the expert interview study.

The ethnographic case studies investigated collaborative design activity in industrial design, architecture, and design research. The aim of this stage of the research was to generate a descriptive study (DS-1) of the substantive aspects of collaborative design activity rather than evaluate a prescription (DS-2), therefore I selected case studies from contrasting milieus and professional backgrounds to maximise the variations in the respondents’ experiences and descriptions.

4.2.4.4. Case 1: Industrial design

The first case concerned the collaboration between a large government department of conservation and a small industrial design company. Three senior industrial designers and one junior industrial designer worked in the company, which produced biodiversity management devices. I immersed myself with the designers and observed their everyday work. I observed the parallel development of projects from initial concept development to redesigning existing devices. Furthermore, I participated in testing prototype devices in remote environments with the designers and staff from the government conservation department. I recorded five interviews with the participants and conducted 60 hours of observation.
4.2.4.5. Case 2: Architecture
The second case study was conducted in a small architectural practice of two senior architects and two junior architects. The architectural practice specialised in residential design and emphasised the design of architecture as both building and a form of cultural production. Here I observed the architects’ everyday work in their design studio from the early stage conceptual design until the presentation of the developed design to clients. I recorded three interviews with the participants and conducted 40 hours of observation.

4.2.4.6. Case 3: Design research
The third case study was undertaken at a large market research agency. I embedded myself within a qualitative research team comprising of three senior researchers and six junior researchers. The team I followed had specialist experience in conducting design research for large multi-national consumer electronics companies and large service design projects. I observed the everyday work of the researchers and followed several projects concerning design research for interaction design, information design, and service design projects. I recorded five interviews with the participants and conducted 100 hours of observation.

4.2.4.7 Triangulation
Interview and observation are data collection methods well suited to studying real-world design activity because of their flexibility to deal with complex situations. However, as with all data collection methods, they are subject to forms of bias. One significant source of bias is the fact that the researcher is the instrument that collects data. Bias may be introduced through selective attention because the researcher observes some aspects at the expense of others. Moreover, the researcher’s expectations might affect what they record. Furthermore, leaving time between the observation and theory construction means that the researcher may only recall particular aspects. In addition, interpersonal factors such as age, gender, or experience may lead the researcher to focus on certain members of the group, which affects their picture of the whole group. However, while these biases cannot be eliminated, I attempted to account for their effects through triangulating the findings across multiple data sources and through observing multiple cases (Robson, 1993; Seale, 1999).

Triangulation uses several methods at once so that the biases of any one method might be cancelled out by those of others (Seale, 1999, p. 473). Because triangulation integrates multiple perspectives it enhances the quality of research projects characterized by different viewpoints (Seale, 1999, p. 475). In this study, I used methodological triangulation by utilising...
interviews and observation, and data triangulation through observing multiple cases. However, it should be noted that I use data triangulation to build findings from one case upon another case rather than to produce statistical generalization. Furthermore, the multi-case approach does not attempt to produce replication of the phenomena under study in the experimental sense, but it does aim to increase coherence and depth.

4.2.4.8. Data analysis

Data collection and data analysis proceeded concurrently until the analysis reached theoretical saturation (Hallberg, 2006, p. 144). Analysis of the interview transcripts and field notes was supported through using NVivo computer-assisted qualitative data analysis software. Insights were interpreted using constant comparative method to generate theory from the data (Hallberg, 2006, p. 145). Constant comparative method is a data analysis technique whereby all codes, categories, and concepts are constantly compared with all other parts of the data to explore variations, similarities, and differences (Hallberg, 2006, p. 143). This approach grounds the researcher’s final theorizing in the participants’ experiences so that the reader can make connections between analytical findings and the data from which they were derived. The data analysis process proceeded through four stages: compiling, disassembling, reassembling, and interpreting (Yin, 2011, p. 177). In the first stage, the raw data in the form of the audio recordings of the interviews and in the form of field notes from the observations were processed into a consistent format. This involved transcribing the interview recordings and raw field notes using word-processing software. In the next phase, disassembling, I imported the processed data into NVivo qualitative data analysis software and coded the data. This process began with open coding whereby I sorted sections of the content of the processed data into similar and dissimilar groups. Once all the data was coded into groups I sorted similar groups into categories, thus moving my understanding of the data to a higher conceptual level. In the third stage, reassembling, I looked for themes and concepts that made sense of the data and disclosed broader meanings. This process involved finding concepts that integrated different or conflicting categories within a common frame of reference. This meant looking for aspects or ideas that were shared, overlapping, compatible, or negotiable. This process of reassembling was further supported by finding patterns in the data by arranging the categories using matrices and generating graphical models of factors and their links of influence between factors (Blessing & Chakrabarti, 2009, p. 20). The reassembling process proceeded in an iterative fashion with many cycles of compiling,
disassembling, and reassembling. The fourth phase involved crafting meaning through interpretation. The goal of this phase was to arrive at a comprehensive interpretation whose themes provided understanding of the entire study. This process involved producing descriptive accounts that provide deep understanding of the social conditions of the situation through portraying the people, events, and actions within their locally meaningful context.

4.2.5. Ethical Considerations

To ensure that the fieldwork was conducted ethically, three aspects were considered; respect, beneficence, and justice (NHMRC, 2007, 2007 Updated December 2013). Respect for the respondents’ self-determination to participate was ensured through explaining the background and purpose the research such that respondents could make a free and informed choice to consent to participate in the research. Explaining the risks and benefits of participating in the research and then answering any of the respondents’ questions ensured beneficence. Justice was ensured through selecting respondents in a manner that did not unfairly single out participants due to their particular subcultures. Participants’ involvement was completely voluntary and they were free to withdraw and end their involvement at any time without question or explanation. The participants signed consent forms.

Anonymity and confidentiality was ensured through replacing all potentially identifiable information concerning the participants contained within the interview transcripts and field notes with generic labels or pseudonyms. The Coordinator of Research and Research Studies at Swinburne University of Technology kept the original transcripts in a locked cupboard, and the consent forms were stored separately. A copy of the de-identified data was kept on the researcher’s password protected computer during the writing up process of the project.

4.3. Conclusion

In this chapter I introduced a framework for understanding the research process and I illustrated objectivist, constructionist, and subjectivist epistemological positions in design research. I then described the detail of the objectivist epistemological position that underpins this research project, its post-positivist theoretical perspective, the DRM design research methodology it takes, and the interview, observation, and analysis methods that were used to collect and interpret data. In chapter five I present the analysis and interpretation of the data and reveal nine modes of interactions that influence the collaborative design activity in interdisciplinary design teams.
This chapter investigates the interactions that participants in design teams employ during collaborative design activity. The chapter draws together empirical insights from the fieldwork and integrates the findings with the literature. The study finds support for existing knowledge about the forms of interaction found in collaborative design activity, and clarifies and explains some of the central aspects of the collaborative design process. My presentation of the interpretation of the data in this chapter addresses the first research question that motivates this research project *How do people in collaborative design teams interact?*

The focus of the interpretation is on the naturally occurring activity of collaborative design work. The data disclose nine modes of interactions that may influence the designers’ collaborative activity. For example, these modes of interaction include immersing the team in the context of the issue, integrating knowledge through iterative prototyping, and building shared understanding through dialogue. Since a central argument of this chapter is that the success of collaborative design activities is influenced by the interactions that the design team employ, it is useful to briefly articulate the kind of interaction and social interactivity involved here. We can distinguish between two conceptual levels of interaction: (1) the qualitative nature of interactions between people in social groups and situations, for example, the substance and meaning of their joint interactions; (2) the quantitative frequency or rate of individuals’ interactions. The focus of this chapter is the qualitative conceptual level of interaction where the group is understood as composed of interacting human beings who are not interacting “roles” but interacting “people”. Of main concern is the meaning of the social
acts of people involved in teamwork, rather than looking for regularities of human behaviour. Consequently, the notion of interaction that provides a frame of reference for this chapter has an emergent, open, and indeterminate character, one that is useful in describing the unpredictability and creativity of social interactions in collaborative design activity.

The following sections develop empirically grounded descriptions of social interactions gleaned from interviews and ethnographic case studies of professional designers. The nine modes of interactions take their cues from the experiences of the research participants and reflect the ways that knowledgeable insiders perceive and construct their reality.

5.1. Mode 1: Appreciating Systems

When designers appreciate that issues are embedded within existing systems of environmental and social factors, then they may recognise that their success is dependent on everyone’s success within the system. Appreciating the systemic context of design issues implies that complexity is introduced through the nature of the work and the organisational environment. The following quote from James, an industrial designer from Case 1: Industrial Design, illustrates how he views the systemic context of his collaborative design work:

… design is a methodology and not sketch or a model but a process that you apply. The quality of your process defines the quality of the product… So everything is essentially collaborative, even with our clients, because they are part of our design process… So it’s a collaboration not even by choice a lot of the time, what we can design is defined by other people whether we like it or not. It’s defined by our customers, it’s defined by our networks of manufacture, or even further it’s defined by our history, the people that contributed to the technologies that we can use, the paradigms we are working within. (James, Case 1, Industrial Design).

The effect of the systemic context of the organisation is further illustrated in the following episode from Case 3: Design Research. Chloe and John are providing background about their work with a major client to Richard, a new member of the team. Chloe explains that they have a long and successful relationship with their major client and have completed many projects together, however, they have learned over time that they need to take special care because the client’s internal organisation has many stakeholders with conflicting relationships. During the discussion Chloe says “We have to keep the Research Managers and Marketing in the loop to avoid political upsets, sometimes we get the [vendor] people contacting us directly and we have to be careful.” John adds “[The client] is really a collection of separate companies that historically were separate and only in the last ten years have they been under a single entity… [The business units] are all run by different people and that there is
competition between the various units” (Case 3: Design Research, Field notes 28-06-11). This episode illustrates how improving collaborative design is not simply a matter of refining theory and methods, designers also should understand that organisations have specific potentials and constraints the affect the practical implementation of the design process. Chloe elaborates on how the social and organisational context introduces complexity into the projects in the following quote:

There’re two factors that influence it, how much we know about the area before we go into it and how early stage exploratory it needs to be, and how political it is. So there’re some projects that we work on that have complex stakeholders, the team internally, so you will have a group of people who are more critical of the findings or they have to go to a higher kind of order. (Chloe, Case 3: Design Research, Code 1.1).

The data suggest that designing to meet people’s needs in an intentional way means that designers must investigate what people actually do, what they value, and how they understand things within a particular context with particular qualities. Design projects are embedded within historical, social, cultural, and organisational situations, and the context may impose constraints that mean that particular desired solutions are simply not feasible. For example, the design work may be culturally or politically sensitive, or the problem owners or design team may lack group cohesion or specific expertise, or the group may be rigidly set into existing systems and procedures.

The insight of the significance of appreciating the systemic nature of design activity corroborates Pahl and Grote’s (1996, p. 302) claim that the notion of the individual genius designer is no longer practical within the complex and highly interrelated network of applied engineering; consequently teamwork and product management is essential. Pahl and Grote (1996) argue that “Technical knowledge and ability requires an ethical approach that can only be achieved in an interdisciplinary organisation and an appreciation of the complex relationships binding together mankind, science, and the environment” (p. 292). The data also corroborate Kleinsmann et al. (2007, p. 66) who state that since the aspects of the design process are interrelated, when designers have a full understanding of the network then they can understand the dependencies of their particular tasks, which can overcome barriers to communication within the team. Furthermore, the insight also corroborates Brown and Eisenhard’s (1995) claim that while the development of innovative products is the basis of competition for many firms it is also “a critical means by which members of organizations diversify, adapt, and even reinvent their firms to match evolving market and technical
conditions” (p. 344). In this sense collaborative design activity is not just needed to create new products but also to support organisations themselves to be innovative.

The argument that collaborative design activity should take the organisational context in account implies the design team should maximise participation of stakeholders to activate as much knowledge within the system as possible. The importance of bringing together diverse stakeholders to address complex issues was described by the respondents in two main ways, first, in terms of providing access to different perspectives, and second, in providing additional specialist skills and expertise. As Anthony describes, his design work requires a team of specialists:

So the team I manage is designers, industrial designers, um but the larger [device] design team has user interface, user experience, user experience researchers, information architects, those kinds of people. So it’s quite a multi-spectrum team but my part is focussed on industrial design. (Anthony, Case 4: Interview Study, Industrial Design, Code 1.2).

The team members provide diverse perspectives on a problem by utilising different approaches, responses, and questions, to identify weaknesses and opportunities to evolve an undefined idea into a developed concept. The following extracts from Ryan and Vincent illustrate this point:

Keeping ideas inside you can go round in circles, clarify quickly, really quickly see the strengths and weaknesses of something when you are working with someone else. (Ryan, Case 2: Architecture, Code 3.4)

[My colleague] wasn’t sure how to do this, he hadn’t done anything like it before. Through investigation he found a company that makes inflatable castles, which kicked off a three-month collaboration with these people who had no understanding of the work we usually do, and we had no understanding what they do. Through working through and problem solving this thing we came up with one the most interesting inflatable tent structures I’ve ever seen, it’s still one of the most interesting things I’ve worked on I reckon. And that’s purely because we trusted these guys, we went to them with a problem that we didn’t know how to solve because we thought they could bring experience to the project that we couldn't. (Vincent, Case 4: Interview Study, Interior Design, Code 1.2)

In the second sense of providing multiple specialist skills and expertise, collaboration may involve utilising stakeholders’ professional know-how to create a more powerful or larger thinking footprint that may be needed to solve more complex problems. As William describes:

I think there’s always the little things, the projects are the best when the details are good because that can change an average project to a really good project, is when the details are well managed. Other people can notice something obscure that you wouldn’t have, and those details are what make the thing really good, and not necessarily that they will pick up a problem that you haven’t seen, you might be struggling with a detail because you are on a
train of thought of how this thing works, ok, well maybe you can solve this problem in a completely different way. (William, Case 1: Industrial Design, Code 1.2)

The data suggest that collaborative design work may deal with complex issues where the scope of knowledge required is beyond the cognitive limits of a single designer. Consequently, the team must integrate knowledge from different disciplines and specialisations. By taking advantage of the capabilities of the various stakeholders, the team can innovate at different levels and with greater detail, generate greater variety of ideas, and uncover tacit aspects of the problem. Through accessing expert knowledge and experience, the team should be able to integrate facts, theories, principles, or techniques that fall outside the design discipline. Consequently, they can increase the degree of innovation and number of alternative ideas produced. In addition, integrating knowledge from diverse disciplines may require the creation of new or modified approaches that mean that stakeholders must work within unfamiliar fields.

These insights corroborate Leonard and Sensiper’s (1998, pp. 118, 127) argument that innovation requires heterogeneous groups because differences in perspective helps the team to push beyond obvious solutions because tacit knowledge can become out-dated, and by the time it is noticed that it is out of date, the organisation will be in trouble. Also, Cross and Cross (1995, p. 145) state that teams should be able to generate greater number and more variety of ideas than individuals, and Arias et al. (2000, p. 87) add that including diverse perspectives within design activity can help uncover tacit aspects of problems. Similarly, Sonnenwald (1996, p. 277) argues that to design innovative artefacts within complex environments, the integration of diverse knowledge from different domains, disciplines, and contexts through concurrent engineering design methods is required. Furthermore, collaborative design activity may also involve “the creation of new technical and scientific knowledge, and knowledge about the design process to be applied to new design experiences” (Sonnenwald, 1996, p. 278). Moreover, Gunther et al. (1996) remark that “in industry, engineering designers are collaborating more and more in teams crossing departmental and even company borders, thus, the work of a single designer is part of a complex technical and social process” (p. 117). This form of collaborative design implies that innovation is created out of individuals’ interactions with each other and with the world though processes of teaching and learning, which means that “collaborative design is an inherently social activity characterised by multiple interconnected forms of information exchange, compromise, and negotiation” (Vande Moere et al., 2008, p. 151). However,
Goldschmidt (1995) found that the purpose of bringing together diverse stakeholders’ different perspectives or specialist skills is not necessarily to create new knowledge. Rather the team members may be selected to develop “a pattern of production that takes advantage of the strongest capabilities of all participants in order to advance toward the best possible results” (Goldschmidt, 1995, p. 208). The team members may simply work within their respective disciplinary specialisations and share their expertise as required.

The data reveal a driving force for interdisciplinary collaboration is the appreciation of the systemic nature of complex design problems. By appreciating that the design issue at hand is situated within a system of environmental, organisational, and social factors, the team members can recognise that their success is dependent on everyone else’s success within the system. Furthermore, the insights from the data suggest that interdisciplinary collaboration often does not start with a solution already in mind. Rather it means that designers should look outside themselves and into the environment to bring together a diverse team to address the different aspects of a complex issue. Here knowledge is a driving force. First, not enough is known about the issues, and second, a diverse team of participants are brought together because their particular stocks of knowledge can provide principles, facts, procedures, and perspectives that can potentially bring direction to resolving issues at hand. However, the team members must do more than simply be co-located, they must actively participate in the collaborative design activity.

5.2. Mode 2: Supporting Active Participation

Collaborative design activity involves stakeholders’ active participation in the design work within an organisations’ systemic context. Participation involves activating the knowledge and expertise of diverse participants to reduce the potential that something important might be left out. However, participation cannot be taken for granted, is not simply the result of being co-located with the group, it requires that the participant becomes involved in the design work through contributing relevant input. For example, James describes how their design is better off because they work with Dave to develop the product:

[Dave], technically he’s our supervisor on these commissioned or subsidised projects, he will go out and work with our products directly and give us feedback directly and we will ask him questions directly… So in the lab we can show him technical stuff but in the field he’s been doing this stuff for 25 years… So we don’t just go to him as a customer and say, “what do you need?” Try and fill a gap. We work with him to make that solution. Because of it, our product, that collaboration means that our product covers so many aspects of the problem. So it’s not just “it’s gotta be lighter” or “it’s gotta go off more times” or it’s not
just “it’s gotta be easier for the user” or it’s not just “we’ve got to be able to fit more in a pack”, it’s all of those things… we could have just done it from a design point of view, and made it pretty and functional and that’s it. But we did it from an ecological point of view, a design point of view, a financial point of view, a customer point of view, that why it makes sense, people understand it. (James, Case 1: Industrial Design)

However, involvement needs to be intentionally supported because the data suggest that participation is likely to be influenced by aspects such as hierarchy, roles, trust, and group cohesion. For example, according to Helen:

Well you know some people are more naturally dominating, ah either by their personality or by their position in the company, it’s hard to ignore what the director is saying, in this apparently kind of equal brainstorming session, his opinion does carry more weight.

(Helen, Case 4: Interview Study, Exhibition Design, Code 1.4)

This insight corroborates the finding that participants’ input within a collaboration can be influenced by their position in the group’s hierarchy (Austin, 2001; Matthews, 2009). However, the data suggest that the design team can keep the development of ideas progressing by taking the time to manage the influence of hierarchical control of decision-making. By negotiating leadership roles as stakeholders explore issues the impact of hierarchy may be reduced, thus maintaining the flow of design activity through allowing both ambiguity and control, and for the unplanned and unexpected to arise. As Chris describes:

It’s very fluid. No one has set roles even though we do have very set, very, we don’t have set roles per se because there is so much variation in our work, but we do have roles that we are, within our organisation that we are experts at. [Max] is an expert in one field and I am in another, not in a world sense but within our organisation, but anyone of us can hopefully pick that up quite quickly, you never get to the level that the other person is at, but assist and give feedback and critique and kind of say you know “this is going well keep going” or “hey should we reassess that?” (Chris, Case 1: Industrial Design, Code 1.4)

The insight that continual negotiation of roles supports participation in the design activity corroborates Bayazit’s (2003, p. 126) findings that participation in a team affects the stakeholders’ behaviour and that cohesive groups can better withstand environmental pressures. Furthermore, Poggenpohl (2004, p. 142) elaborates that participation in collaboration involves a more informal “working with” approach rather than a prescriptive “working for” approach. In this sense, collaboration emerges through sharing responsibilities and making critical decisions together, which can then crystallise into a stable group and attract more participants (Kreiner & Schultz, 1993, pp. 189-200; Poggenpohl, 2004, p. 142). However, Kreiner and Schultz (1993, p. 203) maintain that participation in informal networks also requires a great degree of mutual trust of shared information. Furthermore, in early stages of collaboration, different participants’ roles and contributions may be unclear, and
time is needed for those roles to be solidified. While a priori roles play a part, they are also constantly negotiated during the collaborative conversation, with different members taking up leadership roles at different times, or with both designers and users taking on the role of refining the design or exchanging information at different times (Cross & Cross, 1995, p. 148; McDonnell, 2009, p. 49). Cross and Cross (1995, p. 145) add that roles may be based on either seniorities of position or particular job roles, and this can affect collaboration due to participants occupying equal positions in the organisational hierarchy although they have differing levels expertise.

Austin (2001, p. 217) observed that when a team member appoints themselves as the leader without consulting the other group members, discontentment can grow and the team will start to lose cohesion and fall back into their disciplinary sub-teams. In such situations the quality of the collaboration can be compromised because a participant may use their position in the hierarchy to overstep the limits of their knowledge to make inappropriate decisions. McDonnell (2009, p. 48) found that the status of group members as “experts” within collaborative conversation can cause members to defer responsibility for decision-making. Consequently, McDonnell (2009, p. 49) cautions that designers should be careful to neither over privilege nor to under-rate both designers’ and users’ expertise. For example, building designers have experience of using buildings, and users’ naive understandings can become a starting point that can then inform design. Moreover, McDonnell (2009, p. 49) claims that the recognition or assertion of expertise is a social act that is aimed at getting things done, and reducing users’ ability to contribute to design activity to only identifying functional needs should be questioned because this view does not take into account the complex web of relationships of those contributing to a design.

The significance of attending to social aspects of collaboration is further corroborated in the literature for example by Oak (2009, p. 54; 2011, p. 224) who shows, through using a Conversation Analysis approach, that within institutional and professional settings, even simple conversations, such as asking and answering questions, are mediated by social norms and power differences. According to Oak (2011) designers manage and perform their roles “in relation to the constraints of institutionally-oriented behaviours as these occur in professional design practice” (p. 223). Furthermore, Oak (2009, p. 62) argues that participants’ roles within the institutional or professional context may unconsciously affect the participant’s behaviour. Organisational roles may impact upon the topics and sequence of a conversation, for example “a client’s talk may help an architect perform initiative and
ownership, while an architect’s talk may help a client perform ambiguity and relative
acquiescence” (Oak, 2009, p. 62). In addition, Brereton et al. (1996) maintain that these social
aspects of negotiation involve persuasive strategies, such as, appealing to common sense, or
higher principles, or established experts. However, negotiation may also involve linguistic
approaches, such as, carefully moderating a participant’s commitment to an idea, avoiding
280) found that interdisciplinary boundary roles and interpersonal boundary roles were
significant in interdisciplinary collaborative work. These stakeholders performed important
informal activities, such as using neutral language and seeking parallel concepts in other
domains to explain their perspective, or meeting informally to obtain feedback on their
design decisions (Sonnenwald, 1996, p. 292). In addition, learning about other actors’
language and preferred interaction styles was helpful when discussing areas where
disagreement or conflict could arise.

The insights from the data reveal that group cohesion can also be affected by clashing
personalities, egos, and motivations. When a participant feels intimidated, or has less
responsibility than they would like, or when another participant takes over, the collaboration
can become one-sided. Furthermore, bringing an outsider into a group, whose role does not
bear upon the problem or in an on-going situation where roles have already become
understood, can cause distrust and misunderstanding. Participants also have responsibility to
move the development process forward, because it is easier to criticise another participant’s
idea and show how it will not work rather than build on their idea. In addition, it can take a
long time for a participant to share responsibility for something they have been working
intensively on, as Chris describes:

Initially, I took a long time to, I was really bad at giving over things, giving it entirely to
someone else, giving over parts of the business to other people, we were sensitive to giving
over the things we had been working intensively on. But now all those rough edges don’t
exist. The net gain of everybody feeling involved is colossal; everyone is doing it for the
same goal. Now we all can have suggestions, we all know what a financial spread sheet
looks like and we all know what the inside of [the product] looks like. (Chris, Case 1:
Industrial Design, Code 1.5)

Lacking a feeling of responsibility for the collaboration can also create feelings of
vulnerability as if another participant has hidden something important. Responsibility can
also create feelings of obligation to the collaboration, which can complicate the boundary
between the interests of the group and the interests of the individuals. Questioning or
showing a lack of respect for another participant’s contribution can cause that participant to mentally withdraw from the collaboration. As Anthony explains:

Usually when one set of people in the team don't have respect for what the other people are doing, they get dismissive of the other person’s role, which builds bad blood. I need to have respect for what the other person is doing otherwise they aren’t going to respect me and we aren’t going to get along, we aren’t going to talk enough. (Anthony, Case 4: Interview Study, Industrial Design, Code 1.5)

Team size, team tenure, and form of communication also have an effect on group cohesion. Vincent, an industrial designer, describes the effect of team size on collaboration:

Once the team gets to a certain scale it seems like it’s um a true collaboration, like everyone is working to achieve the presentation or the goal or the package. In the smaller teams, it feels like there is a bit more of an emotional attachment to the outcome. So it seems like you might have one person who is really trying to get their idea across, they don’t really want to hear your idea, it’s about them achieving what they want to achieve, you are their tool, they want you to help produce it for them. (Vincent, Case 4: Interview Study, Interior Design, Code 1.7)

The data suggest that smaller teams may be more highly influenced by one person trying to achieve their personal vision, while in a larger team there may be less personal ownership of the outcome and the workload may be more greatly distributed. Chris described how, since their organisation is small, they develop solutions more quickly than the large organisation they collaborate with and consequently there may be a loss of synchronisation of goals.

[The client is a] big organisation, it moves really slowly, we are already onto the next thing and they are still struggling with the last, you want this to move quickly but the process is very slow, which is stifling. (Chris, Case 1: Industrial Design, Code 1.7)

The data corroborates Austin’s (2001, p. 217) findings that a confrontational atmosphere and lack of cohesion can also result when team member takes too much control, for instance by advancing through activities without consulting the other team members. According to Vande Moere et al. (2008, p. 153) group cohesion, the degree of interrelatedness of the team's ideas, progresses through stages of divergence and convergence, and iterative interaction among participants leads to cohesion and shared understanding. Ostergaard et al. (2005, p. 171) add that high group cohesion can be both a benefit and a constraint. Ostergaard et al. (2005, p. 172) explain that while high group cohesion may be constructive, it can also lead to group think symptoms, where a group’s illusion of invulnerability can lead to the belief that they are incapable of error or to the rationalisation of poor decisions. Furthermore, according to Brown and Eisenhardt (1995, p. 368) team tenure and communication are important factors that influence group cohesion and performance. The duration that project team members have worked together affects the frequency and type
communication within the group. Brown and Eisenhardt (1995) found that teams with a short history demonstrate greater external communication, while teams with longer tenures favour internal communication. Frequent internal communication is essential to effective group work because it breaks down barriers and reduces misunderstandings, which then increases the amount of information conveyed and improves speed and productivity (S. L. Brown & Eisenhardt, 1995, p. 368). The significance of developing trust within collaboration also corroborates Poggenpohl’s (2004, p. 147) perspective that due to their different domain knowledge, perspectives, and processes, participants cannot validate each other’s conjectures and therefore require intensive trust to work through uncertainty.

The insights from the research indicate that supporting participation in collaborative design activity requires the continual negotiation of leadership and roles to allow both ambiguity and unplanned ideas to arise. The negotiation of leadership and roles rather than relying on hierarchy, increases group cohesion and supports greater participation. Hierarchy can be introduced into the team through either seniority or particular job roles; both these aspects affect the degree to which a participant’s expertise is integrated into the collaborative design activity. Where participants use their hierarchical position or role to overstep their expertise there can be a breakdown of the continuity of the design activity. Furthermore, ongoing interactions throughout the design activity support participants to gain buy-in which supports group cohesion. Since new design ideas are not unexpectedly introduced in high-pressure situations they overcome formal barriers such as client-designer relationships. When barriers between stakeholders are reduced, then individuals more readily focus on the collaborative work rather than simply performing their roles within their formal limitations.

Institutional settings and norms affect collaboration and point to the significance of social aspects of design activity. For example, organisational roles may impact upon the topics and sequence of a conversation or a stakeholder may moderate their commitment to an idea to avoid personalising a discussion. Attending to social aspects of collaboration is essential for supporting group cohesion. Learning about other stakeholders’ language and interaction style helps to deal with disagreements or conflicts when they arise. Moreover, when the group employ neutral language, moderate commitment to particular ideas, defer status, preserving ambiguity, and avoid personalisation of discussion, they maximise the scope of knowledge integrated, test more ideas and earlier in iterative prototyping processes, increase group cohesion by reducing the impact of hierarchy, gain individual buy-in, and overcome formal roles limitations, therefore increasing the degree of participation of the
stakeholders. Consequently, greater participation increases the scope of knowledge utilised in the collaborative design activity and so the potential for innovation. When designers work to understand other participants’ personal interaction styles and language, and take time to explain decisions rather than relying on hierarchy, they create common ground, more equal relationships, and increase trust. Furthermore, the data shows that participation within collaborative design activity is likely to be further supported when the stakeholders are immersed in the actual context of the design issue.

5.3. Mode 3: Co-experiencing the Context

A vivid introduction to the role of immersion in collaborative design activity was during the fieldwork for Case 1: Industrial Design. In an interview Max described how working with the users in their everyday environment showed him that the existing design the client was using could be significantly improved. Max said “The advantage of going out with these guys is that there is no way I am going to carry those things again, big heavy wooden boxes up the mountains, it makes no sense… we’ll never get on top of the country if we have do it like that” (Max, Case 1: Industrial Design). The immersion activity supports learning as reciprocal process between stakeholders that takes place over a longer series of interactions. Since learning is situated in a local context and in actual practice rather than in formal descriptions or procedures, then participants can better appreciate boundaries where potential common ground can be found between conflicting perspectives or assumptions. As Dave describes:

The best way is to go and do a real job, but in that period we’ll talk and discuss a range of things we are working on as well as future stuff, we work better in the field discussion-wise than formal meetings… the learning stuff goes on in the field… they’ll never reach a start point unless they understand it from our point of view, they see exactly what we are doing and understand it, then provide solution (Dave, Case 1: Industrial Design, Code 2.4)

An example of this learning process was shown in an episode during the fieldwork with Case 1: Industrial Design. Our scheduled task during the fieldwork was to travel to a remote site to prepare to test a new prototype design, however, while we are working in context, Max, one of the industrial designers, and Dave, the client and user of the device, also discuss the differences in approaches to innovation between the client and the industrial design company. Dave remarks about how previous products developed at his organisation have focussed on innovation as a single step without iterative testing of prototypes in the field. He describes a previous design for a device that did not work because they went from prototype to mass manufacture without properly testing the product in the field. Dave and Max discuss
how their current collaboration with the industrial design company has an approach that is more like gradual innovation where they test their prototype devices in the field as quickly as possible. We can see from this episode that doing the fieldwork in the context together was not just about preparing to test the prototype, but crucially, it was also an opportunity to understand the context and talk about ideas and strategies.

The data show that during immersion, group members work closely together and there is opportunity for on-going dialogue and feedback. This form of immersion enables stakeholders to participate in the design process and allows them greater “buy-in” to the outcome and this may make solutions seem more acceptable. Furthermore, immersing stakeholders and designers in the context together provides more opportunities to share conversations and to understand each other’s worldview. Immersion may support the group to develop greater innovation since it enables stakeholders to express more tacit knowledge than simply treating the user as a customer and asking them to describe their needs. John describes the importance of immersion in his work as follows:

[The] research itself was lots of fun and I really like working, being in the environment with the designers and going “actually this is really interesting talking about cultural stuff”… that’s where it kind of thrived, when we were in the actual environment. (John, Case 3: Design Research, Code 4.2)

The data suggest that immersion allows designers to discuss issues with stakeholders at the site, provides the opportunity to have direct experience of the situation, and to see whom they are designing for. In addition, immersion supports stakeholders to test ideas by triangulating findings and by providing evidence for decision making. As Emma describes, rather than solving a defined problem, immersion can be aimed at disclosing insights that can inspire innovation within the design company:

[The project] was meant to be a very early stage, inspirational, almost “the word [product] is banned”. We are trying to understand their lives and talk about trends that are going on in their areas and with them, linked to technology… it was much more about understanding their worlds and being inspired about that, it was much more rooted in the individual participant’s life than the implications [i.e. product concepts]. (Emma, Case 3: Design Research, Code 4.2)

These insights from that data corroborate Friedman’s (2001, p. 13; 2002, p. 26) position that knowledge is created through our interpretation and transformation of experience through a dynamic learning cycle. Nonaka (1994, p. 24) describes how this dynamic learning cycle uses the co-experience characteristic of immersion to convert tacit knowledge among participants through socialization of common perspectives. In addition, my findings corroborate Leonard
and Sensiper’s (1998, p. 114) argument that tacit knowledge can be acquired through learning behaviours that are non-conscious. According to Leonard and Sensiper (1998, p. 120), when designers immerse themselves within the environment for which they are designing, they can gain empathic understanding of potential users and their use environments, and in these circumstances tacit understanding is shared and more knowledge gained than can be externalised. Similarly, Sonnenwald (1996, pp. 278-279) maintains that designers should investigate the context of products to explore and integrate knowledge to meet users’ needs.

The data suggest a strong connection between immersion and learning. As we have seen, immersion of stakeholders and designers within the context may challenge their assumptions and provide meaning and context to insights. This form of co-experience may support learning in two main ways. First, learning can be simply sharing experience and knowledge, or sharing the results of experiments or processes, or teaching new group members to apply a particular approach and procedure. Second, learning can occur informally during the design development process rather than as an explicit task. In this second sense, learning is often a more reciprocal process between stakeholders that takes place over a longer of time. For example, in Case 1: Industrial Design, James describes how their collaboration has helped Dave to understand new ways that design can be used to solve the issues his organisation faces:

I think the really nice thing about our relationship with Dave for example is we have given him a much greater understanding of what can be created, so he starts looking at his problems from our point of view as well. (James, Case 1: Industrial Design, Code 2.4)

The co-experience characteristic of immersion has not only allowed the designers to gain insight into the context of the stakeholders’ milieu but also support the stakeholders to learn more deeply about how design can provide innovation. Since learning is situated in a local context and in actual practice rather than in formal descriptions or procedures, then participants can better appreciate where potential common ground can be found between conflicting perspectives or assumptions. For example, by “sitting in” on an activity to learn from an expert or by sharing skills or specialised equipment within a community of practice, more assumptions are challenged more quickly because when learning activities happen in context they are tested against direct experience. Furthermore, when participants use immersion they can work together to find opportunities for innovation rather than the designer asking to client to formally specify their needs. In addition immersion can lead the team to develop of culture of innovation because knowledge in context not only supports
participants to learn, it also shows when principles do not apply, and inspires new alternatives, rather than simply applying isolated techniques, facts, or tools. Finally, linking learning to context and practice supports innovation and new ideas, while formal descriptions or procedures reduce learning to simple training determined by capacity of replication of knowledge.

These findings corroborate research within the knowledge management literature, for example, Nonaka and Konno (1998) equate learning with the internalization mode of the knowledge creation cycle. According to Nonaka and Konno (1998, p. 45) internalization is the embodiment of explicit knowledge in practice through putting strategies and programmes in action; a process of learning by doing. However, Nonaka (1994, p. 34) argues that organisations should go beyond learning and towards knowledge creation. Similarly, my findings corroborate research within the situated learning stream. For example, Brown and Duguid (1991, p. 40) argue that understanding work requires considering the actual practice because abstractions omit the essential role that intricacies play. Furthermore, collective learning is inseparable from practice because it is socially constructed and contextually situated through sharing stories, opinions, in an informal community rather than transferred through training (J. S. Brown & Duguid, 1991, pp. 46-47). Moreover, learning is not a formal process of receiving abstract “expert” knowledge but by “becoming a practitioner not learning about practice” (J. S. Brown & Duguid, 1991, p. 48). Such learning produces “know-how” through tacit experience in practice (J. S. Brown & Duguid, 1998, p. 95).

The significance of learning within collaboration that this research shows, clarifies Langan-Fox at al. (2004, p. 345) who argue that developing team mental models should be supported through skills training and efficient communication. In contrast, this research corroborates Brown and Duguid’s (2001, p. 205) argument that “shared practice demarcates the extent to which knowledge can spread” rather than self-sufficiency or repeatability. Brown and Duguid (1991, p. 47) maintain that theories of information transfer that isolate knowledge from practice are based on a training view of knowledge. In contrast, they argue that a learning view of knowledge includes the contexts in which knowledge has meaning, and therefore:

[Learning] can in one way or another be seen to construct their understanding out of a wide range of materials that include ambient social and physical circumstances and the histories and social relations of the people involved. Like a magpie with a nest, learning is built out of the materials to hand and in relation to the structuring resources of local conditions. (J. S. Brown & Duguid, 1991, p. 47)
From this perspective, learning does not only take place inside individuals’ heads, rather “what individuals learn always and inevitably reflects the social context in which they learn it and in which they put it into practice” (J. S. Brown & Duguid, 2001, p. 48). This implies that the design of collaborative technologies should support participants’ access to the “implicit, extendable, informal periphery” rather than be solely framed around formal descriptions of work (J. S. Brown & Duguid, 1991, p. 48). Brown and Duguid (2001, p. 200) also maintain that sociocultural environment effects how knowledge moves within an organisation and that sociocultural accounts offer much richer explanations of organisational knowledge than accounts that treat the capacity of knowledge to move as a property of knowledge itself.

We have seen that learning and innovation are intimately connected, and that understanding the details of actual practice, not only formal descriptions and procedures, needs to be supported within collaborative design work. The data suggest that learning supports participants to express greater variety of responses, explore unexpected lines of inquiry, find common ground amongst conflicting perspectives, and challenge assumptions. Consequently, participants gain more robust shared understanding and develop a culture of innovation together. For example, when participants are immersed in the context they have more opportunities to share conversations because direct experience prompts participants to express greater variety of responses and impressions. Furthermore, since responses can be put into context and elaborated upon, then there are more opportunities for participants to ask follow up questions and explore unexpected lines of inquiry. Consequently, immersion, rather than explicit reports, enables participants to share interactions that support deep learning, because participants can explicate more tacit knowledge and so gain greater understanding and more potentially innovative ideas.

5.4. Mode 4: Integrating Knowledge with Iterative Prototyping

The interpretation of the data suggests that prototyping and iteration are approaches that designers use to integrate knowledge within collaborative design activity. For example, Josh describes how an iterative approach to design is important within their design work at Case 2: Architecture

… there’s this iterative process that happens in that discussion, at lots of different scales, but we actually work that iterative process into our design process, into our programming. So we are aware that we are going to have to go through several kind of “washes” of
design to get the refinement that we need to complete a stage... you'll start with quite a simple thing and then overcomplicate it, keep adding and testing, trying out things, which is fine you know, having that freedom to experiment, and then realise that it is getting awful and then pull it all back to its essences, but having gone through that process you feel you always add something even if it's a subtle thing that comes through from quite an elaborate idea. It just gets stronger and stronger each time you come around. (Josh, Case 2: Architecture, code 1.6.01)

The data indicate that iteratively testing prototypes and drawings involves an explorative process to prompt unexpected opportunities. This process involves testing potential designs to produce failures and find potential improvements. When prototypes are quickly tested back and forth against different participants’ values and worldviews, the process becomes an informal “conversation” within the design group that supports innovation at the detail level as well as meeting the broad issue.

The iterative process of design development is illustrated in the following episode at Case 2: Architecture when the architects work to progress the design from a concept to a developed design to show the client. The architects need to make changes to the initial concept to respond to the implications of a new boundary line they had just received from a new site survey. They need to adjust the plan of the house to respond to the implications of the new boundary line, however, changing the plan also has significant effects on the design as a whole. The team works to develop the design by making changes to the CAD model to get accurate dimensions, they then print out the technical drawings and use tracing paper to hand-draw changes over the printouts to develop the design. Within this activity the team rapidly create ideas for particular aspects of the design and test them by hand drawing, they then check the overall effect the changes have on the design as whole by applying the changes to the CAD model on the computer. The design activity involves an iterative cycle between hand drawing and updating the CAD model. The architects talk about how the new boundary line will allow them to extend the eave to the building, however, Peter adds that they need to preserve the idea of the solid-void concept that guides the design. Peter hand-draws changes to the design on the tracing paper then asks Josh to update the CAD model, to “see what it looks like”. Josh manipulates the CAD model to incorporate the extension to the eave. The architects discuss the new iteration of the design, stand and point and the monitor as Josh works, they look and comment “that’s alright, kind of interesting, now you can… we can pull the roof down... that’s a nice rhythm... way better proportions”. They then print out the new CAD drawings and start another cycle of design development (Case 2: Architecture, Field notes 07-02-11).
The insights from the data reveal that utilising prototypes within design activity is an influential factor within collaborative design activity. Prototyping was used to develop, evaluate, and refine designs. Furthermore, where there is a high frequency of prototype testing, there was also a high degree of iteration because the various components are dynamically interrelated, and so changes to one component affect the performance of the other components and the overall success of the design. Thus, prototyping is a technique for managing design development where parameters and specifications are both highly interrelated and constantly changing. The process evolves prototypes through testing designs and exploring possibilities in response to the results of experiments or in light of new knowledge and so on. The respondents commonly referred to prototyping as a means for testing ideas and concepts rather than to “brainstorm” ideas. As Max describes:

[We] tend to make things as soon as we have an understanding of what it is. Soon as we have an understanding of how it might work we immediately go and make it and trial it, make it and put it in the [field]… Because you can sit around and guess it, you can think about, you can make assumptions about how things might work but in the end you can only put it in the field and test it to prove it. And that is where everything has to be proven. So model making is sort of a funny thing I guess in terms of, I mean, a model is a working functioning thing around here… so we make the object but it has to perform and function in the environment. So it can be kind of limited in a way you know, because we can’t just make a cardboard model because it will never withstand the environment, also we can’t just print it out because the print out can’t withstand the physical rigours you know? (Max, Case 1: Industrial Design, Code 2.1)

The data suggest that within the design process, prototyping and iteration are strategies that are used to deal with the complexity of dynamically interrelated elements. During design development different components might be in various stages of development and are often being redesigned and modified concurrently with testing and retesting of the components in the field or laboratory. As James describes:

We compromised a lot on our first product and it bit us, we had this thing we designed it was working pretty well but then made wholesale changes to go into production… and it turned out those things didn’t work but we had gone into production. What we learned from that was even in the production stage, if we have to change something, we have to test it. We know we have to test it and know it works before we commit to it, and it’s such a beautiful process and of course it’s so logical but we had to learn it the hard way, it’s just all about iterations and proof. (James, Case 1: Industrial Design, Code 2.1)

The data show that iteration forms part of design process where prototypes are tested and refined in a cycle. This approach enables the design to cross disciplinary boundaries as well as develop greater detail and meet high-level goals. I found that testing prototypes involves an explorative process to prompt unexpected opportunities. When prototypes are quickly tested
back and forth against different participants’ values and worldviews, the process becomes an informal “conversation” within the group that increases participation and supports innovation at the detail level as well as meeting the broad problem. This insight corroborates Brown and Eisenhardt (1995) who found that teams that engaged in “experiential or improvisational product design through frequent iterations, more testing, frequent milestones, and powerful leadership” (p. 364), developed designs more quickly than teams who attempted to compress product-development cycles, for example, though extensive planning. Also, Geisler and Rogers (2000, p. 397) maintain that collaboration within interdisciplinary teams is more like a cycle than a network. They argue that team members develop aspects using their own disciplinary tools, then share their own work, propose ways to move forward, discuss the implications of the proposals, ratify a proposal, then update their own disciplinary understanding before commencing another cycle of work. Similarly, Brown and Eisenhardt (1995) found that teams whose collaborative activities were more interactive and iterative, were better able to overcome cross-functional barriers than those teams who utilised a sequential and functionally dominated phase model. However, in contrast Kleinsmann and Valkenburg (2005, p. 148) argue that having many iterative loops indicates that a collaborative team lacks shared understanding and effective communication. Crabtree et al. (1997, p. 71) also add that too many changes within design development causes delays and cost increases because each part constrains the other parts of the design and changes to one part necessarily require revision of the others. According to Crabtree et al. (1997, p. 71) this frustration within iteration is due to each different part of the design process constraining the others, where changes have effects on other aspects of the design that are difficult to predict. This can result in critical resources, information, feedback, or design decisions being delivered either late or very close to the end of the development process, which results in knock-on effects that force reworking of the design and produce a disjointed development process. Adelson (1999, p. 134) suggests that better scheduling of time and financial resources would reduce such constraints. However, while Crabtree et al. (1997, p. 75) acknowledge that a lack of procedures and systems to support project management is a significant constraining factor, they also note that often where such systems are in place, different personnel are found to use different systems that are not always well integrated. Crabtree et al. (1997, p. 162) argue that a more integrated product development process is able to reduce significant product development costs through avoiding elaborate changes and reworking.
The data suggest that iteration and prototyping also support the team to integrate knowledge. Integration is useful because different disciplines have different approaches to work as well as different ways of thinking to solve problems, and so gaining an appreciation for a discipline’s day-to-day logic of practice as well as a working understanding of its fundamental knowledge is necessary for stakeholders to understand each other. Differences in disciplinary approaches can affect the success of collaboration in a number of ways. For instance, respondents reported that the collaboration can fail when a participant is motivated by applying the latest, but ultimately inappropriate, knowledge from another field, or by trying to apply an approach that is too technical for a particular problem, or by producing a solution where the value is not evident to another discipline. According to Jeff:

I think the toughest aspect is educating yourself on a discipline that you’ve never been familiar with... I was put into a scientific environment and I was mixing chemicals together, I’ve never done chemistry before, I was understanding different manufacturing processes that I’d never been taught before, so I certainly think the most difficult thing and the biggest challenge from cross-disciplinary approach to designing is understanding and educating yourself on the discipline that you are not familiar with. (Jeff, Case 4: Interview Study, Industrial Design Research, Code 1.3)

Sharing a common explanation of the state of affairs of a complex problem situation requires that stakeholders work to integrate diverse knowledge. Integrating knowledge from diverse fields may also require the creation of new or modified approaches that mean that stakeholders must work within unfamiliar territory.

The data suggests that the activity of integrating knowledge requires iterative negotiation of viewpoints because, as participants develop a new shared understanding together, they challenge their assumptions and beliefs. This insight corroborates research within the knowledge management influenced design literature. For example Friedman (2001, pp. 10,17; 2002, pp. 9-10) and Leonard and Sensiper (1998, p. 112) claim that designers must work in teams or lead teams because complex industrial products and services are embedded in large interacting systems, and the therefore the professional designer should work as a synthesist that integrates individual tacit knowledge and design knowledge with other understandings, and a generalist who uses principles, facts and theories. Furthermore, Leonard and Sensiper (1998, p. 117) maintain that individuals’ tacit knowledge is what makes them valuable within a team, however, tacit knowledge can only be obtained through interaction. Similarly, Nonaka (1994, p. 15) maintains that ideas begin with individuals; however, he argues that it is the ontological conversion of individual knowledge to the group and organisational levels through communities of interaction that develops and amplifies new knowledge.
Communities of interaction may span department or company boundaries and reflect the informal ways that people actually work rather than their formal role descriptions (Nonaka, 1994, p. 23). According to Nonaka and Konno (1998, p. 46) communities of interaction facilitate direct encounters and face-to-face experiences that form part the socialization mode of the knowledge creation cycle. Likewise, Leonard and Sensiper (1998, p. 120) state that groups can develop shared tacit knowledge through sharing experiences. However, Leonard and Sensiper (1998, p. 124) argue that because in practice tacit knowledge is motivated through intuition, flashes of inspiration, or “hunches”, it can create conflict within a team discussion because the individual cannot validate their claims according to different discipline’s criteria.

The interpretation of the data suggests prototyping and iteration are approaches that designers use to integrate knowledge where parameters and features are highly interrelated and constantly changing, which enables the design to cross disciplinary boundaries and supports innovation at the detail level as well as meeting the broad issue. When prototypes are quickly tested back and forth against different participants’ values and worldviews, the process becomes a “conversation” within the design group. The team may develop new shared understanding by testing designs and exploring possibilities together, since appreciating different disciplines’ day-to-day logic of practice as well as fundamental knowledge challenges assumptions and beliefs. The process evolves prototypes through testing designs and exploring possibilities in response to the results of experiments or in light of new knowledge and understanding.

5.5. Mode 5: Maintaining the Continuity of the Design Activity

The data suggest that designers move the design work forward by balancing ambiguity and control and through using analogy. The participants need to maintain the continuity of design activity by supporting the team to integrate knowledge by exploring alternatives while maintaining shared understanding. The team may use analogy as common ground from which all participants can then understand the direction from which new ideas are introduced.

Designers need to deal with uncertainty in their work since there are no logical limits to how to do design. Designers need to trust that an idea will come and click into place even
when the design development is not progressing smoothly. One approach that was commonly revealed in the data was to use analogy to prompt new discussion of the issues to keep the design activity progressing. An example of the significance of analogy was revealed in an episode at Case 1: Industrial Design. Chris was in the workshop explaining to Frank, a new engineering intern, about how the design for one of their devices was developed. Chris showed Frank various prototypes and explained that the idea for the design of the trigger component was developed from the “diaphragm on a scuba breathing apparatus” (Case 1: Industrial Design, Field notes 16-10-11). Chris explained how their collaborative design process often uses existing objects as a point of departure from which to have a conversation to develop a new component. Chris reiterated this point later in an interview where he explains that in an analogous object

... there’s something in there that leads onto something else and that leads on to something else... Collaboration is also not just asking for help but kind of cheating and taking existing stuff... so you kind of jump yourself ahead by stealing stuff and borrowing stuff... Because all of a sudden you know something... and you can have a conversation... you’ve got to keep it really open to avoid missing out on something else. (Chris, Case 1: Industrial Design, Code 2.6)

The data suggest that analogising drives the design activity forward by balancing ambiguity and control, broadening the scope of potential opportunities, and exploring alternatives while maintaining shared understanding. Analogical reasoning may operate through tentatively introducing knowledge to start a conversation to lead on to something else. This approach of bringing together knowledge from different contexts to bear on the issue at hand, involves “building”, “borrowing”, “stealing”, and “throwing things in” to continuously prompt idea generation. This form of analogical reasoning is shown, for example, where stakeholders take an existing technology, process, or system, which has been effective in an adjacent domain and introduce it to the design activity to test whether it addresses the issue at hand.

When the participants share a concept through an analogy, they share common ground from which then all participants can understand the direction from which new ideas are introduced. Therefore, introducing a technique, concept or principle through analogy may be aimed at stimulating conversation or discussion to understand what the problem could be, rather than as a means to adapt a predefined solution to the context at hand. Consequently, using analogy is probably a way to broaden the scope of potential opportunities through creating a moment of common knowledge that supports diverse participation because it prompts, explores, and elicits knowledge rather than applies a solution to a defined problem.
These insights corroborate McDonnell’s (2009) argument that the techniques of intertwining current situations, analogous situations, and “functional, perceptual, phenomenological and symbolic ‘level’ issues” (p. 45), reveals the limitation of theorising collaborative design work in terms of simple correspondences between requirements and features of design solutions. McDonnell (2009, p. 45) also maintains that designers use scenarios as a rhetorical device to attempt to take the users’ perspective and to make a case for a design decision. Moreover, McDonnell (2009, p. 45) argues that simulated scenarios may also work to open up the discussion to other stakeholders to offer more convincing evidence from their more comprehensive experience. Similarly, Détienne et al. (2009, p. 237) show that transferring results from previous design work where integration of viewpoints was already found into a current project, was an important aspect of developing shared understanding and providing weight to argumentation. Furthermore, Adams et al. (2009) and Brereton et al. (1996) argue that analogical reasoning is an important bridging activity between participants that supports the theory of co-evolution of problems and solutions, and helps create shared understanding in interdisciplinary design work. Ball and Christensen (2009, p. 170) also observe that analogical reasoning is a core strategy within the design process aimed at solution generation, function finding, and to deal with the uncertainty that designers face when working through complex or ill-defined design problems.

The data indicates that in addition to the use of analogy, the group members may employ subtle social strategies aimed at maintaining the flow of the team’s collaborative activity. Strategies such as couching ideas in humour and self-doubt, or using tentative language when making suggestions, are used as prompts to keep the conversation going and to explore the implications of stakeholders’ responses. Stakeholders may use each other as a “sounding board” to “bounce” potential solutions back and forth to keep pushing the development forward, or to gain affirmation and to test ideas against other stakeholder’s perspectives. This activity may be related to dealing with uncertainty under pressure and trusting that an idea will come and click into place even when the team is not getting anywhere. Interdisciplinary teams introduce diversity through the rich stock of tacit knowledge within each participant’s different worldview and experience, however, this diversity can also bring disagreement. Because interdisciplinary collaboration deals with greater complexity, it requires greater understanding, more iteration, and involves a greater degree of uncertainty. Designers must take care to maintain continuity of design activity because high uncertainty can cause breakdowns in the flow of design development. Managing the impact of hierarchy on
decision-making and allowing opportunities for reflection, supports the design team to keep idea development progressing.

Stakeholders employ subtle social strategies aimed at maintaining the flow of the team’s collaborative interactions. Group design activity involves using tentative language and bracketing disagreement to keep the conversation going and to explore the implications of stakeholders’ responses. These strategies maintain the flow of interactions to encourage fresh ideas, deal with uncertainty under pressure and investigate unexpected alternatives as they arise. A design conversation becomes a constructed meaningful interaction through the stakeholders’ outward interactions and their inner self-reflexivity when adjusting their responses to each other. At the end of design phases, reflection is a critical activity where stakeholders can evaluate unexpected issues and solutions, and consider how current solutions compare with previous experiences.

The data disclose different strategies employed by stakeholders to keep the pace of design development moving during collaborative design activities. Respondents commonly referred to employing various techniques aimed at maintaining the “flow” of the team’s collaborative interactions. As Mark describes

I think it’s true you do feel the flow sometimes, and actually that’s what experienced people at [design consultancy] learn is that, and slowly get more and more comfortable with, is that whole uncertainty. (Mark, Case 4: Interview Study, Industrial Design, Code 3.4)

Furthermore, the respondents reported that design work requires time away from considering technical details to have “non-thinking time” to let an idea “settle” and to let it “evolve”:

[Because] design is a very holistic thing right, you need a lot of time to kind of go very “Zen” you know? You need some non-thinking time to let things settle… Because you’ve only got a certain period of time to do your hard-core design work, the less time you spend resolving those issues the more time you have for this “Zen” non-design-sit-back-and-let-it-evolve. You never get design right the first time, you can't just sit down and spend a day and then you're done, right? You need to, it's a very iterative process you know, you have fifty, one hundred, two hundred goes at doing something, a lot of that is trying one way and then another and unless you have the time to have that organic approach the outcome isn’t going to be as it could be. (Anthony, Case 4: Interview Study, Industrial Design, Code 3.4)

These insights corroborate Kleinsmann et al. (2011, pp. 495, 500) whose research within reflective practice found that expert designers explicitly postponed details to avoid getting stuck and continue working on the problem, this involved understanding the complexity of the problem but focussing in developing a principle to integrate different views and keep
development progressing. Furthermore, the findings corroborate Poggenpohl’s (2004, p. 147) claim that care must be taken to support the collaborative process itself rather than focusing solely on the problem. Moreover, Pahl and Grote (1996) distinguish good problem solvers as having the ability to make “positive actions even if goals and conditions are unclear” and “the ability to focus on the goal while being flexible in approach” (p. 296). Similarly, research within team mental models research recognises the significance of the dynamic nature of design activity. For example, Badke-Schaub et al. (2007, p. 12) and Dong et al. (2013, pp. 3-4) maintain that existing research on team mental models is not well suited to design because the ill-structured nature of design problems makes them change as different solutions are developed. Consequently, measuring the accuracy of a particular mental model is not very useful in a design context where knowledge is dynamic, emergent and action based.

The data suggest that the role of breakdowns within the continuity of the design activity is closely connected to instances of disagreement. Because an interdisciplinary team introduces diversity through the rich stock of tacit knowledge within each participant’s different worldview and experience, it can also bring disagreement. Since innovation may come from integrating this diverse knowledge and working through disagreement by finding common ground and new understanding, then participants utilize subtle interactions and social processes to investigate implications of disagreements and differences to prompt further ideas. For example, using social strategies such as bracketing disagreement allows the participants to investigate details while remaining open to prompts for new directions. Consequently, these interactions support the team to integrate knowledge through exploring alternatives while maintaining shared understanding. These findings corroborate research within the language informed stream of design research. For example, McDonnell (2012, p. 48) proposes that collaboration is characterised by the rapid movement of focus within a conversation. However, McDonnell (2012, pp. 52-53) found that participants signal tentativeness of their ideas to express agreement towards a shared view of a possible design “conjecture”, to prompt refinement of details, and backtracking to previous design conjectures, to simplify tasks or set them aside tasks to be done later to keep current flow going.

The significance of maintaining the flow of interactions to deal with uncertainty is further elaborated by McDonnell’s (2012, p. 56) finding that because designing requires simultaneous investigation of parallel lines of inquiry, therefore, designers must be at ease with working with “uncertainty, contradictions and with partial knowledge” to be creative. Similarly, Cross
and Cross’s (1995, p. 144) observational study of design teamwork found that explicit planning of design activity is not always apparent, and that in fact it may be necessary for unexpected alternatives to be pursued as they arise. Furthermore, Brown and Eisenhardt (1995) found that management of the design process should “maintain a balance between allowing ambiguity, such that creative problem solving can flourish at the team level, and exercising sufficient control… by communicating a clear vision of objectives to their teams” (p. 362). However, in their study of conceptual design process in software design teams, Catledge and Potts (1996, p. 188) found that designers regularly stopped to reconsider and rethink the project’s goals and core design. They argue that the degree of reflection they observed is likely typical of conceptual design and that it goes beyond incremental product development process models.

McDonnell (2012, p. 61) also suggests that bracketing points of disagreement is an important aspect of expert collaborative work aimed at maintaining such states of flow. Bracketing involves firstly using tentative language during collaborative conversations, and then where disagreement arises, explicitly acknowledging and identifying the points of disagreement so that they can be encapsulated and alternatives considered without losing sight of the fact that the points of disagreement still exist. According to McDonnell (2012, p. 61) bracketing disagreement uses three conversational devices; signalling the propositional status of a conversational turn, acknowledging alternatives yet to be resolved, and naming disagreements to mark off choices. These conversational devices provide “a way of avoiding having to resolve disagreement sufficiently for designing to continue” (2012, p. 61). Oak (2009, p. 57) adds that group members may manage disagreement within a collaborative conversation by couching specific answers with suggestions of doubt. According to Oak (2009, p. 57) this aspect of language is used to avoid making direct personal recommendations that conflict with aspects of an expert designer’s solution. Similarly, Brereton et al. (1996) found that design conversation involves subtle social processes at various levels to develop detailed alternatives while keeping things open and ambiguous enough to maintain the flow of the activity. Designers maintain the flow of ideas to prompt another idea, and return to issues in iterative cycles, to concentrate on detail as well as the broad problem to innovate at many levels (Brereton et al., 1996).

Since there are no logical limits to how to do design, then designers need to deal with uncertainty in their work. The data suggest that designers may deal with uncertainty in their work by balancing ambiguity and control through using analogy to create a moment of
common knowledge that then prompts something new. This approach of bringing together knowledge from different contexts to bear on the issue at hand, to stimulate discussion to broaden the scope of potential opportunities supports diverse participation because it explores and elicits knowledge rather than applies a solution to a defined problem. The data suggest that the role of breakdowns within the continuity of the design activity is closely connected to instances of disagreement but when the participants couch ideas in humour and self-doubt, or use tentative language when making suggestions, they keep the design development moving to explore the implications of stakeholders’ responses while maintaining shared understanding.

5.6. Mode 6: Mediating Designing with Artefacts

The use of artefacts has significant influence within collaborative design activity. Artefacts play the important role of mediating collaborative activity though supporting stakeholders to develop shared understanding of the issues, and though provoking creativity during the flow of interactions within discussions and conversations. The term mediator is used here to describe the use of scenarios, images or artefacts within design activity to drive the design activity forward by generating concepts rather than storing information. Sharing simple sketches and basic artefacts supports the translation of knowledge from one disciplinary language to another more effectively than technical visualisations or models. As William describes:

[In] group meetings, [Max] becomes really good at drawing out things really logically, really clearly and quickly, and then you can discuss things around that drawing. (William, Case 1: Industrial Design, Code 3.2)

Ryan also describes the important link between drawing and idea development in the following quote:

Drawing is so much faster, especially with clients… [when] a client sees something in a computer model they are more inclined to think of it as fixed whereas if it’s pencil or even photocopied pencil and you have a pencil with you, there’s the feeling that everything can be changed. (Ryan Case 2: Architecture, Code 2.6)

The significance of mediating artefacts was richly illustrated in the following episode at Case 2: Architecture through the architects’ activities and through the layout of their office (Case 2: Architecture, Field notes 08-02-11). Within the office, a standing height desk called the bar is the hub of the design development. The architects stand around the bar and discuss and comment on sketches and models. Semi-finalised printouts of technical drawings of the
current state of the design are taped to the wall for reference, but the bar is where the architects develop the design through dialogue mediated with hand sketching over print outs. The bar is a desk area that provides more freedom to work than sitting at a computer because when the architects all stand around the tall desk together they can see each other’s work and comment as they draw. In one particular episode, Jack is leading the design development process. He draws the design in plan and reworks the programme and the living spaces, the size of rooms, their functions, and how they relate to each other. Peter works on the design of the form of the building in elevation and section. Peter develops a solid-void concept for the design of the building using repeating series of cuts and intersecting planes. As Jack and Peter work through developing the design, their negotiation concerns the implications of the changes that Jack makes in plan about the inhabitation of the rooms—moving walls, doors, built-in furniture—with the rhythm and language of the solid-void theme that Peter is developing in section. As they stand at the bar, they discuss changes to the design simultaneously as they draw the sketches.

Peter: I want to protect that outer shell, all the articulation needs to be on the inside, I want the clarity.

Jack: Well we have to work that out.

Peter: Well it could work either way.

Jack: There it works, that solid wall, I can see this as a really nice place for a desk

Peter: Formally I would prefer it as a solid wall

Jack: You could always put a few slats in there, you’ve got the void here, but you have to glaze it. So what’s the question here?

Peter: Well it’s - do they want a window?

The data suggest that artefacts are also used as mediators to cross disciplinary and professional barriers. Within collaboration between stakeholders from different disciplinary fields, specialised representation techniques, for example the orthographic projection of a three dimensional object in a two dimensional drawing, may not be easily understandable by all stakeholders. However, the use of more simplified sketch modelling may support the translation of ideas from one disciplinary language to another. For example, Vincent relates:

[We] tried to document it like you document a building, we tried to produce a 3D model, we tried to produce a drawing, but these guys just had no idea because it was just a different language than they were working in. So in the end [Chris] made a small blue foam model that he cut up with a craft knife, it was really rough, but these guys could get it, they understood and then they went off and made up some mock ups using the language they
were used to and using pattern making techniques that we would have no idea about, and they produced something that was better than we could have ever imagined. (Vincent, Case 4: Interview Study, Interior Design, Code 3.2)

The data also suggests that the mediating role of artefacts within design activity may also be used to make issues more concrete and more detailed, rather than as a means to reduce information such as in a diagram. Artefacts are used to bring stakeholders’ everyday social and cultural context into meaningful presence to provoke designers’ empathy and imagination. As Tim describes:

Should I be delivering a crappy four box quadrant model, which you see all the time in market research reports, should I be reporting back this kind of meta level data… or should I actually stick to the most important bit, which is breaking down the barrier between the problem owner and the consumer. And if you go for that… fundamentally what you end up doing is telling stories about people, and I find photography, as well as it being visually engaging, quite interesting. It works by prodding clients like, “this person exists, this subsistence farmer in Lucknow exists, this is what he looks like, you can’t forget him, he’s not theoretical in any way”. (Tim, Case 3: Design Research, Code 3.2)

Traditionally, when artefacts are used to represent formal solutions to problems they utilise specialised forms of discipline specific language, which may not communicate well in interdisciplinary situations. However, when simplified sketches or other artefacts are used informally they can break down barriers between experts and non-experts and between discipline specific languages. Furthermore, when participants interactively construct drawings, models or other artefacts together they create knowledge, because the artefacts are used as mediators to stimulate imagination, refine perspectives, and synthesise ideas, and not only as memory aids. When artefacts are used as a memory aid, they are used to reduce information in the present and for retrieving information later, however, when artefacts mediate discussion interactively, they are used to stimulate new ideas and therefore create new knowledge. The insights from the data indicate that simple sketches and models may support participants to share knowledge across boundaries because they overcome jargon and break down barriers between experts and non-experts and between discipline specific languages. Moreover, it was shown that discussion between successive iterations of drawings and artefacts is a significant aspect of knowledge construction that builds shared understanding within the group.

The interpretation of the data suggests that sketches and drawings are used as a means to simplify complex elements and to locate group discussion on particular aspects of the design. Artefacts are used to bring stakeholders’ everyday social and cultural context into meaningful presence to provoke designers’ empathy and imagination. Discussion between successive
iterations of drawings and artefacts is a significant aspect of knowledge construction that builds shared understanding within the group. Creating drawings and models can involve both interactively constructing ideas with others and refining one’s own thinking. Furthermore, representation techniques can be used to record and synthesise ideas during discussions, which aids the development of shared understanding of the problem. In addition, designers and stakeholders use artefacts as co-design tools to gain insight and empathy. Moreover, representation techniques, such as concept mapping, can be used to record, transcribe, and synthesise ideas and arguments during a verbal conversation, which aids shared understanding of the problem situation to develop. Furthermore, using artefacts to mediate conversation was found to be especially important within collaborative work aimed at developing intangible products such as strategies or services.

The finding that artefacts mediate the group to build shared understanding corroborates research within the situated learning literature. For example, Brown and Duguid (1998, p. 104) identify boundary objects as a means to bring different communities into negotiation through revealing commonalities and differences in perspectives which supports reflection and compels participants to share interpretations. Similarly, Boujut and Laureillard (2002, pp. 509-510) found that the physical or virtual artefacts function as intermediary objects that coordinate designers’ activity. Intermediary objects are externalizations of tacit knowledge set within a local language within which acts build shared understanding through negotiation and dialogue. The influence of artefacts within design activity is also central to the research on reflective practice, for example Schön’s (1988, p. 182) characterisation of design activity as a form of making where knowledge is expressed through designers' transactions within materials, diagrams, models, and drawings etc. Tang (1991, p. 152) maintains that artefacts play an important role that goes beyond simply representing design ideas, rather, making drawings and prototypes during collaborative design activity can involve both interactively constructing ideas with others or refining one’s own thinking. In this sense, artefacts are not only the solutions to a task but also play a role as a material substrate that mediates design activity.

Furthermore, according to Perry and Sanderson (1998, p. 283) artefacts mediate the interaction of the group by focussing attention on particular aspects when participants point to sections to move the conversation on. Rather than remaining as a static means of information storage, artefacts are modified over time with identifying checks and comments about changes that have to be made as they are brought in and out of the flow of activity and
conversation (Perry & Sanderson, 1998, p. 283). Consequently, sketching should be seen as an activity that not only acts as a memory aid but also as a way of provoking creativity during designing because sketches are characterised by a degree of ambiguity (H. H. Tang et al., 2011, p. 2). Tang (1991, p. 149) shows that there is a difference between making artefacts to document information for later recall and making artefacts to enlist the members of a group to develop ideas. Through participating in creating the artefact, the group members share an experience that communicates more than can be documented. This is indicated by the fact that without also experiencing the accompanying dialogue, interactions and hand gestures, the resulting artefacts often do not make sense by themselves (J. C. Tang, 1991, p. 152).

Furthermore, Catledge (1996, p. 187) found that over time, the significance of artefacts and diagrams within an organisation can change their role from communicating information to becoming symbols or tokens that represent common visions and act as a focus in many various discussions. Peng’s (1994, p. 42) research shows that artefacts can be seen to perform two types of communication patterns which he designates as structuralist or metaphorist. From a structuralist perspective, queries about common artefacts may serve to activate collaboration, and from a metaphorist perspective common artefacts serve as shared metaphors that play a role in coordinating design activities across various disciplines.

The role of artefacts as mediators, as suggested in the data, also links to the synchronisation of knowledge within the group. Synchronisation of knowledge is contrasted with simple externalization of knowledge because synchronisation requires two-sided learning between participants, while externalization is based on one party assuming they know in advance what the other party needs to know. Furthermore, synchronisation involves more commitment than externalization because it requires that the participants adopt a cooperative attitude to work together to build understanding. Consequently, the participants should engage in a dialogue in which they are mutually responsible for each other’s understanding. Moreover, establishing a dialogue enables knowledge to be shared through stories, images, and models as well as speech, which provides more opportunities for feedback and interactive reflection and therefore more synchronisation of knowledge. The process of two sided learning and understanding that supports synchronisation of knowledge is aided when participants utilise artefacts to mediate discussion. Mediators support the translation of knowledge from one disciplinary language to another, and stimulate new ideas and to create new knowledge.
This finding clarifies research within knowledge management research. For example, according to Friedman (2001, pp. 13, 15; 2002, p. 21), tacit understanding enables human action, however, knowledge is created by articulating tacit knowledge by transforming, converting, and shifting it to explicit knowledge. Similarly, Nonaka (1994, p. 20) argues that lacking knowledge conversion can create problems with sharing knowledge with the wider community and into other fields. For example, only combining explicit knowledge and explicit knowledge can result in superficial interpretation of existing knowledge that is not concrete enough to be taken up with a particular social context. Likewise, pure socialization of tacit to tacit knowledge limits its ability to be transferred beyond its specific context.

Within the literature, the complexity of knowledge management is also shown in another sense. For example, Smoulders et al. (2008, p. 357) argue that in formal situations, such as architect-client meetings, the client misses all the implicit design considerations and excluded alternatives that are implicitly held by the architect, because artefacts such as plans and section drawings rely on communicating explicit knowledge only. In addition, in formal architect-client meetings, the knowledge about the design problem is only partially understood by the architect because the client has the factual knowledge of the design problem. Consequently, Smoulders et al. (2008, p. 365) claim that shared understanding is supported through two-sided learning where participants explicate the part of their implicit knowledge that the other participant needs for further understanding the problem or solution and vice versa. In this sense the participants are mutually responsible for each other's learning. Where communication goes beyond information distribution and towards understanding, there is a process of synchronisation. According to Smulders et al. (2008, p. 356), synchronisation is involved for instance within resolving disputes where the participants attempt to explicate their implicit knowledge. However, according to Smulders et al. (2008, p. 356), the difficulty lies in fact that both actors do not know beforehand what part of their knowledge they should make available to the other. They do not know what the others need for understanding their message. According to Smoulders et al. (2008, pp. 358-359), the synchronisation process can be facilitated when participants use future use scenarios and well known cases as reference points that act as boundary objects, which share knowledge without fully explicating it. Smulders et al.'s (2008, p. 365) description implies that each group member is mutually responsible for each other's learning within the synchronisation process and that boundary objects such as analogies and scenarios help to explicate the particular tacit knowledge that the each participant requires. This requires both the actors to adopt a
cooperative attitude and at the same time to refrain from jumping to conclusions without really understanding what the others mean. Similarly, Leonard and Sensiper’s (1998, p. 118) argue that tacit knowledge can be shared within a group without being fully articulated as explicit knowledge. For example, in developing design concepts, participants share ideas through sketching and analogising, where the sketches and analogies retain tacit knowledge that is shared though not fully rendered explicit.

The interpretation of the data suggests that designers use artefacts as mediators to support stakeholders to develop shared understanding and cross disciplinary and professional barriers by making issues more concrete and more detailed. Artefacts are used to bring stakeholders’ everyday social and cultural context into meaningful presence to provoke designers’ empathy and imagination. Moreover, discussion between successive iterations of drawings and artefacts is a significant aspect of knowledge construction that builds shared understanding within the group. The role of artefacts as mediators may also synchronise knowledge within the group since the sketches and analogies retain tacit knowledge that is shared although not fully rendered explicit.

5.7. Mode 7: Building Shared Understanding with Interpretation

A key insight from the data was that designers used an interpretive approach to building shared understanding and to gain empathy and insight. Furthermore, the process of working together to build agreement may be as important to building shared understanding as the outcome of gaining similarity of mental models and ideas. Nathan describes the significance of creating a shared interpretation as follows:

… we take the time to come together and come to an agreed view or useful interpretation, one that gives us leverage, purchase on the situation… a shared interpretation of what we face and a shared construction of where we want to go for us is a very powerful way to bring a group into a natural collaborative situations because that's creating our identity… for us it's that coming together and building those shared frameworks, concepts are the important and necessary precursor for any collaboration to occur. (Nathan, Case 4: Interview Study, Design Thinking, Code 2.2)

In a similar way, the designers at Case 2: Architecture work to build a common interpretation of the design through the development of a consistent theme for the form of the building. This interpretive activity is illustrated in an episode where Peter, Jack, and Josh are working on sketches for the solid-void concept of the design. Josh asks Peter for some feedback on
the design so far. As they all draw over the sketches Peter says “It looks more like interacting
planes and not the solid-void guiding idea. While the voids are there, they’re currently not a
compositional force… We could do it as a screen… what if this is a solid?… We can use
chopping out as a consistent language” (Case 2: Architecture, Field notes 07-02-11). In this
episode, the concept of **solid-void** is used to name a potential theme that helps the group
develop a localized sense of shared understanding.

The interpretive approach to developing shared understanding involves building on the
ideas of others during collaborative work. This approach also requires courage and the tacit
permission of the participants to have their ideas criticised as well as added to. This process
of going back-and-forth can involve arguing about an idea and explaining its logic in a way
that is not disapproving but aimed to enhance the project. Nathan described the process of
creating shared understanding as a conversation:

We’ll take a week and a half, it’s a very careful process of working through four places, it
feels obvious but it’s extraordinary. The first place is “where are we now?” It’s that sense
of “we need to take a really perceptive read on the situation that you face because in a
complex system you can ask a hundred people and you will get a hundred different
opinions, so let’s take the time to come together and come to an agreed view or useful
interpretation, one that gives us leverage, purchase on the situation.” The second place is
“where do you want to be?”. And that’s a “this is what’s wrong let’s solve it”, now let’s go
to a future place and say “that’s what you face but if you could have your dream what
would it be?”. From an argumentation sense that’s really important, if you can imagine a
tent being picked up, that is the place if you can come to a commonly held view of what
would be good or great, that gives a strong, shared purpose. So a shared interpretation of
what we face and a shared construction of where we want to go for us is a very powerful
way to bring a group into a natural collaborative situations because that’s creating our
identity, because “yeah that’s what we are facing” then that allows us to start to build the
series of hypotheses around what is it that will allow us to take us along that road.
(Nathan, Case 4: Interview Study, Design Thinking, Code 2.2)

This interpretive approach aims to develop a sense of shared understanding that is localised
within a particular context that the participants can identify with. Differences in worldview
can lead to difficulties in understanding that may bring some stakeholders to question or
show a lack of respect for another stakeholder’s contribution, and this can cause that
participant to mentally withdraw from the collaboration. Furthermore, excessive use of
jargon and formal language may create misunderstanding and conflict. As Nathan describes

The tough aspects are that um relative to the benchmark of “I sit in a room, I come up
with an idea, I write it down or draw it up”, it can be it necessarily demands more
attention, more input, probably more time… So it’s not quite the simple straight official
line, they are always ambiguous and confused and messy, you’ve just got more people
involved, so more opinions and perspectives and worldviews clashing and mixing.  (Nathan, Case 4: Interview Study, Design Thinking, Code 1.6)

Integrating diverse knowledge and skills supports the design team to innovate by taking into account different contexts, however, those differences in worldview and meaning can also lead to conflicts. The significance of conflicts due to differences in worldview are suggested within the data, for example, Mark states that:

[Industrial] designers are sometimes very quick to leap to conclusions and the human factors people will say “no no no that’s your bias there and let’s not leap to conclusion let’s keep our minds open for longer” and similarly the engineers get frustrated because the human factors people don’t um, you know, the psychologists and anthropologists, um, don’t come up with realistic ideas. (Mark, Case 3: Interview Study, Industrial Design, Code 1.6)

And John, a design researcher, describes:

[Within] the design research process, sometimes there is a language difference… Feeding in what people need into a creative process is quite a big challenge, and actually from our point of view it’s difficult because we are not that close to the other end [i.e. implementation], you know we have to help provide stories about other peoples lives essentially, experiences, ideas which might germinate and become something bigger, but they are very much at the conceptual level… [but] because it’s so different to what we normally do, it’s “did we give them what they wanted?” and “how do we best package this stuff in a way that is useful to people?”. (John, Case 3: Design Research, Code 1.6)

The data indicate that conversation and dialogue may be vital to the interpretive approach to building shared understanding because differences in worldview remain “embedded” within the negotiated meaningful outcome. Since participants can learn about differences through negotiating meaning, then shared understanding is built through interpretation rather than through codifying information. Furthermore, because coming to a collective interpretation requires the participants to negotiate positions and interactively construct shared understanding, the process of working together to build agreement is as important to building shared understanding as the outcome of gaining similarity of mental models and ideas.

Sharing interpretation supports understanding within interdisciplinary collaborative design activity because participants gain empathy and insight into the meanings the underpin differences in viewpoint and so reduce potential instances of conflict which stem from language differences. Furthermore, when participants gain insight into meanings it reduces uncertainty concerning other participants’ intentions and motivations. When participants understand each other’s intentions and worldview more deeply it reduces mistrust, because
the testimony of the participant’s knowledge seems more justified and believable, therefore reducing the potential for conflict.

This insight corroborates Smulders et al. (2008, p. 356) and Kleinsmann et al. (2007, p. 71) who claim that shared understanding is developed through an empathetic process of synchronising mental models. Kleinsmann et al. (2007, p. 71) found that the most frequent barrier to building shared understanding at the actor level was their ability to transform knowledge and overcome language differences. Furthermore, Smoulders et al. (2008, p. 365) argue that re-framing individual perspectives can de-escalate conflict while exploring differences.

The insight that collaborative teams can build shared understanding through interpretation corroborates research within the knowledge management influenced design research literature. For example, Leonard and Sensiper (1998, pp. 122-123) claim that innovation is unlikely to be the result of specified objectives because it is difficult to anticipate all the needs and aspects of a radically new product or process, and therefore individuals must use their judgement within a guiding purpose beyond explicitly stated goals. Similarly, Friedman (2001) states that critical comprehension “integrates experience into knowledge through cycles of action and feedback” (p. 14); knowledge supports understanding existing situations and determining future activities. Nonaka (1994, pp. 16-17) describes communication of tacit knowledge as an activity of “parallel processing” the complexity of issues to build shared understanding. Moreover, Nonaka and Konno (1998) state the externalization involves individual participants to commit to the group and “become one with the group” through “transcending the inner and outer boundaries of the self” (p. 43). Nonaka (1994, p. 24) explains that this processes of concept creation requires mutual trust between participants because trust forms a base from which collaborative dialogue converts tacit knowledge into explicit knowledge.

The finding that dialogue and discussion supports shared understanding rather than formal communication corroborates Brown and Duguid’s (1998, pp. 105-106) claim that formalisation of communication through technology can disrupt more productive informal interactions. Furthermore, according to Brown and Duguid (1998, p. 96) shared understanding is created in a community of practice through their practice, and so the development of the community and the development of understanding are interrelated because as the community develops understanding about itself it can change and extend the community.
Shared understanding is defined in the team mental model literature as similarity between team members’ beliefs or the extent to which team members’ beliefs and knowledge overlap (Dong et al., 2013, p. 2; Kleinsmann et al., 2007, p. 61). According to Badke-Schaub et al. (2007), mental models are working representations stored in the memory that are simplified “structural analogues” the world consisting of “concepts, propositions, scripts, frames, or mental images” that “reflect our tendency to categorize what we know” and allows us to “quickly understand and act even in new and unknown situations” (pp. 7-8). Moreover, team mental models enable team members to explain tasks, coordinate actions, and adapt behaviour to the situation (Badke-Schaub et al., 2007, p. 8; Langan-Fox et al., 2004, p. 335). Furthermore, Langan-Fox et al. (2004, p. 343), following Klimoski and Mohammed (1994), suggest that team formation of shared understanding involves systematically establishing norms of roles, processes, and relationships. However, my findings on the significance of dialogue and informal interpretation contradict Langan-Fox et al. (2004, p. 343) who emphasise systemic formalisation as the basis of developing shared understanding.

Within the linguistic design literature, Dong (2005, p. 451) and Yang et al. (2011, p. 121) found that high semantic coherence is a measure of shared understanding. However, Dong (2005) states that measuring the similarity of semantics in language provides a metric for the existence of shared representation but it “[does] not illustrate the social process of constructing the representation” (p. 454). My findings clarify this research because it shows that dialogue and collective interpretation are important social interactions that support shared understanding, which can be represented through semantic coherence.

The finding that teams build shared understanding through collectively developing a set of propositions corroborates research within reflective practice literature that mains that developing shared understanding is a process of framing by creating boundaries and selecting particular aspects to address (Schön, 1988, p. 182). For example, Kleinsmann et al. (2011, p. 487) describe framing as a sense making process whereby the team members negotiate the parameters of the problem and thus develop shared understanding. Consequently, Kleinsmann et al. (2011, p. 486) characterise collaboration as a knowledge sharing and integration process.

According to prescriptive approaches, shared understanding is a form of pragmatic intersubjectivity that indicates that there is similarity of perceptions about the content of design concepts, processes, or ideas (Kleinsmann et al., 2007, p. 61; Vande Moere et al., 2008, p. 153). At their core, I argue that prescriptive approaches rest up the assumption that to be
mutually intelligible all group members should communicate using a common language, such that by capturing and structuring team members’ communication within a common language, misunderstanding will be eliminated and shared understanding obtained. This position has a long history within design methodology: from experiments in cognitive psychology (Lewis, 1964); to supporting coordination and planning decision processes through design rationale (Conklin & Yakemovic, 1991; Kunz & Rittel, 1970); through using process guidelines to remove emotion and establish fair working practices (Adelson, 1999, p. 136); to developing integrated physical and computational environments for externalising knowledge (Arias et al., 2000); and developing graphical illustrations of team behaviour that can support self-reflection (Vande Moere et al., 2008, p. 152). In contrast to the prescriptive approach, McDonnell (2009, p. 44) argues that shared understanding is created through negotiation during conversation when participants invoke the position or knowledge of the other participants or where they make assertions based on their own territory of expertise. As Bucciarelli (1984, p. 187) argues, the aim of working collaboratively may in fact be to gain insight and to learn rather than produce a solution to specific problem. Kleinsmann and Valkenburg (2005) argue that “the process of creating shared understanding, might be as important as having shared understanding” (p. 148). They argue that at the early stages of the design process, stakeholders do not know each other’s field and so have to explain their perspectives (Kleinsmann & Valkenburg, 2005, p. 148). This diversity of thought leads to learning situations and to innovation. Conversely, at the later stages of a project interaction between the disciplines becomes more routine and number learning opportunities decreases (Kleinsmann & Valkenburg, 2005, p. 148).

McDonnell (2009, p. 50) supports Rittel’s claim that when stakeholders participate in design decisions that affect them, they are more likely to feel comfortable with the design once it has been implemented. McDonnell (2009, p. 50) identifies that this sense of ownership is gained through negotiation of design contributions and collective agreement over the justifications for those decisions. Arias et al. (2000) argue that users should take part in design activity as co-developers rather than only as consumers, because, as owners of problems, end-users bring “perspectives to collaborative design activities that are of special importance for framing problems” (p. 90). Similarly, Brown and Eisenhardt (1995, p. 352) maintain that early customer involvement in the product development process allows team members to develop a common understanding of who the customer is, and this ultimately contributes to accelerating product-development pace. McDonnell (2009, p. 44) also
supports user involvement in collaborative design, she maintains that stakeholder involvement allows designers to gain understanding of users’ practical, social, and psychological needs.

According to Smulders (2008, p. 380), conflicts that centre on tasks involve cognitive content while socio-emotional conflicts concern social relationships. Similarly, Anderl et al. (2009, p. 166) found that different working processes and organisational cultures can create confusion in global engineering and international cooperation. Moreover, Austin (2001, p. 217) notes that clashing of personalities can exasperate this resulting lack of agreement. Cross and Cross (1995, p. 166) also found that these differences in worldview cause different interpretations or understandings of the problem or solution may lead to conflict.

This finding is consistent with Anderl et al. (2009, p. 164) who argue that there is an “inherent gap” between the respective approaches of some disciplines, such as that between humanists and engineers. According to Anderl et al. (2009, p. 164) the aim of humanists’ work is to describe social situations in detail and so is divergent, while in contrast, engineers’ working attitudes seek to minimise difficulties and so their working method is more convergent. However as Détienne et al. (2005, p. 226) observed, a particular aspect of a design problem may have a different meaning in the viewpoints expressed by stakeholders from different disciplines, rather than such differences being somehow “objective” or “inherent”. Similarly, Kleinsmann et al. (2007, p. 60) explain that conflicts in meaning may be due to the fact that design communication is often jargon-laden and therefore difficult to understand for outsiders.

A key insight from the data was that designers used an interpretive approach to building shared understanding and to gain empathy and insight. Furthermore, the process of working together to build agreement was indicated to be possibly as important to building shared understanding as the outcome of gaining similarity of mental models and ideas. This interpretive approach aims to develop a sense of shared understanding that is localised within a particular context that the participants can identify with. Excessive use of jargon and formal language may create misunderstanding and conflict. The data also indicate that conversation and dialogue may be vital to the interpretive approach to building shared understanding because differences in worldview remain “embedded” within the negotiated meaningful interpretation. Since participants can learn about differences through negotiating meaning, and coming to a collective interpretation requires the participants to negotiate positions and interactively construct shared understanding. When participants understand each other’s
intentions and worldview more deeply it reduces mistrust, because the testimony of the participant’s knowledge seems more justified and believable, therefore reducing the potential for conflict.

5.8. Mode 8: Reflective Dialogue

Communication should be expected to be fundamental to collaborative design work due to the social nature of team work. But the form of communication that is most insightful for this investigation of collaborative design concerns more than transferring information, rather it concerns developing ideas and reaching acceptable solutions through dialogue. Indeed, Nathan explicitly linked collaborative design with dialogue when he said “for us conversation is so central to everything that we do because we see conversation as just the most natural and effective way for collaboration to occur” (Nathan, Case 4: Interview Study, Design Thinking). Mark also reiterates the significance of conversation with design teams and he emphasises the link to idea generation:

… all those conversations, it’s frequently about getting to that point of agreement and consensus around what we should recommend to the client, and what is true and what is best, um, so you know a lot of conversation back and forth between the teams members, like arguing effectively, but normally nicer. (Mark, Case 4: Interview Study, Industrial Design)

This mode of dialogue that Mark describes, concerns the process of idea generation through “talking about the ideas that we’ve had, evolving those ideas”, rather than project management or distributing information. This process of dialogue to evolve ideas is further illustrated in the following passage from Case 2: Architecture. Peter, Jack, and Ryan are working to refine a drawing of the building, when Ryan points out implications that a change John made has for the design of the elevation of the building. Peter offers a suggestion:

Peter: Let’s say we shuffle it along.

Ryan: There’s an opportunity for this as a void.

Jack: It’s possible.

Peter: No what I’m saying is this here is a void... I’m thinking formally here... we can have a second layer here, but then your balcony doesn’t exist… it doesn’t work huh?

Jack: But we are letting light into the staircase, which would be nice eh?

Peter: But by putting the balcony there you get this little notch eh?

Jack: You can do it as long as you push that back again.
Through their dialogue Peter, Jack, and Ryan develop the design by making suggestions and refining them through interactive reflection. The episode suggests that dialogue in collaborative design work is different from formal communication of information because it involves on-the-spot feedback and interactive reflection between participants rather than simply transferring information. Furthermore, when dialogue is supported by stories, images, sketches, and models and so on, the communication is more meaningful because participants can see the context within which issues are situated, consequently the team members become more empowered to make critical decisions to react to unexpected changes more quickly.

Efficient project management through good communication supports productivity because participants have quick access to relevant information. Communication is a significant aspect of collaborative design because a large proportion of teamwork involves communication of project management aspects since the scope of knowledge required goes beyond the limits of an individual’s cognitive power. Participants must communicate project management aspects such as deliverables, estimates of resources, progress updates, and so on. However, while efficient communication is an essential aspect of effective project management, the data indicate additional forms of communication, such as dialogue, are also significant.

The data suggest that dialogue is different than communication of information because it involves feedback and interactive reflection between participants. When team members share dialogue they can interactively reflect on the situation, which creates knowledge by supporting the team to evaluate progress, develop understanding, and to investigate opportunities. When team members share dialogue they can interactively reflect on the situation because while explaining their perspective to another, the participant can reconsider their own behaviour or ideas. Furthermore, the process of outward explanation and inner self-reflection supports dialogue because it creates a form of reasoning between participants where they adjust their behaviour and interpret their own actions; consequently exchanges become more meaningful. Reflection was shown within the flow of design activity where designers paused to consider what they had produced and to move the design development forward. In addition, it was shown that reflection was an important activity at the end of design phases where the designers would consider the larger issues of the design, or evaluate unexpected solutions that had arisen during the design activity, or to contemplate how current solutions compare with previous experiences.
The significance of reflection within design practice has received significant attention with the literature of design research and methodology. However, it is striking that reflection was not top of mind for the interview respondents when they described their experiences of collaborative design work. And yet, the observation data corroborates the literature that reflection is a significant aspect of the design process. This may indicate that reflection was considered by the respondents to be a factor that falls outside their view of the design process and points to the significance of informal interactions within collaboration within interdisciplinary design teams. Mark describes how when the team returns from their design research phase, they reflect their data and develop starting points for more formal design development processes:

[Then] we come back and we do synthesis, which is the most collaborative part probably, in that we lock ourselves in a room for, or our project space, for two weeks and try to figure out what it all means. And we get to design frameworks rather than, sort of insights, frameworks, opportunities, and then ah, we um, then we go through sort of the generative stage where based on the frameworks we create “how might we statements”, we hold brainstorm round those. (Mark, Case 4: Interview Study, Industrial Design, Code 2.3)

Reflection has an important connection between the development of shared understanding and iterative prototyping because once the team has developed a provisional understanding of “what the problem is” and begins prototyping, then there are also reflective moments where the participants evaluate prototypes and consider unexpected outcomes. Consequently, they can reconsider their understanding of the problem and begin a new iterative cycle of prototype testing. In sum, interactive reflection is an activity interwoven within the continuity of the design process, which creates knowledge by supporting the team to evaluate progress, develop understanding, and to investigate opportunities for innovation.

The significance of dialogue and reflection is strongly corroborated in the literature on design activity; however there were few references to reflection coding the data in this research project. Nonetheless, I argue that the significance of reflection within interdisciplinary collaborative design activity should be preserved because the low degree of corroboration within this research project is likely due to its research design. Since this research project utilised semi-structured interview and observation as its main data collection methods, it was less well suited to capturing respondents’ internal thoughts during design activity. Semi-structured interviews are retrospective while observation captures behaviours. Since reflection is an internal process, a different data collection method such as think aloud protocol analysis could have delivered more insightful findings.
The significance of dialogue within collaboration corroborates findings in a number of streams of design research within the literature. For example Kreiner and Schultz (1993, pp. 193-194, 200) found that personal encounters were especially important opportunities where information and ideas were shared. Dialogue was an important event where knowledge and experience blend in an unplanned manner and new meanings may unexpectedly arise and participants may be inspired to pursue a new idea. Within the knowledge management literature, dialogue is conceptualised as an important process of externalization of tacit knowledge. For example, Nonaka (1994) states:

Dialogue, in the form of face-to-face communication between persons, is a process in which one builds concepts in cooperation with others. It also provides the opportunity for one’s hypothesis or assumption to be tested... dialogue has a congenetic quality, and thus the participants in the dialogue can engage in the mutual codevelopment of ideas.” (p. 25)

According to Nonaka (1994, p. 25) the quality of a dialogue is enhanced when participants utilise dialectic to stimulate ideas through contradiction and paradox. Nonaka (1994) provides some “field rules” to support the process of dialectical dialogue:

First, the dialogue should not be single-faceted and deterministic but temporary and multifaceted so that there is always room for revision or negation. Second, the participants in the dialogue should be able to express their own ideas freely and candidly. Third, negation for the sake of negation should be discouraged. Constructive criticism substantiated by reasoned arguments should be used to build a consensus. Fourth, there should be temporal continuity. Dialectic thinking is a repetitive, spiral process in which affirmation and negation are synthesised to form knowledge. (p. 25).

Nonaka and Konno (1998, pp. 44, 47) characterise dialogue and inference as processes of externalization to convert tacit knowledge into explicit knowledge. Externalization converts individuals' ideas or images into words, metaphors, analogies, or visuals. Dialogue is a form of interaction where participants engage jointly in the creation of meaning that translates personal or professional knowledge of experts and non-expert users into simple articulate language (Nonaka & Konno, 1998, pp. 44, 47). Similarly, Smoulders et al. (2008, p. 359) found that externalization occurs when participants evoke future use scenarios in the form of storytelling during design development discussions. Glock (2009, p. 11) observed that within a design conversation, the members will carefully moderate their language to keep the dialogue open and fluent. For instance, a participant may act as a reporter of an idea rather than the originator to allow the participant to take less responsibility for the impact of the query and to give non-experts, clients, or users, access to contribute (Glock, 2009, p. 11).
My findings also corroborate research within the situated learning literature. For example, Brown and Druid (1991, pp. 44-46) found that collaborative story telling is a process where the participants confront a problem and construct a mutual interpretation of the situation. Such interpretive stories can then spread and become added to the community's collective knowledge. Similarly, Baird et al. (2000, pp. 345-346) found that stories concerning case histories worked as a form of anecdotal reasoning that facilitated a “black market” of skill trading. Furthermore, Boujut and Laureillard (2002, p. 508) found that externalization of knowledge in symbols, forms an interface that supported participants to express conjectures that crossed domain boundaries.

Within the mental models literature, my findings corroborate Dong et al. (2013, pp. 5-6) who maintain that design concepts emerge through connections between individuals' knowledge through informal communication rather than prescribed reasoning processes. This form of discursive enactment is a process of shared cognition in action that integrates knowledge through connecting individuals’ tacit and explicit knowledge to create a new team-level set of belief structures about a future preferred situation. Furthermore, Badke-Schaub et al. (2007, p. 18) argue that diversity of mental models is of no value in itself within creativity, rather it is the externalization of knowledge, abilities, and experience that is needed for action to take place.

Linguistics focussed design research also corroborates the significance of dialogue. For example, Dong (2005, p. 447) claims that while images and models are important, language based communication facilitates the transformation of individual knowledge to shared team knowledge. Furthermore, Dong (2005, pp. 453-454) found that teams that were able to build a socially held representation of each other's ideas through conversation and exchange of ideas. Moreover, Yang et al. (2011, p. 120) propose that domain specific language can be a barrier to integration of knowledge, and inability to recognise domain specific differences can reduce success of the collaboration. However, Sonnenwald (1996, pp. 291-292) found that interdisciplinary discussion was facilitated by carefully avoiding the use of specialized language, and rather seeking analogous concepts between domains and using neutral language.

This finding that connects reflection and dialogue corroborates significant research within the reflective practice literature. For example, according to Kleinsmann et al. (2011), design progression is collaboratively negotiated within conversation and through reflection:
When reflecting, designers question the direction of their actions. Reflecting provides insight into the team’s progress and the quality of concepts developed. It can lead to re-framing of the design problem or new moves... Frames, therefore, provide the team with guidance towards further activities. The inability of design teams to construct frames implies that their actions are undirected. (p. 487)

Valkenburg and Dorst (1998) define reflection as a “conscious and rational action that can lead to reframing the problem (when the frame is not satisfactory), the making of new moves, or attending to new issues (naming, when the reflection leads to satisfaction)” (p. 254). Furthermore Boujut and Laureillard (2002, p. 511) found that reflection on the situation during practise shares knowledge and creates common ground where individuals negotiate rules and co-ordinate their activity within the group. Moreover, Pahl and Grote (1996, p. 296) argue that specialised experience upon its own does not directly produce highly competent problem solving because, without reflection and abstraction of experience to a higher level, experience can lead to narrowed perspective and inability to deal with changing circumstances.

The insights shown in the data concerning reflection within the flow of design activity corroborate many findings in the literature, for example in terms of conceptualising collaborative design activity as a form of conversation. According to Oak (2011, p. 217), a conversation is oriented both outwardly though offering explanations to others, and inwardly wherein an individual reflects upon their behaviour or perceptions. A design conversation becomes a constructed meaningful interaction through the participants’ outward interaction and through their inner self-reflexivity (Oak, 2011, p. 217). Furthermore, Vande Moere et al. (2008, p. 152) maintain that by engaging in self-reflection, team members can engage in evaluation of their collaborative design process, which may then lead to voluntary changes in their behaviour to achieve the common goal of successful teamwork. Moreover, Vande Moere et al. (2008, p. 152) have shown that graphical visualisation of collaborative activity is a useful means of provoking reflection. The authors argue that visualisations that convey aesthetic, entertaining, or ambiguous qualities may be more effective at provoking participants to interpret their own actions than formal forms of data visualisation. The results shown in Peeters et al. (2008, p. 462) support the argument that careful integration of knowledge, and adjustment based on reflection are important aspects of effective design processes. Additionally, Valkenburg and Dorst (1998, p. 269) have shown that reflecting is a crucial means by which the design team decides to start a new activity. Reflection on behaviour at the beginning, and then frequently throughout the process, allows shared
understanding to be maintained (Valkenburg & Dorst, 1998, p. 269). According to Schön’s (1983) concept of reflection-in-action, during the problem solving activity participants experience breakdowns, and this leads them to reflect on their actions and explore associated information spaces. Arias et al. (2000, p. 104) build on Schön’s concept of reflection-in-action when they argue that support for design activity should assist this integration of action and reflection.

The interpretation of the data indicates that communication of project management aspects is fundamental to collaborative activity, however, developing ideas and reaching acceptable solutions through dialogue was especially significant. Dialogue is different from communication of information because it involves feedback and interactive reflection between participants to evaluate progress, develop understanding, and investigate opportunities. Interactive reflection is an activity interwoven within the continuity of the design process, which may involve outward explanation and inner self-reflection to support reasoning between participants where they adjust their behaviour and interpret their own actions.

5.9. Mode 9: Contributing to Culture

The insights from the data suggest that collaborative design may be more successful when the passion for creating design work goes beyond producing just another product or commercial. Feeling that the work makes a contribution to culture or community, rather than focussing on how much time it takes or the method used to create the outcome, ultimately makes for a more satisfying result. Collaboration is a process that involves looking outward beyond the immediate tasks of the project towards making higher-level contributions to culture and to encourage dialogue with the community.

The significance of a higher contribution is illustrated in the following episode at Case 1: Industrial Design when Max and Dave and I travelled to a remote site to prepare to test a new design (Case 1: Industrial Design, Field notes 10-02-11). When we got to the site, the entrance to the hiking trail was obscured by a wall of trees and marked only by a pink coloured plastic marker. We scrambled up the bank using our hands to grab roots and branches, and then climbed up a steep slope using footholds and rough steps. We shouldered our packs and started walking up the ridge. As we continued up the ridge the sound of cicadas faded away and Max and Dave pointed out different birds and species of native trees in between their constant conversation about design and conservation. Our boots rustled
through the undergrowth and we clambered over fallen tree trunks and pushed vines away from in front of our eyes. Max pointed out the deep gouges in a tree trunk and tells me they are possum markings, and the depth of the cuts shows that this area has been their territory for many years. Then, from further up the track Dave called out,

Dave: Kiwi shit!

Max: Where?

Dave: Right here. A beauty. Someone must be parking up eh?

Max: This is where we normally see it eh?

Dave: Yeah here and little bit higher. This is fresh as too. Wicked!

We walked over and saw Dave kneeling on the track and poking a white spodge in the dirt. He poked his finger in the white goo and then brought his finger to his nose to smell it. He says Kiwi shit has a really distinctive smell. He explained that Kiwi have recently been reintroduced to this area and they are the first Kiwi to have been seen there in 160 years. Later, Max reiterates the significance of working with Dave:

One thing that Dave is good at doing is keeping the enthusiasm for people to develop things, to help people understand their contribution to the overall picture of things. (Max, Case 1: Industrial Design)

The data suggests that collaboration requires more than a goal to merely provide a technical solution, since diverse stakeholders also need to understand and believe in their contribution to higher goal. In this sense, collaboration is more than just supplying goods or services, or working out who does what when and then delivering your responsibility. Collaborative design is most successful when the passion for creating design work goes beyond producing just another product. Feeling that the work makes a contribution to the cultural context, rather than focussing on how much time it takes or the method used to create the outcome, ultimately makes for a more satisfying result. The design process involves looking outward beyond the immediate tasks of the project towards making higher-level contributions to the discipline of design and to encourage dialogue with the community. Collaboration is more successful when the stakeholders share passion for design practice. Making a contribution to culture is a goal that goes beyond the formal specification of the project deliverables and involves considering the place of design within culture and building design knowledge.

Developing a goal may involve testing whether there are aspects of the client’s brief that overlap with the interests of the designers requires work during the early stages of the design
process. Mark describes the significance of developing a common goal in the following quote:

We have internal kick offs as well as kick off meetings with the client, where we share what our goals are for the project. So we all sort of define how we understand the brief for the project, what is it that we are trying to do for the client, and we talk about what we'd like to get out of the project ourselves as well. So “I’d love to learn something new in terms of a skill” or “I’d like to spend more time with the client because that’s not something I get to do very often and I’d like to interact with the client professionally”. (Mark, Case 4: Interview Study, Industrial Design, Code 5.2)

Similarly, James describes how lacking a common goal affects a participant’s motivation and commitment to the collaboration:

That’s what happened with the [product], we were a collaboration… but we had a disagreement on what the product was, I wanted it to be this really consumable thing, they wanted it to be this really high end thing, no middle ground, we couldn’t come to an agreement, I just had to let it go. And then suddenly I felt I had no ownership of it and I felt like I had no responsibility for it and therefore no contribution to it, and because of that, you kind of work differently you know, because you don’t represent it the same, your effort is not the same. (James, Case 1: Industrial Design, Code 5.2)

The data indicate that collaboration is more successful when the stakeholders share passion for design practice. Feeling that their work made a contribution to the design discipline makes for a more satisfying result than focusing on time or process. Making a contribution to culture is a goal that goes beyond the formal specification of the project deliverables.

Basically a lot of the stuff we churn out, and it will be the same in all facets of design, makes its way just to retail, it’s selling someone a product at the end of the day. It gets to the point where you call it “bread and butter”… part of being kind of a healthy human is change and so the common goal that we are going to achieve out of this, and we’ve all talked about it, is escaping everyday design life for commercial purposes, and I don’t know, basically achieving the satisfaction of creating something on screen for other people. (Paul, Case 4: Interview Study, Motion Graphics, Code 5.3)

Developing a shared interpretation of the design problem or a common goal has been identified as a significant factor in the success of collaborative work (Bucciarelli, 1994). Having too many goals, or when one participant has a different goal from the rest of the participants, can result in a loss of integration and a disjointed development process that undermines investigating any single aspect sufficiently. Furthermore, Goldschmidt (1995, p. 191) argues that individual design work can be superior to group work because where there is no personal penalty for slacking or no reward for successful performance, group members motivation tends to decrease. Similarly, Adelson (1999, p. 134) states that team goals should be both technically and professional beneficial to stakeholders. In addition, Anderl et al.
(2009, p. 162) argue that in internationally distributed teams, goals should be appropriate for intercultural contexts.

Respondents reported that collaborative design involves looking outward beyond the immediate tasks of the project towards making higher level contributions to the practice and discipline of design and to stimulate dialogue with public. A key concept that Case 2: Architecture use to describe how their work involves a making a contribution to the cultural context is “conversation”:

A building is a conversation. A conversation between the people who designed it, the people who use it, and anyone else who cares to express an opinion… The great buildings begin more like fantastic pub conversations. Only in reverse. It starts with a lot of arm waving. And then comes the brilliant lofty world-changing stuff, the bit where the grand idea coheres and becomes a plan. Then it slowly feels its way down to the details and the realities. And finally, it concludes with brief, affectionate formalities. Then the building throws its front doors open and the conversation begins all over again. Only this time it’s the right way round. (Document 01, Case 3: Architecture, Code 1.3)

The concept of a building as a conversation is both a metaphor for the architects’ design process and for how architecture should become manifest as a response to its cultural conditions. An example of this design approach is brought out in an interdisciplinary collaborative design project with a fine artist. According to Peter, over time art and architecture became physically and institutionally separated, beginning when ancient frescos were

… literally severed, like a limb, from architecture and cut and sent off to London museums, and architecture became a frame or quiet background for art rather than its inseparable partner. One of the goals of the project was to make the whole thing valuable from the discipline of painting specifically, so it could be critiqued and understood and read and kind of received from or received by the discipline of painting, but equally be discussed, reviewed, received by the discipline of architecture, but you couldn’t walk around the building and go “there’s the art bit, we should chop it out with a chainsaw and hock it off to the national museum”. (Peter, Case 2: Architecture, Code 1.3)

The aim of this interdisciplinary approach was not to narrow the different contributions of art and architecture to a common denominator but to expand approaches to find opportunities to contribute to both painting and architecture equally. According to Peter, most architecture is what he terms “elegant engineering” and not a response to cultural conditions. He argues that this approach to architecture uses disguised language like “programme”, “density”, and “infrastructure”, but what he argues really matters is how architecture operates on the discipline of architecture rather than the “questionable rationality” that it might bring. Design needs to be deployed to stimulate discussion with the
public about the place of design within culture. Designing should be a form of dialogue that seeks to expand discussion rather than narrow it. Designers have a responsibility to contribute to the discussion with the public about the place of design within culture.

This progressive intention is repeated by Mark, a senior industrial designer interviewed in Case 4: Interview Study, he describes how innovation cannot be reduced to an algorithm or a tool, rather innovation needs to be supported at the level of organisational culture:

[Most] clients come to us not just for the specific problem but also to learn how to be more innovative... when we are teaching people how to be innovative, we talk a lot about a culture of innovation rather than an innovation process or an innovation. There are skills that make up that, there are tools and there are processes that you can hang things on, but in reality the way in which you succeed in being innovative is around the culture. (Mark, Case 4: Interview Study, Industrial Design, Code 2.4)

The data suggest that since collaboration is strongly affected by the willingness of the participants to overcome the difficulties of working together and contribute their knowledge to the team, participants need additional motivation beyond resolving a technical solution. Interdisciplinary collaboration also involves a progressive goal to contribute to culture. The focus moves beyond finding a mutually beneficial common goal and shifts to the collaboration as a whole making a contribution. The commitment to progressing the discipline pushes interdisciplinary collaboration beyond a mode of serially additive coordination aimed at completing specified deliverables, rather collaboration involves considering the place of design within culture and building design knowledge. Crucially, the importance of contributing to culture and community brings the significance of interdisciplinary collaboration as a part of a knowledge building cycle to the fore. This cycle of knowledge building ties the contribution to culture to the complexity of the problem as the point of departure for the collaboration. Complex problems are always already embedded within context and culture and the discipline. The “collaborative conversation” may begin with basic research concerns or with new technology or it may concern social and culture influences. However, the deep significance of knowledge throughout all the “stages” of interdisciplinary collaboration reveals its purpose as a knowledge building activity.

In sum, the interpretation of the data suggests that designers may overcome the difficulties of working together and contributing their knowledge to the team, when they feel the work will make a contribution that goes beyond the formal project deliverables and involves considering the place of design within culture and community.
5.10. Conclusion

In this chapter I have presented the interpretation of the data collected during the fieldwork to address the research question *How do people in collaborative design teams interact?* The focus of the interpretation has been on the naturally occurring activity of collaborative design work. The insights suggest nine modes of interactions that people may employ when they are involved in collaborative design activity. This interpretation is based on empirically grounded descriptions of social interactions gleaned from interviews and ethnographic case studies of professional designers.

In chapter six I report the results of the data analysis that illustrate the distribution and frequency of the coding of nine modes of interaction between the cases. I then identify the significance of informal interactions within collaborative design activity.
6

Context in Collaborative Design

This research set out to investigate how designers interact and collaborate in interdisciplinary team situations. In chapter three I concluded that investigating the process of collaborative design means to investigate the substance of participants’ interactions within a communicative context. Since substantive interactions are context dependent and may be difficult to specify in advance, I decided to investigate informal interactions, meaning both the dialectical and rhetorical interactions in collaborative design activity. In chapter four I outlined the research framework that guided the fieldwork and in chapter five I reported the interpretation of the insights of the fieldwork. The interpretation of the data disclosed nine modes of interactions that participants in design teams may employ during collaborative design activity. The nine modes present descriptions of interactions within collaborative design activity drawn from the reported experiences of the research participants and from my observations of their work. The descriptive nature of the insights is useful for providing a comprehensive sense of the substance of each of the nine modes and a holistic understanding of the methods of thought and action that underpin collaborative design activity. However, since the descriptions are drawn from a heterogeneous sample, in this chapter I consider how the modes reflect different contexts and subject matters of design. Furthermore, I address the second research question What is the significance of informal interactions in collaborative design activity?
6.1. Data Analysis

Table 3 shows the percentage distribution of each of the nine modes within each case according to the total words coding each mode drawn from the interview transcripts and the field notes. Case 1: Industrial Design shows more references to integrating knowledge through iterative prototyping, using co-experiencing the context, but few references to dialogue. Case 2: Architecture shows references to integrating knowledge through iterative prototyping and maintaining the continuity of the design development, and there are also references to using dialogue and contributing to culture, but few references to participation or co-experiencing the context. Case 3: Design Research case shows references to co-experiencing the context, participation, and using dialogue and interpretation for building understanding, but few references to iterative prototyping. Case 4: Interview Study shows references to participation, iterative prototyping, and building shared understanding within dialogue, but few references to co-experiencing the context. The variation in distribution suggests that closer consideration of the detail of the distribution of references between the cases may reveal their different contexts and subject matters.

Table 3

<table>
<thead>
<tr>
<th>Mode</th>
<th>Industrial design</th>
<th>Architecture</th>
<th>Design research</th>
<th>Interview study</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>11%</td>
<td>5%</td>
<td>8%</td>
<td>15%</td>
</tr>
<tr>
<td>Participation</td>
<td>8%</td>
<td>2%</td>
<td>20%</td>
<td>18%</td>
</tr>
<tr>
<td>Co-experience</td>
<td>12%</td>
<td>0%</td>
<td>14%</td>
<td>3%</td>
</tr>
<tr>
<td>Integration</td>
<td>36%</td>
<td>28%</td>
<td>4%</td>
<td>17%</td>
</tr>
<tr>
<td>Continuity</td>
<td>12%</td>
<td>19%</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>Mediation</td>
<td>2%</td>
<td>2%</td>
<td>7%</td>
<td>5%</td>
</tr>
<tr>
<td>Understanding</td>
<td>4%</td>
<td>5%</td>
<td>11%</td>
<td>14%</td>
</tr>
<tr>
<td>Dialogue</td>
<td>4%</td>
<td>21%</td>
<td>20%</td>
<td>11%</td>
</tr>
<tr>
<td>Contribution</td>
<td>9%</td>
<td>19%</td>
<td>11%</td>
<td>9%</td>
</tr>
</tbody>
</table>

Table 3 Distribution of Words Coding Modes by Case

Table 4 shows that each of the nine modes of collaborative design interaction is influenced by several factors. These factors represent categories of coded data that underpin and give detail to the boarder meaning of the modes of interaction. As I described in chapter four, I used constant comparative method to explore similarities and differences within the data. Through comparing all the codes and categories with each other, I crafted an
understanding of the patterns of influence that each factor generated and their relationships within each mode of interaction.

In the next sections I consider the variation in distribution between the cases by reporting the results of the analysis of the coding for each influencing factor within each mode of interaction. The extent of the influence of each factor is indicated by the frequency of references coding the factor within the interview and observation data. The distribution of influence is calculated from the number of words coding the factor across the four cases.

Table 4

<table>
<thead>
<tr>
<th>Mode</th>
<th>Influencing Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appreciating systems</td>
<td>Complexity of the problem</td>
</tr>
<tr>
<td></td>
<td>Diversity of expertise</td>
</tr>
<tr>
<td>Supporting active participation</td>
<td>Influence of hierarchical control of decision-making</td>
</tr>
<tr>
<td></td>
<td>Trust in social relationships</td>
</tr>
<tr>
<td></td>
<td>Group cohesion</td>
</tr>
<tr>
<td>Co-experiencing context</td>
<td>Immersion within the context of the problem</td>
</tr>
<tr>
<td></td>
<td>Learning within design activity</td>
</tr>
<tr>
<td>Integrating knowledge with iterative prototyping</td>
<td>Integration of knowledge</td>
</tr>
<tr>
<td></td>
<td>Prototype testing</td>
</tr>
<tr>
<td></td>
<td>Iteration within design activity</td>
</tr>
<tr>
<td>Maintaining the continuity of the design activity</td>
<td>Continuity of flow within design activity</td>
</tr>
<tr>
<td></td>
<td>Using analogical reasoning</td>
</tr>
<tr>
<td>Mediating designing with artefacts</td>
<td>Mediation of interactions by artefacts</td>
</tr>
<tr>
<td></td>
<td>Synchronisation of knowledge</td>
</tr>
<tr>
<td>Building shared understanding with interpretation</td>
<td>Shared understanding of the problem</td>
</tr>
<tr>
<td></td>
<td>Conflict due to differences of worldview</td>
</tr>
<tr>
<td>Reflective dialogue</td>
<td>Communication</td>
</tr>
<tr>
<td></td>
<td>Reflection within design activity</td>
</tr>
<tr>
<td>Contributing to culture</td>
<td>Sharedness of common goal</td>
</tr>
<tr>
<td></td>
<td>Meeting high-level goals and contributing to culture</td>
</tr>
</tbody>
</table>

Table 4 Factors Influencing Modes of Interaction

6.1.1. Mode 1: Appreciating Systems

The interpretation of the data suggests that designers should recognise that their success is dependent on everyone else’s success by appreciating that the design issue at hand is situated within a system of environmental, organisational, and social factors. Since one person cannot
know the whole system, then forming a diverse team is needed to provide principles, facts, procedures, and perspectives that can potentially bring direction to resolving the issue. This mode of interaction is influenced by two factors: complexity and diversity.

6.1.1.1. Complexity of the problem

The frequency of references coding the influencing factor *Complexity of the Problem* (n=13) was within the first quartile of results. Figure 2 shows that the coding references were all found in the interview transcripts, there were no references coding this factor with the observation field notes. This distribution indicates a low degree of methodological triangulation. The lack of instances within the observation field notes that code this factor may be due to complexity being seen as a ubiquitous driving force for bringing together stakeholder within an interdisciplinary collaborative team. The respondents more commonly referred to the effect of complexity, for example the need to organise a diverse team. Therefore, we can understand complexity as more of a driving force within collaboration rather than a visible effect, and so it is reasonable that the references should be found within the interviews rather than the observations.

![Coding by case and Coding frequency](image)

*Industrial design*  *Architecture*  
*Design research*  *Interview study*  
*Interview*  *Observation*

Figure 2 Complexity of the problem

The distribution of coding amongst the case studies was at a mid level. Almost half of the data coded was within Case 4: Interview Study (45%), about a third (32%) coded Case 1: Industrial Design, and close to quarter (23%) coded Case 3: Design Research. None of the data coding complexity were found within Case 2: Architecture. This distribution of coding indicates a mid degree of data triangulation. While there is moderate distribution between
three of the cases, the influence of complexity as a driving factor of collaboration was not found within the interviews with the architects within Case 3: Architecture. This may be due to the driving force for undertaking collaborative work in Case 3: Architecture being more strongly associated with the goal of contributing to culture than in response to a complex problem.

6.1.1.2. Diversity of expertise

The number of references coding the influencing factor Diversity of Expertise (n=40) falls within the fourth quartile, indicating that the respondents considered that diversity had a significant influence on collaboration. There was a low degree of methodological triangulation; most the references were within the interview transcripts (n=92%) and few were within the observation field notes (n=8%). Consequently, we can infer that the meaning of collaboration to the respondents was strongly linked to their understanding of collaboration as a form of group work of diverse team of experts.

![Diversity of expertise](image)

![Coding by case](image)

![Coding frequency](image)

The distribution of references shown in Figure 3 suggests that this understanding was well corroborated across respondents from all four case studies. This result indicates a high degree of data triangulation and implies that the perspective of a diverse team working together is a common understanding of collaborative design activity irrespective of professional discipline.
6.1.3. Informal interactions

The significance of appreciating that the design issue is situated within a system of environmental, organisational, and social factors, may be that it implies that the locality and the background to the design issue bears on the substance of the collaborative design activity. When the design team adapt the content of the design work to its context they work with an informal approach, since the intelligibility of the design is affected by its relevance to its context rather than merely the logic of the relationship between the features of the product and the requirements. Therefore, this mode of collaborative design activity supports the perspective that aspects of collaborative design may have rhetorical and argumentative dimensions that may be overlooked within logical design methods (Tindale, 1999, pp. 75-77). For example, Case 1: Industrial Design’s intention to address biodiversity decline through designing a mechanical device to remotely kill pests is more intelligible when it is understood as a response to particular urgent current events, namely the need to provide a humane and toxin free alternative to poisons. Similarly, Case 3: Design Research were particularly careful to take the complex organisational context of their major client into account and so simply focussing on the outputs of the design research would not explicate the way that they had to deal with the client’s organisational structure, the prior projects they had completed, and their desire to maintain an ongoing relationship with the client.

6.1.2. Mode 2: Supporting Active Participation

The interpretation of the data suggests that active participation in collaborative design activity requires supporting ambiguity and unplanned ideas to arise. Continually negotiating leadership by learning about other stakeholders’ language and interaction styles, rather than simply performing their formal roles, allows the participants to focus on the substance of the issues, maximize the scope of knowledge integrated, test more ideas earlier in iterative prototyping processes, and increase group cohesion. Three factors, hierarchy, trust, and group cohesion influence this mode of interaction.

6.1.2.1. Influence of hierarchical control of decision-making

The respondents reported that hierarchical control of decision-making had a significant influence on the team’s ability to maintain the continuity of their design activity. The number of references coding this factor (n=37) was in the fourth quartile, which indicates a high degree of corroboration. Figure 4 shows that there was a moderate degree of methodological
triangulation with two thirds of the references coming from the interview transcripts (n=68%) and one-third from the observation field notes (n=32%).

![Coding by case and Coding frequency charts]

6.1.2.2. Trust in social relationships

The influence of the factor Trust in Social Relationships has a moderate degree of corroboration (n=33), with the frequency of references coding this factor being in the third quartile. Similarly, we can see in Figure 5 that there was a moderate degree of data triangulation, with the majority of references coding data from three cases only. The significance of trust in social aspects of collaborative teamwork was predominately shown within the interview transcripts (n=67%) rather than the observation field notes (n=33%). This may be expected as trust is an internal state and it is likely that during events where a respondent was
experiencing a lack of trust, they might choose to hide it from the researcher rather than express verbally or show it through their behaviour.

![Coding by case](image1.png)

- Industrial design: 33%
- Architecture: 29%
- Design research: 34%
- Interview study: 4%

![Coding frequency](image2.png)

- Interview: 34%
- Observation: 66%

n=33

Figure 5 Trust in social relationships

There were few references to the influence of trust within the data from Case 2: Architecture (n=4%). The references were evenly distributed between Case 1: Industrial Design (n=29%), Case 3: Design Research (n=34%) and Case 4: Interview Study (33%). The low distribution of data coding trust in social relationships within the Architectural practice may indicate a link between their high degree of skill at maintaining the continuity of flow of their design work and the degree of trust within the team.

6.1.2.3. Group cohesion

There were few references (n=11) coding the influencing factor Group Cohesion, which situated this factor within the first quartile of results. Due to the low degree of corroboration of the factor, conclusions derived from the data have a low degree of reliability. Furthermore, we can appreciate that the low degree of corroboration has also influenced the reliability of the degree of methodological triangulation and data triangulation that the data show in Figure 6. Because the majority of references to the influence of group cohesion were coding data from Case 4: Interview Study and because Case 4: Interview Study was an interview only case study, it follows that the majority of references would be within the interview transcripts. Moreover, the few references to group cohesion within the observation field notes could also be due to the influence of the presence of the researcher during data collection. The respondents may have taken extra care to support group cohesion while the researcher was
observing, and rather wait until the privacy of the interviews to discuss the significance of group cohesion in their work.

Figure 6 Group cohesion

6.1.2.4. Informal interactions

The significance of supporting active participation may be that it implies that it matters who is involved in the collaborative design work. When designers actively support participation in the collaborative process to generate the intentions and meanings with stakeholders, they interact in an informal way, given that negotiating and learning to cope with the influence of hierarchy, roles, and disciplinary approaches for example, is dealing with the composition of the group. Bringing the composition of the group to bear upon the collaborative design work is a rhetorical strategy that relates to context rather than universal logical methods (Tindale, 1999, pp. 77-80). Furthermore, being concerned with activating the knowledge and expertise of diverse participants to reduce the potential that something important might be left out, means that the premises cannot be specified in advance. Consequently the experiences and values of particular participants, and the composition of the group, affect the reasonableness of the design. For example, in Case 1: Industrial Design, the designers specifically integrated the experiences and values of the stakeholders into the design through testing the devices with the future users in the field. The composition of the collaborative team affected the intentions and meanings that were integrated into the design such that the merit of the design is more comprehensible because of who was involved in the design process.
6.1.3. Mode 3: Co-experiencing the Context

The interpretation of the data suggests co-experiencing the context supports learning as a reciprocal process between stakeholders that takes place over a series of interactions situated within a context, because immersion provides more opportunities to share direct experiences that may prompt participants to express greater variety of responses and impressions. In addition, stakeholders may find common ground between conflicting perspectives or assumptions since responses can be more quickly tested and elaborated upon, because there are more opportunities for participants to ask follow up questions and explore unanticipated lines of inquiry. This mode of interaction is influenced by two factors: immersion and learning.

6.1.3.1. Immersion within the context of the problem

This significance of immersion with collaboration was corroborated to a moderate degree within the data as shown in Figure 7. There were n=35 references coding this influencing factor, which situates this factor within the third quartile of results. The influence of immersion was shown more strongly in the interview data (n=69%) than in the observation field notes (n=31%), which indicates a moderate degree of methodological triangulation. However, the few immersion events observed, is probably due to the few opportunities available to the researcher to observe immersion events during the fieldwork, rather than an indication that immersion was not significant.

There was a low degree of data triangulation of the influence of immersion. The majority of references coding the influence of immersion within collaboration were found within Case 3: Design Research (n=50%). This result is probably due to the fact that conducting immersive ethnographic studies were a core activity that the research agency was employed to do. Moreover, immersion was an activity that the design researchers felt was one of their significant contributions to collaborative design work, so naturally this activity would be top of mind for these respondents and so we should expect a high number of references coding immersion within Case 3: Design Research.
Immersion was also a significant influencing factor in Case 1: Industrial Design (n=40%). This result may be due to the nature of product that the industrial design company produced, as well as their design process. Because Case 1: Industrial Design produces complex devices that must perform in remote environments, their design process necessarily required significant testing of prototypes in the field. The device had to operate successfully in extreme environmental conditions and the designers found that testing prototypes in the field through immersion with future users was more successful than relying on testing prototypes in a laboratory. In contrast, there were no references coding the influence of immersion with Case 3: Architecture. Here the nature of their architectural design work may also account for this result. This architectural practice specialised in small residential projects with a focus on making critical and cultural contributions to the discipline of architecture. Immersion within the context of the design problems that they typically engaged with did not require, for example, testing prototypes in remote environments. Consequently, it is understandable that immersion would not be top of mind as a significant aspect of their architectural design process. However, due to the critical and cultural nature of their practice, the architects reported that their projects required significant conversation and discussion with stakeholders to develop concepts to inform the design. I argue that “immersion” of the architects within the intellectual and historical context of their projects was essential to their practice. Moreover, it is understandable that the respondents would not describe this process of intellectual immersion using the same terms as the design research agency for example, and
therefore the lack of references coding this factor by the architects might be explained and the significance of immersion within collaboration maintained.

6.1.3.2. Learning within design activity

The number of references coding the influencing factor *Learning within Design Activity* (n=15) was within the first quartile of results as shown in Figure 8. Due to the low degree of corroboration of the factor, any conclusions derived from the data have a low degree of reliability. Furthermore, we can appreciate that the low degree of corroboration has also influenced the reliability of the degree of methodological triangulation and data triangulation that the data show. The results show that the majority of references are within the data from Case 1: Industrial Design (n=63%) and found more often in the interview data (n=60%) than the observation field notes (n=40%).

While there were few references to the influence of learning within collaboration, we can infer that learning was of comparatively more significance to the industrial designers. To the industrial designers, collaboration was more than sharing knowledge in an additive or serial manner; rather collaboration involved integrating knowledge from diverse domains. This may indicate a more interdisciplinary approach than a multidisciplinary approach.

![Figure 8 Learning within design activity](image)

6.1.3.3. Informal interactions

Like *Mode 2: Supporting Active Participation*, the significance of co-experiencing the context is that the stakeholders and users of the design affect the collaborative design process and the reasonableness of the design. Consequently, the design team may interact in an informal way
when they share direct experiences with the stakeholders of the design issue to reveal conflicting perspectives or assumptions to be addressed, since designing to address stakeholders’ needs and values means that the stakeholders contribute to the design process. Co-experiencing the context is an informal interaction because bringing the context to bear upon the collaborative work is a rhetorical strategy (Tindale, 1999, pp. 75-76). From a logical approach, who the stakeholders are and what they value is irrelevant to the rationality of the product. Likewise, in a dialectical critical discussion, the stakeholders are opponents that the designer intends to convince with their arguments. But in rhetorical argumentation, the stakeholders contribute to the persuasiveness by forming communion with the design team (Tindale, 1999, pp. 84-87). Furthermore, immersion activity is not only intellectual but involves the whole body within an experience. The environment acts on the senses and emotions of the team. For example, in Case 1: Industrial Design, when the designers participated in the everyday work of the stakeholders by co-experiencing the context together they were able to physically feel the substance of the behaviours and actions that the stakeholders employed in their everyday work. The designers gained empathy and learned from the stakeholders through social interaction, not only reported explicit statements. Co-experiencing the context supported the team to transform experience into knowledge that affected the design.

6.1.4. Mode 4: Integrating Knowledge with Iterative Prototyping

The interpretation of the data suggests that prototyping and iteration are approaches that designers use to integrate knowledge where parameters and features are highly interrelated and constantly changing, which enables the design to cross disciplinary boundaries and supports innovation at the detail level as well as meeting the broad issue. The team may develop new shared understanding by testing designs and exploring possibilities together, since appreciating different disciplines’ day-to-day logic of practice as well as fundamental knowledge challenges assumptions and beliefs. Three factors, integration, prototyping, and iteration influenced this mode of interaction.

6.1.4.1. Integration of knowledge

The number of references coding the influence of integration within collaboration (n=33) was within the third quartile of results. Figure 9 shows that two thirds of references coding this factor were from the interview transcripts, the remaining third from the observation field notes. This distribution of references indicates a moderate degree of methodological
triangulation for the influence of integration within collaboration. We can appreciate that it may be intuitive for the respondents to describe the importance of bringing together diverse experts in terms of integration of their knowledge. Moreover, we can expect that observing instances of integration of diverse knowledge would be comparatively less frequent than instances reported within interviews because integration of knowledge is an internal state that respondents can verbalise rather than a behaviour that the researcher can observe.

The significance of integration of knowledge within collaboration was shown within all case studies indicating a high degree of data triangulation. Two thirds of the references were distributed between Case 1: Industrial Design (n=36%) and Case 2: Architecture (n=30%). This may be due to the respective types of complexity informing the projects: the complex performance requirements for the industrial design company’s device necessitate integration of knowledge from engineering and natural sciences; the architectural practice’s critical and cultural approach requires integration of knowledge from the arts and humanities in particular. The comparatively fewer number of coding references in Case 3: Design Research may be due to a greater influence of objectivist psychological perspective within their approach, for example the design researchers commonly referred to “testing stimulus” on their research participants. This objectivist perspective is underpinned by a view that psychology is more rigorous than interpretivist approaches. Moreover taking this view may be understandable in Case 3: Design Research because the researchers that participated in this study were a small internal team that focussed on qualitative research, compared to the majority of the agency that conducted quantitative research. That the team often downplayed
the role of interpretation in their work, and framed their approach more as “testing”, could possibly be seen as a appeal for legitimacy with a business context that did not value qualitative research methods as highly as quantitative research methods.

6.1.4.2. Prototype testing

Prototyping was shown have significant influence within the respondents’ collaborative design process, with number of coding references (n=36) falling within the third quartile. Furthermore there was a high degree of methodological triangulation across the interview (n=47%) and observation (n=53%) data. However, as we can see in Figure 10, two thirds of the references coded data from Case 1: Industrial Design, while there were almost no references in prototyping within the data from Case 3: Design Research, which indicates a low level of data triangulation.

![Coding by case and Coding frequency](image)

Figure 10 Prototype testing

Prototype testing is a core aspect of the tradition of industrial design and so we can expect that there would be a significant influence of prototyping within the data from Case 1: Industrial Design. Interestingly, the very low number of references coding Case 3: Design Research (n=1%) as well the very low number of references from this case also coding factor Iteration may indicate that the design research process was undertaken in a comparatively more linear sequence than the industrial design or architectural design processes. This more linear approach is probably due to the significant costs that would be involved in conducting immersive ethnographic fieldwork using an iterative prototyping approach. Moreover, while the design researchers conducted ethnographic fieldwork with stakeholders and designers,
after the fieldwork had been conducted and the insights delivered, the research agency was not significantly involved in the conceptual development of the products. This more linear sequence limits the researchers’ ability to prototype ideas within the broader design process of their client’s design processes.

6.1.4.3. Iteration within the design process

The influence of iteration was a highly corroborated in the data (n=40), with the number of references coding the factor falling within the fourth quartile. Moreover, the there was a high level of methodological triangulation with the references distributed almost evenly across the interview transcripts (n=48%) and the observation field notes (n=52%). As Figure 11 shows, iteration was significant from the respondents’ point of view and it was reinforced within the observation data.

![Figure 11 Iteration within the design process](image)

The majority of references were within the data from Case 1: Industrial Design (n=45%), Case 2: Architecture (n=29%), and Case 4: Interview Study (n=24%). There were very few references shown in Case 4: Design Research (n=2%). The very low number of references within the Design Research agency, as indicated in the previous section, may be due to their more linear design research process. The high degree of iteration shown within the industrial design company and architectural practice is consistent with our common understanding of group work based design processes within more traditional design disciplines. It should also be noted that the significance of iteration within Case 1: Industrial Design was an intentional approach employed by the designers to cope with difficulty of developing a design where the
device is very complex, the environment it must perform in is unpredictable, and the components heavily dynamically interrelated meaning that small changes can have large effects.

6.1.4.4. Informal interactions
The collaborative activity of integrating knowledge suggests that it may be partly dialectical and partly rhetorical since the activity relies on both the dialogue and expression of the participants. Therefore, this mode may be considered to involve informal interactions, given that the process of originating meanings and synthesising knowledge by testing ideas back and forth against different participants’ worldviews and the environment is affected by the medium of expression and the knowledge and values of the participants involved. When the medium of expression of the concepts—a drawing, a model, or an artefact for instance—affects the reasonableness and persuasiveness of the design, it brings values into presence by acting on the senses of the participants, not only their intellect. Consequently, there is a rhetorical dimension, since who is involved and how they express their knowledge bears upon the design process (Tindale, 1999, pp. 80-84). Furthermore, there is a dialectical dimension when the iterative cycles of prototype testing become a critical discussion of proposals. Within the informal interactions of integration of knowledge, the medium of expression is not only limited to explicit statements as in a logical proof, but in terms of visualisations and artefacts that retain implicit knowledge and act on the participants’ senses.

6.1.5. Mode 5: Maintaining the Continuity of the Design Activity

The interpretation of the data suggests that designers deal with uncertainty in their work by balancing ambiguity and control through using analogy to create common ground from which to prompt something new. Breakdowns within the continuity of the design activity are closely connected to instances of disagreement, but when the participants couch ideas in humour and self-doubt, or use tentative language when making suggestions, they keep the design development moving to explore the implications of stakeholders’ responses while maintaining shared understanding. This mode of interaction is influenced by two factors: continuity and analogy.

6.1.5.1 Continuity of flow within design activity
Taking care to maintain the flow of design activity within collaborative work was shown to be an influential factor with a high number of coding references (n=50) placing this factor
within the fourth quartile of results. Moreover, there was a strong degree of methodological triangulation between the interview transcripts (n=46%) and the observation field notes (n=54%). This result indicates that the influence of maintaining the flow of design activity was well corroborated within the data. This high degree of corroborated data is supported by a moderately high degree of data triangulation, with references from all cases well represented within the data as shown in Figure 12. Case 2: Architecture featured the highest proportion (n=42%) of references coding the influence of maintaining the flow of design activity, which is consistent with the high influence of iteration within the architects’ design process and low impact of hierarchical control of decision-making within the group.

6.1.5.2. Using analogical reasoning
The number of references coding the influence of analogical reasoning within the data (n=20) was within the second quartile. A moderate degree of methodological triangulation was shown, with the majority of references within the observation field notes (n=70%) rather than the interview transcripts (n=30%). This result is unexpected to a degree because analogy is commonly associated with reasoning, an internal state that respondents should more easily articulate when describing their behaviour rather than an activity that the researcher can observe. However, the field notes show that analogy was significant in interdisciplinary interactions where respondents utilised sketches and models to communicate ideas across disciplinary boundaries. The role of analogy was shown particularly strongly in Case 1: Industrial Design.
Figure 13 shows that there was a high degree of data triangulation with coding references distributed across all cases. More than half the references were coded within Case 1: Industrial Design (n=57%) indicating that analogical reasoning was a significant aspect of the company’s design process. The work at Case 1: Industrial Design required a high level of integration of knowledge from different disciplines including traditional design disciplines such as industrial design, engineering, and human factors, but their work also required significant input from ethology, conservation biology and habitat conservation. Analogy was a technique that played an important role in translating knowledge between these different disciplines and as a support for implementation of insights into product concepts. Moreover, as the design process at Case 1: Industrial Design was strongly influenced by an iterative prototype testing approach the use of analogy was an important technique to adapt existing technologies to new applications.

6.1.5.3. Informal interactions

Like Mode 4: Integrating Knowledge with Iterative Prototyping, the interactions involved in maintaining the continuity of the design activity indicate that the generation of ideas in collaborative design is influenced by the dialogue and expression of the participants. The design team may interact in an informal manner when, for example, the participants couch their ideas in humour and self-doubt, or use tentative language when making suggestions, or bracket disagreement to keep the conversation flowing, since they moderate and adapt their expression to the qualities of the design team. Because the participants take the composition
of the design team into account during the collaborative work then it is reasonable to suggest that their design process is influenced by rhetorical argumentation (Tindale, 1999, pp. 77-80). Furthermore, the use of analogy is an informal form of reasoning since it is a technique that uses common ground to introduce something new by showing similarity between the two pairs involved. Evoking similarity is a rhetorical technique rather than a method of logical inference. However, using rhetorical aspects to maintain the flow of the design activity was not primarily directed towards winning a debate or proving one party’s proposal was correct, but at keeping the generation of ideas progressing.

6.1.6. Mode 6: Mediating Designing with Artefacts

The interpretation of the data suggests that designers use artefacts as mediators to support stakeholders to develop shared understanding and cross disciplinary and professional barriers, by making issues more concrete and more detailed. Artefacts are used to bring stakeholders’ everyday social and cultural context into meaningful presence to provoke designers’ empathy and imagination. The role of artefacts as mediators also synchronizes knowledge within the group since the sketches and analogies retain tacit knowledge that is shared though not fully rendered explicit. Two factors, artefacts and synchronisation influence this mode of interaction.

6.1.6.1. Mediation of interactions by artefacts

The mediation of interactions with artefacts is a factor influencing collaboration that has both a high level of methodological triangulation and data triangulation. As shown in Figure 14, the number of references coding this factor was within the second quartile (n=28), indicating a medium degree of support within the data. Furthermore, there was an even distribution of references coding the interview data (n=50%) and the observation field notes (n=50%). This shows that the respondents articulated the significance of artefacts as mediators within their work and that this perspective was corroborated through my observations of their design activity. Moreover, references coding the influence of artefacts as mediators of collaborative interactions where shown within all the case studies. Interestingly, the highest number of references was coding the data from Case 3: Design Research (n=40%) rather than the “traditional” design professions of industrial design (n=23%) and architecture (n=14%).

The comparatively higher number of references coding Case 3: Design Research is due to taking a broad meaning of the term “artefact” to include data collection stimulus, for example product prototypes and concepts, as well as research instruments such as interview
questionnaires and self-documentation booklets. Furthermore, the design researchers’ data analysis and synthesis processes were mediated through artefacts such as sticky notes, persona profiles, and in particular, articulation of research insights and recommendations through the preparation of slide presentations. This result shows that, when taking a broad view, artefacts may play just as a significant role within the professional practice of design research, a design profession that is commonly considered to be less “practical” than design disciplines with a long history of craft skills.

6.1.6.2. Synchronisation of knowledge

There were few references (n=10) coding the influencing factor *Synchronisation of Knowledge*, which situated this factor within the first quartile of results. Consequently, there is a low reliability of the conclusions drawn from this data. Figure 15 shows that synchronisation of knowledge was not top-of-mind for the respondents due and references were distributed between only two cases.
6.1.6.3. Informal interactions

The significance of mediating design activity with artefacts is that the communication between the participants acts on the participants’ senses as well as their intellect. Mediation with artefacts may make the object of discourse more present to the participants and subsequently support sharing knowledge across communication barriers by overcoming jargon and breaking down differences between experts and non-experts. These aspects may be considered as informal interactions given that they imply that communication in collaborative design may not only be supported through formalising messages in explicit statements but also by getting the other participants to listen. Supporting listening implies that communication is not merely about logical demonstration but adapting expression to the qualities of the group. When the designers use artefacts, drawings, stories, scenarios and so on within the collaborative activity, they make issues more concrete and more detailed and locate group discussion on particular aspects. Adapting the medium of expression and considering the composition of the participants can be considered as rhetorical strategies that aim to make an object of discourse present to the mind to establish commonalities between the interlocutors (Tindale, 1999, pp. 80-84).

6.1.7. Mode 7: Building Shared Understanding with Interpretation

The interpretation of the data suggests that designers used an interpretive approach to build shared understanding and to gain empathy and insight. Using conversation and dialogue embeds differences in worldview within the negotiated interpretation. Sharing understanding
of each other’s intentions and worldview reduces mistrust, because the testimony of the participant’s knowledge seems more justified and believable, therefore reducing the potential for conflict. This mode of interaction is influenced by two factors: shared understanding and conflicting worldview.

6.1.7.1. Shared understanding of the problem

The number of references coding the influence of shared understanding within the data (n=27) was within the second quartile. A low degree of methodological triangulation was shown, with the majority of references within the interview transcripts (n=85%) rather than the observation field notes (n=15%). This result is expected to a degree because understanding is an internal state that respondents can more easily describe verbally than an activity that the researcher can observe. As we can see in Figure 16, there was a moderate to high level of data triangulation, with references coding all cases but with close to half the references coding Case 4: Interview Study (n=48%). This result indicates that developing shared understanding is an important factor across the design disciplines. Furthermore, the result is more greatly corroborated because the majority of references were shown with the data from Case 4: Interview Study where the respondents were drawn from many different design disciplines.

6.1.7.2. Conflict due to differences of worldview

Conflict due to differences in worldview was shown to have an important influence on the collaborative design work of the respondents with the number of references coding this
factor (n=26) falling within the second quartile. This moderate degree of corroboration was distributed with approximately two-thirds within the interview transcripts (n=65%) and one-third within the observation field notes (n=35%), indicating a medium degree of methodological triangulation (Figure 17). When respondents were interviewed about their experiences of collaborative work, the discussion of difficult aspects of collaboration commonly concerned clashing personalities and approaches. While there were fewer events overtly displaying conflicts in worldview, we can attribute this as an effect of the participant-as-observer role taken by the researcher. It is understandable that the respondents might take special care to hide conflicts from the researcher’s observations and rather reveal the significance of conflicting worldviews within the privacy of an interview.

![Coding by case](image)

![Coding frequency](image)

**Figure 17 Conflict due to differences of worldview**

6.1.7.3. Informal interactions

The significance of using an interpretive approach to building shared understanding is that it suggests that the features of the issue that the design team addresses are not given in advance as self-evident facts: the team negotiates which aspects to emphasise and which to leave in the background. The process involves participants’ values as well as facts, and generates agreement on the premises and shared identity. The interpretive process can involve ongoing negotiation of conflicting worldviews and values to build agreement on the intentions and meanings of the design work. Consequently, building shared understanding with interpretation may be considered an informal interaction, given that the participants discussed and negotiated their agreement of the issues to address. Since negotiating the premises is an interpretive technique that emphasises certain aspects over others in light of
facts and that particular participants’ worldviews, then it may be considered a rhetorical strategy because agreement of the premises is more intelligible in relation to the particular team members’ values and not only a matter of the internal relations of the reasoning (Tindale, 1999, pp. 109-112). Furthermore, the use of conversation and dialogue, where pro and con positions on interpretation of the premises were discussed, also indicates a dialectical dimension to building shared understanding.

6.1.8. Mode 8: Reflective Dialogue

The interpretation of the data suggests that communication in collaborative design activity concerns developing ideas and reaching acceptable solutions through dialogue. Dialogue is different than communication of information because it involves feedback and interactive reflection between participants to evaluate progress, develop understanding, and investigate opportunities. Dialogue may involve outward explanation and inner self-reflection to support reasoning between participants where they adjust their behaviour and interpret their own actions. Two factors, communication and reflection influence this mode of interaction.

6.1.8.1. Communication

Communication was the most highly corroborated factor identified in the data. There were almost two times as many coding references to communication (n=86) than to the second most corroborated factor (continuity with n=50). Communication can reasonably be considered as an outlier factor because it was so highly corroborated compared to the other factors. Figure 18 shows that there was a moderately high degree of methodological triangulation with a greater number of references with the observation field notes (n=60%) than the interview transcriptions (n=40%), however, this is expected due to the behavioural nature of communication. The degree of data triangulation was also moderately high, with most references distributed between Case 2: Architecture (n=34%), Case 3: Design Research (n=37%) and Case 4: Interview Study (n=21%), than Case 1: Industrial Design (n=8%).

The relatively low degree of significance of communication within Case 1: Industrial Design can be accounted for due to the high degree of influence of prototyping within their design process as well as the influence of using artefacts as mediators. Consequently we can infer that communication using artefacts and prototypes was comparatively more significant for the industrial designers rather than verbal or written communication.
6.1.8.2. Reflection within design activity

Reflection is revealed in the literature to be a significant aspect of professional design activity (Schön, 1990, 1992, 1995; Valkenburg, 2000; Valkenburg & Dorst, 1998), however, interestingly it was not top of mind for the respondents, as we can see in Figure 19. In fact, the influence of reflection was the least corroborated factor within the data (n=9). Furthermore, of the few references to reflection, most were from the observation field notes (n=78%) rather than the interview transcripts (n=22%). This is a curious distribution because reflection is an internal state that we should expect respondents to articulate verbally rather than an activity that a researcher would observe. Without further research it is unclear whether or not this result is a significant contradiction to the prevailing consensus in the literature that reflection is essential to professional design practice.

The majority of coding references for influence of reflection were within Case 1: Industrial Design (n=67%), there were no references within Case 2: Architecture. This indicates a low degree of data triangulation. However, these results may be unreliable due to the few references actually recorded; consequently the significance of reflection within collaborative design activity cannot be determined within the data from this research alone.
6.1.8.3. Informal interactions

Reflective dialogue represents the most explicitly dialectical mode of interaction disclosed within this research, given that the data suggest that the team used communication by face-to-face conversation to express their perspectives and receive feedback to co-develop acceptable concepts. The counter play of outward explanation, feedback, and inner self-reflection shows that the team members’ questioned differences in each other’s opinions. The activity of exchanging speech to establish acceptable concepts against different standpoints is a dialectical approach, and so reflective dialogue may be considered as an informal interaction. All the cases show references to communication and dialogue so this mode is highly corroborated. This result indicates that communication in collaborative design activity may not merely involve transferring information but dialectically developing the intentions and concepts together in the group.

6.1.9. Mode 9: Contributing to Culture

The interpretation of the data suggests that designers may be more likely to overcome the difficulties of working together and contribute their knowledge to the team when they feel the work will make a contribution that goes beyond the project deliverables and involves considering the place of design within culture and community. This mode of interaction is influenced by two factors: sharedness of common goals and contribution to culture.
6.1.9.1. Sharedness of common goal

The number of references coding the influence of sharing a common goal (n=25) was in the second quartile of results. Almost all references were within the interview data (n=96%) rather than the observation field notes (n=4%), which indicate a low level of methodological triangulation. However, due to the cognitive nature of goals we might expect the distribution to be skewed towards the interview data. The majority of references code data from Case 3: Design Research (n=45%) and Case 4: Interview Study (n=32%), with few references found within Case 1: Industrial Design (n=7%) and Case 2: Architecture (n=16%) (Figure 20).

There is a possible link between significance of the influence of sharing a common goal within Case 3: Design Research and the high degree of influence of hierarchical control of decision making. The design research team had to carefully work with many different stakeholders from large companies where decisions often required approval from executives outside the immediate team. This situation may account for the significance of sharing a common goal being top of mind for the design researchers.

6.1.9.2. Meeting high-level goals and contributing to culture

The significance of collaboration as a means to meet high-level goals and to contribute to culture was shown to be of particular significance to the designers from Case 1: Industrial design (n=31%) and Case 2: Architecture (n=48%). Figure 21 shows that the number of references (n=33) coding the factor was within the third quartile meaning that the degree of corroboration was moderately high.
6.1.9.3. Informal interactions

The significance of the mode of contributing to culture is that it shows that the success of the design is not merely concerned with matching features of the design to given requirements. In collaborative approaches the success of the design may be more intelligible in relation to higher cultural and contextual contributions of the work. A high-level goal may work as a shared idea of reasonableness that is based on the expected beliefs and values of the future users and communities. The success of the design may be more cogently assessed with regard to its relevance and acceptability to the expected higher-level contribution rather than standards of self-evident timeless validity. Consequently, we may consider the mode of contribution to culture as an informal interaction. Looking outward beyond the immediate tasks of the project to make higher-level contributions to culture and to encourage dialogue with the community involves to constructing a figure of reasonableness that is drawn from a particular context. When reasonableness is intelligible in relation to its relevance and acceptability to the expected values and beliefs drawn from a particular community, rather than standards of self-evident timeless validity, then it may be considered as a rhetorical strategy (Tindale, 1999, pp. 117-120). For example, the success of Case 1: Industrial Design’s device is more intelligible in relation to their goals of conserving a particular region’s biodiversity using methods that are humane and targeted. Similarly, Case 2: Architecture was concerned with creating architecture that responded to cultural conditions of particular contexts and not only objective engineering requirements. These are models of
reasonableness that indicate that the design’s success is not fully reducible to whether their features are logically correct but to values drawn from a specific cultural context.

6.2. Conclusion

This chapter has investigated the distribution of the modes between the cases, and considered the significance of informal interactions in collaborative design activity. The common thread across all the cases was the understanding of interdisciplinary collaborative design as an approach that involved forming a diverse team that builds shared understanding within the group to respond to a complex issue. The complexity of the issue is due to social and cultural context of the issue but also the meaning of the design work. Building shared understanding is needed to deal with conflicting worldviews of the participants. The approach to collaboration within Case 1: Industrial Design was probably the most interdisciplinary. The team learned from each other by using immersion in the context to test prototypes with stakeholders in iterative cycles. In contrast, while immersion was also highly corroborated in Case 3: Design Research, here immersion was more a service that the researchers provided, rather than an opportunity for reciprocal learning. While iterative prototyping was highly corroborated in Case 2: Architecture, immersion in the context was not, and this may be consistent with the subject matter of architecture and their approach of using drawing to develop their designs within a group “design conversation”. Furthermore, their architectural practice was perhaps more concerned with design as a form of meaningful production that contributes to culture rather than addressing a complex socio-technical design issue. The collaborative work of Case 3: Design Research was probably the least interdisciplinary. This may be due to their more linear approach with less focus on learning or integrating knowledge. Collaboration within the context of Case 3: Design Research was probably a response to conflict due to the high influence of the social complexity of their work and the impact of hierarchy and roles within the large group of stakeholders.

My interpretation of insights of the activities that the design teams performed during their collaborative design practice also reveals the influence of informal interactions in their work. The significance of informal interactions in collaborative design activity may be that it reveals how the design teams utilised aspects of the context within their reasoning. Table 5 presents a model of nine modes of informal interactions that people in interdisciplinary design teams may employ in collaborative design activity.
Table 5

Model of Informal Interactions in Collaborative Design Activity

<table>
<thead>
<tr>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Adapt the work to the place and the background of the issue to strengthen its connection to its setting given that success depends on everyone’s success since design issues are set within a system with particular conditions.</td>
</tr>
<tr>
<td>2. Work with others to agree on responsibilities to keep group members actively engaged in the design project to bring their knowledge and values to bear on the design.</td>
</tr>
<tr>
<td>3. Share direct experiences of the setting with stakeholders to understand people's worlds and learn since the conditions act on the senses of the team not only their thinking because including the whole body within an experience helps to incorporate stakeholders’ values into the design process.</td>
</tr>
<tr>
<td>4. Adapt the medium of expression of ideas to the participants and act on their senses to bring values into presence, since who is involved and how they express their knowledge matters. Structure the activity as a discussion that brings together different ideas by testing and redesigning prototypes with group members to find more weak points and potential for creating something new.</td>
</tr>
<tr>
<td>5. Keep the design activity moving forward by adapting the medium of expression to the qualities of the group, balancing many meanings, and by using analogy to create new ideas while building on common ground.</td>
</tr>
<tr>
<td>6. Use stories, images, and artefacts in conversation to make issues more real and clear and bring out empathy and imagination. Use communication that acts on the participants’ senses as well as their thinking to get the other people to listen by making the messages present to the mind to establish communion within the group.</td>
</tr>
<tr>
<td>7. Build agreement on the issues the group faces by creating local accounts of how things work through working with others to decide which aspects are important to focus on and which to leave in the background. Integrate participants’ values as well as facts to create agreement and build shared identity.</td>
</tr>
<tr>
<td>8. Use dialogue to give messages context and develop ideas. Exchange a counter play of speech acts through outward explanation, feedback, and inner self-reflection that questions differences in each other’s opinions to establish acceptable ideas against different points of view.</td>
</tr>
<tr>
<td>9. Support group members’ desire aim beyond the immediate demands of the project and to contribute to the community and culture. Build a shared idea of success that is connected to the expected beliefs and values of future users and communities.</td>
</tr>
</tbody>
</table>

The model of informal interactions presented in Table 5 indicates that people engaging collaborative design may share experiences, integrate perspectives, build interpretations, and learn through their social interactions. Consequently, we can see that collaborative design activity involves working within the context of social interaction. First, through adapting the substance of the design work to the locality and background of the issue. Second, by bringing the stakeholders’ values to bear upon the design process through co-experiencing the context.
together, and by mediating communication with artefacts. Third, by negotiating agreement on the premises and creating shared identity, through prototype testing through iterative cycles within a discussion of proposals, and by adapting their expression to the qualities of the group to establish acceptable concepts against different standpoints. Fourth, by looking outward beyond the immediate tasks of the project towards making higher-level contributions to culture where success is intelligible in relation to its relevance and acceptability to the expected values and beliefs drawn from a particular community, rather than standards of self-evident timeless validity.

In this chapter I have considered the variation between the cases by reporting the results of the analysis of the coding for each influencing factor within each mode of interaction. Furthermore I have answered the second research question *What is the significance of informal interactions in collaborative design activity?* by presenting a model that articulates ways that design teams may utilise aspects of context within their reasoning.
This research project indicates that informal interactions probably influence aspects of successful collaborative design activity. The interpretation of the data suggests that informal interactions may support collaborative design team to bring context to bear upon their design work. In this chapter I compare the model of informal interactions with two theories of collaborative design that take the context of innovation as a crucial aspect of their approaches. First, Ikujiro Nonaka’s (Nonaka, 1994; Nonaka & Konno, 1998; Nonaka & Takeuchi, 1995) theory of organisational knowledge creation, second, Jacob Buur’s (Buur et al., 2013; Buur & Larsen, 2010; Buur & Matthews, 2008; Buur & Mitchell, 2011; Buur & Sitorus, 2007) participatory innovation approach to business model design. Considering these theories helps to contextualise and evaluate the significance and limitations of the model of informal interactions.

7.1. Organisational Knowledge Creation

All firms are in essence knowledge organizations. Their ability to outperform the marketplace rests on the continuous generation and synthesis of collective, organizational knowledge. For all organizations, the cultivation of this knowledge—often an implicit, unreflecting cultivation—is the essence of developing a core competency to maintain the organization and resist its dissolution. (J. S. Brown & Duguid, 1998, p. 91)

Nonaka (1994, p. 14) argues that the pressures of the knowledge economy mean that firms cannot simply process information but must innovate through creating organisational knowledge. According to Nonaka (1994, p. 24), experience-sharing and continuous dialogue of cross-functional teams are the basic building blocks of the organisation's knowledge

creation cycle. Furthermore, leaders can foster the dynamism of knowledge creation by developing visionary proposals and giving individuals resources to participate in the full knowledge creation cycle (Nonaka & Konno, 1998, p. 53). According to Friedman (2001, p. 10) the design process is a system without a central actor; it is a network of linked events which implies that designers can only succeed when the entire team succeeds. The team can create knowledge by reflection but also strategic judgement for the future through understanding the interactions of events in the complex network of the design process (Friedman, 2001, p. 14). Explanations of why and how events in the network interact is a source of better design practice and creates knowledge that serves the longer term needs of the field (Friedman, 2001, p. 21). Strategic judgement and explanation supports the knowledge creation cycle by transforming and converting knowledge across the epistemological spectrum and through ontological levels from individuals, to groups, to organisations, then inter-organisationally, and finally up to the social and cultural knowledge scales (Friedman, 2001, p. 15). The general principles and specific skills needed to understand and explain the systemic network of the design process and strategic judgement to convert knowledge and shift it ontologically, is what distinguishes design professionals prepared to work within the knowledge economy from designers who craft objects.

7.1.1. The Knowledge Creation Cycle

From Nonaka’s knowledge management perspective, collaborative design is an activity that forms part of a knowledge creation cycle. When stakeholders collaborate, they undertake various activities that convert knowledge between tacit and explicit forms. Tacit knowledge is beliefs, intuitions, know-how, or skills that apply to specific contexts and behavioural patterns that are embodied practice (Nonaka, 1994, p. 16). Explicit knowledge is knowledge that is expressed in words or numbers or formula, and which can be codified in statements and databases (Nonaka, 1994, p. 16). According to Nonaka’s (1994; Nonaka & Konno, 1998; Nonaka & Takeuchi, 1995) S.E.C.I. model, this process of knowledge conversion brings knowledge out of action and experience into judgment and interpretation. It is though the processes of converting knowledge across the epistemological spectrum and through ontological levels that organisations create knowledge (Nonaka & Takeuchi, 1995, p. 72). According to Nonaka’s (1994, p. 19) S.E.C.I. theory, knowledge is shifted and transformed between tacit and explicit forms through four types of knowledge conversion: socialization, externalization, combination, and internalization. Significantly, Nonaka’s theory asserts that when
the four modes of knowledge conversion dynamically interact, knowledge can be produced at a higher ontological level. Nonaka (1994) describes this dynamic dialectical interaction that creates organisational knowledge as a spiral:

… organizational knowledge creation can be viewed as an upward spiral process, starting at the individual level moving up to the collective (group) level, and then to the organizational level, sometimes reaching out to the interorganizational level. (p. 20)

The first type of knowledge conversion is socialization. Socialization is a process that transfers tacit knowledge in one individual to tacit knowledge in another individual through sharing experiences and learning through observation, imitation, and practice (Nonaka, 1994, p. 19). Socialization can occur through direct interactions and experiences without the use of language. The second type of knowledge conversion makes tacit knowledge explicit through externalization. This process may involve an individual articulating their ideas and beliefs in words and analogies. In addition, externalization may occur when one individual facilitates another individual to articulate their tacit knowledge into an understandable form through dialogue (Nonaka, 1994, p. 19). The third type of knowledge conversion encompasses converting explicit knowledge into explicit knowledge through combination. When individuals sort and reconfigure existing information by editing, recategorizing, and recontextualizing explicit knowledge in documents and databases they convert knowledge through combination (Nonaka, 1994, p. 19). According to Nonaka (1994, p. 19), transforming explicit knowledge into tacit knowledge through internalization is the fourth mode of knowledge conversion. Internalization is the embodiment of explicit knowledge in practice through putting strategies and programmes in action—a process of learning by doing (Nonaka & Konno, 1998, p. 45). This mode of learning is inseparable from practice because it is socially constructed and contextually situated through sharing stories and opinions in an informal community, rather than transferred through training (J. S. Brown & Duguid, 1991, pp. 46-47). Here, learning is not a formal process of receiving abstract “expert” knowledge but learning by becoming a practitioner rather than learning about practice. Situated learning through internalization produces know-how through tacit experience in practice (J. S. Brown & Duguid, 1998, p. 95). Furthermore, the four modes of knowledge creation converts knowledge through ontological levels:

[An] organization cannot create knowledge by itself. Tacit knowledge of individuals is the basis of organizational knowledge creation. The organization has to mobilize tacit knowledge created and accumulated at the individual level. The mobilized tacit knowledge is “organizationally” amplified through four modes of knowledge conversion and crystallized at higher ontological levels. We call this the “knowledge spiral,” in which the
interaction between tacit knowledge and explicit knowledge will become larger in scale as it moves up the ontological levels. Thus, organization knowledge creation is a spiral process, starting at the individual level and moving up through expanding communities of interaction, that crosses sectional, departmental, divisional, and organizational boundaries. (Nonaka & Takeuchi, 1995, p. 72)

The ontological levels of an organisation can be depicted in a hierarchical model. We can view an organisation with a strategic level consisting of corporate and then business levels, and then below that a tactical level containing products and design aspects. According to Nonaka’s (1994, p. 20) S.E.C.I. theory, innovation is created when the spiral of organisational knowledge creation shifts knowledge from the tactical level of design opportunities up to the strategic level of business opportunities, and then back into practice. Consequently we can see that the role of design is not only to focus on individual design solutions, but also should create organisational knowledge out of individual experience and integrate it at business, corporate, and cultural levels, and then link theory to practice.

### 7.1.2. Dialectic and Meaning

Both the model of informal interactions that I outlined in chapter six and the S.E.C.I. model are models of knowledge processes. The S.E.C.I. model presents a process of knowledge conversion that brings knowledge out of action and experience into judgment and interpretation by experience-sharing and continuous dialogue of cross-functional teams. Similarly, the insights from the model of informal interactions disclosed interactions such as originating meanings and synthesising knowledge by testing ideas back and forth within a discussion, and responding to a controversial issue by testing and combining knowledge from different sources to produce a more comprehensive understanding. Consequently, we can see that both models involve working with knowledge, changing it, and transforming it. Furthermore, both models support working with tacit knowledge and not only knowledge codified in explicit statements or assertions.

There are specific interactions that the model of informal interactions and the S.E.C.I. model share. Given that both models theorise that complex industrial products and services are embedded in interacting systems, and that the knowledge creation process is built upon sharing experience and continuous dialogue within cross-functional teams. Like the model of informal interactions, the S.E.C.I. model indicates that co-experience through immersion transforms experience and converts individuals’ tacit knowledge amongst the team through socialization. Socialization also supports integration of knowledge through communities of
interaction that facilitate direct encounters and face-to-face experiences. Also, dialogue converts tacit knowledge into explicit knowledge through externalization. Moreover, the process of externalization is an essential mode of interaction that supports building shared understanding in the team. Lastly, learning by embodying knowledge in practice by testing strategies and prototypes in action supports internalization.

Nonaka describes the S.E.C.I. model of organisational knowledge creation as a dialectical process that centres on the dynamic synthesis of two dimensions, first, tacit knowledge and explicit knowledge, and second, individual agency and social structure. This sense of “dialectic” is closer to philosophical theories of development, such as in Hegel or Marx, where a thesis gives rise to an antithesis and the resulting contradiction is resolved by means of a synthesis, rather than as a form of critical discussion aimed at resolving a difference of opinion put towards a standpoint. Nonaka describes dialectic as a method of thinking and acting, rather than argumentation. When considering the S.E.C.I. model from the perspective of argumentation, we cannot say that one participant’s tacit skill is a standpoint that refutes another participant’s explicit assertion in the same way that interlocutors exchange discussion moves during a debate about the pros and cons of an issue. Therefore, Nonaka’s model of the interaction between tacit and explicit knowledge, and individual agency and social structure, is unlikely to be considered as a model of dialectical argumentation in the same sense as Rittel’s argumentative model of design. Consequently, Nonaka’s perspective on dialectic is best understood as a philosophical system rather than as a theory of argumentation as defined in the tradition of informal logic that I outlined in chapter three. Nevertheless, the crucial significance of dialogue within Nonaka’s externalization mode of knowledge conversion lends support to the S.E.C.I. model as involving aspects of argumentation. Indeed, Nonaka characterises dialogue as an opportunity to test hypotheses and assumptions, where participants exchange positions and build shared understanding through face-to-face communication.

A key aspect of Nonaka’s S.E.C.I. model is that the movement of knowledge through the four modes is a spiral rather than a circle. When knowledge is converted, it is amplified and mobilised amongst the participants. Nonaka’s model presents a dynamic process of social learning that creates shared common knowledge within the group. This common knowledge supports the participants to develop critical comprehension that can guide their perception and action to solve problems rather than repeat or imitate existing ideas. Nonaka presents a powerful model of organisational learning that shares several close similarities to the model
of informal interactions, however, the dimension of ontological conversion of knowledge that Nonaka’s model proposes was not strongly supported within the analysis of the fieldwork from the case studies in this research project. The case studies showed few techniques in place to support and manage the form of organisational knowledge creation that Nonaka’s model advocates. However, an intuitive understanding of the necessity of ontological knowledge conversion may have been shown within the mode of informal interaction of aiming beyond the immediate limits of the given design issue to contribute to social and cultural domains. Furthermore, since Nonaka’s S.E.C.I. model is a model of social learning, the output of the knowledge creation cycle is not a collection of information but a richer stock of knowledge held by the individual participants that provides critical comprehension and mastery of practice. This notion indicates that Nonaka’s model is closer to a process of critical inquiry rather than the production of outputs such as guidelines and tools. Furthermore, critical inquiry can be supported by skilful use of argumentation, since the movement from reflection to strategy requires judgment, and judgement can be supported by identification and evaluation of arguments and reasoning.

The discussion of Nonaka’s theory of organisational knowledge creation has identified several similarities and differences with the model of informal interactions. Furthermore this discussion highlights two significant implications for this investigation of collaborative design activity. First, that the role of collaboration should be expanded to constitute a knowledge creation process that operates at the level of organisational knowledge, rather than in terms of crafting object and products. Second, that Nonaka’s S.E.C.I. model is aligned with a model of collaboration that takes epistemology as its focus, while in contrast, the model of informal interactions is more closely focused on the supporting the meaningfulness of communication within the community of participants.

The concept of collaborative design activity as a knowledge building process that should operate at the level of the organisation lends supports to the role of design thinking and action as a strategic endeavour. Meaning that the model of informal interactions should take into account the wider organisational context, and that collaborative design should take a strategic approach to support community and organisational level innovation. Furthermore, the claim that Nonaka’s model of knowledge creation is more closely aligned with a model of collaboration that takes epistemology as its focus is highlighted by the emphasis that Nonaka places on the type of knowledge as either tacit or explicit. Nonaka’s emphasis on conversion of knowledge types is a useful philosophical system that can account for crucial interactions.
in design that are not codified as explicit statements or assertions, for example the roles of prototyping, mediating artefacts, and immersion activities. However, a limitation of this epistemological focus is that the S.E.C.I. model may lack detail on how to support the meaningfulness of the knowledge within the community of participants.

The investigation of Nonaka’s theory of organisational knowledge creation has highlighted several important aspects for evaluating the model of informal interactions. To gain a more comprehensive understanding of the issues, in the next section I will consider participatory innovation and the business model design approach.

### 7.2. Participatory Innovation

Participatory innovation focuses on developing techniques for facilitating participatory design workshops that aim to provoke discussion and support reflective practice (Boer, Donovan, & Buur, 2013; Buur et al., 2013; Buur & Larsen, 2010; Buur & Matthews, 2008; Buur & Mitchell, 2011; Buur & Sitorus, 2007; Gudiksen, Poulsen, & Buur, 2014; Pedersen, Buur, & Djadjadiningrat, 2003). The participatory innovation approach rests on the notion that since innovation increasingly requires collaboration with external parties, then cross-disciplinary conversation is essential to discuss not only product concepts but also organisational issues (Buur et al., 2013, p. 55). Buur and Larsen (2010) describe participatory innovation as “an approach that seeks to combine participatory design and design anthropology with a business orientation” (p. 122). Participatory innovation integrates “the depth of design anthropology with the methods of participatory design and the technological and market orientation of lead-user methods [and so] offers the potential to address some of these organisational issues in a way that has not been pursued until now” (Buur et al., 2013, p. 271). Buur et al. (2013) describe participatory innovation as:

- Participatory innovation gathers theories and methods from across different academic fields to describe how people outside an organisation can contribute to its innovation, and identify ways for industry, the public sector and communities to expand innovation through the participation of users, employees, suppliers, citizens, members, etc., on a strategic level, in concrete methods and in day-to-day interactions. (p. 57)

According to Boer et al. (2013) both human-centred innovation in product design and in organisational culture aim to change stakeholders’ “fundamental, unconscious, shared values and beliefs… to trigger dialectical processes of change within the organisation, to encourage fundamental assumptions to surface” (p. 76). Boer et al. (2013, p. 86) state that objects and visualisations spread and sustain human-centred arguments within organisations to critique
prevailing values, contextualise conceptual tensions, and actively trigger dialectical processes of change. Participatory innovation utilises processes of embracement around current values to create a shared platform of understanding, and estrangement through presenting unpredictable challenges to support a dialectical change process (Boer et al., 2013, pp. 86-87). However, Buur et al. (2013, p. 270) also note that dialectical conflict can either support innovation through providing creative tension or block potentially innovative exchanges between users and organisations. Furthermore, Buur and Larsen (2010) reject the conceptualisation of innovation as a goal directed effort, rather, they describe innovation as the development of new meaning through “the emergence of novelty that comes about in local interactions between people with different intentions” (p. 123). Buur and Matthews (2008, p. 256) claim that participatory innovation is best supported by understanding how to practically implement the approach in existing organisations rather than refining innovation theory. For example, Buur and Matthews (2008) write:

We are convinced that an important aspect of the solution to this issue is not necessarily in refining user-driven innovation theory, but in better appreciating many of the practical difficulties in applying user-centred approaches in existing organisational structures. To make user-driven innovation work as a practicable option for businesses, it is essential to understand not only the contribution that users can make to innovation and how this contribution can best be harnessed, but also the potentials and constraints that exist within the business organisations and how realistic these approaches may be to implement. (p. 256)

Consequently, the majority of work within the participatory innovation research programme focuses on developing and testing practical tools within workshop settings (i.e. small group meetings). These workshops involve design researchers guiding participants to refine ideas into product concepts that aim to provoke critique of current values (Buur & Matthews, 2008, p. 26). However, Buur (Buur et al., 2013, p. 57; Buur & Larsen, 2010, pp. 136-137) elaborates that since the negotiation of stakeholders’ conflicting perspectives drives innovation, therefore, traditional participatory design workshop formats that focus on new product development should be expanded to provoke stakeholders to discuss and map value exchange chains, business activities, and actors and their relations. According to Buur and Larson (2010, p. 137) participation simply means to engage in ongoing conversation with others, a shared goal may emerge but one is not necessary for collaboration. Furthermore, good quality conversations do not let the users’ voice disappear from the organisations continued conversation (Buur & Larsen, 2010, p. 137). Ethnographic material provides provocations that instigate and frame dialogue between the organisation, the participants, and
design team (Buur & Sitorus, 2007, p. 140). Hence, the process fundamentally concerns participants in the organisation’s activity system being heard in the design process (Buur & Sitorus, 2007, p. 140).

Within the participatory innovation approach, tangible materials such as objects and images are utilised to mediate discussion and interaction to support social processes of sense-making and organisational learning (Boer et al., 2013, p. 76). According to Buur and Matthews (2011, p. 373) using objects and images makes verbal articulation easier because they provide an indirect means to talk about difficult topics, reduce the impact of hierarchical imbalance, and provoke discussion on unexpected topics. In the first instance, tangible materials aim to shift focus from individual products to organisational issues. These organisational issues are identified through ethnographic field work and workshops with stakeholders. Second, tangible materials are intentionally deployed to project values and beliefs that are antagonistic to current taken-for-granted understandings of stakeholders. By surfacing assumptions, tangible materials “aim to overcome barriers of understanding that are usually difficult to express” and to “challenge [the stakeholders] to reconcile the different voices” because “ideas and opportunities develop in the crossing of understandings” (Boer et al., 2013, pp. 74-75). Participants use tangible materials to create metaphors to express situations in their organisations. According to Buur et al. (2013) these metaphors usually concern negative associations that portray “an organisation’s relations as fraught with matters of power differences, competition and struggles” (p. 59). Either the properties of the object inspire the participant to identify an actor in their value network that embodies that property for them, or the participant already has an actor in mind for which they then choose an object that matches their understanding (Buur et al., 2013, p. 59).

7.2.1. Business Model Design

Participatory business modelling tools are designed to support stakeholders to express difficult to articulate tacit knowledge and support deliberation and discussion about “value creation, value capture and value delivery” (Gudiksen et al., 2014, p. 17). Buur and Matthews (2008, p. 270) state that ethnographic user studies generate knowledge that provokes and challenges stakeholders to reflect upon their values and identities, and that such reflection may lead to innovation. Buur et al. (2013, p. 70) maintain that the core innovation activity that business model design approach supports is questioning prevailing concepts and co-creation of new meaning through encouraging understanding of other stakeholders’
perspectives through experimentation with personifying with new roles. In this sense, shifting stakeholders’ points of view is the event that supports innovation.

In their literature review Zott et al. (2010, pp. 5-6) identified that business models have been defined as a statement, a description, a representation, an architecture, a conceptual tool or model, a structural template, a method, a framework, a pattern, a set, and so forth. Arguably, this great variety of descriptions and lack of consensus reflects the relative novelty of the business model concept within the management and organisational science fields. Despite the variation of definitions of business models, we can identify some key elements: a notion of value, financial aspects, exchange relationships, competencies, and activities (Brunswicker, Wrigley, & Bucolo, 2013, p. 2). According to Zott and Amit (2010) the key to understanding an organisation’s business model is to consider its activity system:

An activity in a focal firm’s business model can be viewed as the engagement of human, physical and/or capital resources of any party to the business model (the focal firm, end customers, vendors, etc.) to serve a specific purpose toward the fulfilment of the overall objective. An activity system is thus a set of interdependent organizational activities centred on a focal firm, including those conducted by the focal firm, its partners, vendors or customers, etc. The firm’s activity system may transcend the focal firm and span its boundaries, but will remain firm-centric to enable the focal firm not only to create value with its partners, but also to appropriate a share of the value created itself. (pp. 217-218)

A business model is not a simple description of an organisation’s hierarchy but, following Zott and Amit (2010, pp. 217-219), an explanation of how a system of interrelated activities creates value. Buur et al. (2013, p. 56) conceptualise a business model in terms of a map of an organisation’s value network, that is, a visual representation of the web of actors (nodes) and their relationships (arrows) that generates value. When stakeholders discuss present and future configurations of their value network, innovation may come about. Significantly, Buur and Mitchell (2011) identify that a particular challenge to the participatory innovation approach to business model design is to

… bridge the gap between mapping and business modelling. Whereas value network mapping is a rather straightforward participatory activity, the design of tangible business models that encourage experimentation and conversation is a demanding creative intellectual endeavour about as difficult, it seems, as designing a successful new product concept. (p. 373)

Buur et al. (2013, pp. 66-67) conceptualise business model design within Schön’s constructionist epistemological position as reflective practice. By locating the theoretical position of their participatory innovation workshops within the cross-over of constructionist reflective practice and subjectivist research-through-design, the approach does not aim to
produce generalizable knowledge, rather “the knowledge gained lies not only in the resulting designs but even more in the design actions, choices and reflections along the way” (Gudiksen et al., 2014, p. 16). Pedersen et al. (2003) state that Schön’s concept of reflective practice in participatory innovation

... challenged us to abandon the rational understanding of the use context being independent of the product and therefore something that the designer can observe objectively from a distance. To design, one needs to impose an order on the situation while at the same time listening for the backtalk of the situation. This “order” is an understanding that grows out of framing and reframing the problem rather than a theory to be formed once and for all. (p. 464)

From this Schönian epistemological position, business model design is an activity that concerns individuals performing a series of “design moves” with tangible materials (e.g. objects, visualisations, role-playing) to see if qualitative judgments of new arrangements provide greater aesthetic appreciation. According to Buur et al. (2013):

[In] the mapping and staging methods we describe here, participants cannot appreciate the new situation they intend until they have made a move... Once they move, the new situation will provide what Schön called ‘backtalk’ in how the new situation is seen or felt, in how other participants react, and so on. (pp. 66-67)

Buur (2013) elaborates that “the moves constitute small experiments with positions, roles and meanings that trigger backtalk, both in participants’ own experience of the new situation and in how the other participants respond” (p. 69). Gudiksen et al. (2014) describe business model design as moving away from the traditional business plan document towards “tangible and craftsmanship-oriented learning approaches” that use participatory design to create “settings, activities, and... design tools that lead to quality dialogues over (re)framing of problems and future business scenarios, followed by qualitative judgment on the most promising scenario” (p. 16). According to Gudiksen et al. (2014) business model design through exploratory making “instantiates a kind of decision-making, which is not dependent on rules of logic found within rational systems of inquiry”(p. 28). However, Buur and Sitorus (2007) claim that textual forms of communication are not adequate to provoke stakeholders to question their values because they “submit to the logics of rational argumentation” (p. 149). Rather, Buur and Sitorus (2007, p. 149) maintain that physical and visual materials are more effective for engaging stakeholders in sense-making activities. While it is reasonable to claim that textual forms and explicit statements have communication limitations, as we saw in chapter three, there are other textual forms of reasoning, such as dialectic and rhetoric, that do not use formal logic to put forward arguments.
7.2.2. Conflict and Reflection

From the description given above, we can see that the participatory innovation approach and the model of informal interactions share a similar concern with the substance of dialogue and argumentation rather than demonstrating validity of logical systems. Participatory innovation uses various different workshops and materials to support the participants to exchange dialogue on the substance and content of their perspectives. For example, a business model design workshop is not intended to generate a causal explanation of an organisation’s activity system, rather the mapping exercises are used as representations and metaphors to support the participants’ to become more aware of their social position, and then to have a conversation about the implications of their perspectives. The business modelling activities are intended to provoke conversation about values and perspectives, and not to demonstrate necessary connections between self-evident truths. When the participants exchange their perspectives and intentions during these conversational interactions their conflicting standpoints provoke them to readjust their positions, and then new meaning emerges from the subsequent reframing of perspectives. Consequently, we can see that participatory innovation shares similar concerns to the model of informal interactions since it also focuses on the substance of the participants’ values and intentions rather than establishing the logic of a chain of reasoning.

The model of informal interactions and the participatory innovation approach also share several specific modes of interaction. Both approaches propose that industrial products and services are situated within systems, and that innovation can be supported by the participation of diverse stakeholders in the collaborative design process. Both models also recognise the value of ethnographic or immersive investigations in bringing the locality and background of the design issue to bear upon collaborative design activity. Furthermore, dialogue and conversation are key forms of interaction used in both models to provoke participants to surface assumptions and bring together conflicting perspectives. In addition, both models support mediating communication with artefacts and other tangible materials to make the focus of discourse more present and support discussion.

The proponents of participatory innovation explicitly identify the theoretical position of their approach as situated within Schön’s theory of reflective practice. From this perspective, collaborative design activity has as much to do with finding and framing problems as it does with producing solutions or persuading stakeholders. Consequently the approach emphasises
techniques for provoking participants to recognise the way they frame their perspectives, and then supporting them to reframe their situation and so bring new meaning. In contrast, this research project took Rittel’s argumentative model of design as its point of departure and has investigated collaborative design activity from within the philosophy of argumentation and informal logic. The participatory innovation approach positions itself in contrast to models of reasoning, however, the model of informal interactions that I developed indicates that notions of argumentation should not limited to logical problem solving, given that integration of dialectic and rhetoric may also be able to account for the activities that participants undertake within collaborative design activity. However, reflective practice is comparatively more closely concerned with lived experience than the model of informal interactions. Within participatory innovation, tangible materials are provocations aimed to stimulate crossing of intentions and reflections, and are not necessarily utilised within argumentation to convince or persuade an audience to undertake a course of action. Furthermore, because the model of informal interactions is underpinned by a theory of argumentation, it supports generating knowledge in both written language as well as in conversation in a way that reflection may not. For example, reflection cannot produce generalizable knowledge in the same way that argumentation can drive theory construction. Furthermore, argumentation supports critical thinking and strategic judgement in a different way than reflection, since it provides means for retrospective and prospective argument evaluation, and so argumentation may provide more conceptual resources for forming reasonable judgements than reflective practice.

Although participatory innovation is described as dialectical, like Nonaka’s S.E.C.I. model of organisation knowledge creation, this notion of dialectic is underpinned by an understanding of dialectic as a philosophical system of synthesising contradictions, and not as a theory of argumentation. However, unlike Nonaka’s model of knowledge conversion between tacit knowledge (experience) and explicit knowledge (dialogue), the dialectical force that underpins participatory innovation centres on the synthesis of the confrontation between shared current values and disruptive provocations. Moreover, the discussion of the participatory innovation approach implies that collaborative design activity should account for the relationship between individual agency and the organisational structure. Organisations have potentials and constraints that present practical difficulties that affect the application of collaborative approaches. For example, opportunities for innovation may be found in integrating particular product functions from across separate business units, which can only
be identified when the organisational level is understood and not only the product level. The participatory innovation approach takes the organisation level as a primary focus, whereas the participants in the case studies in this research project were comparatively more concerned with individual products. While many of the participants in this research project were aware of the relationship between individual agency and organisational structure, they did not take the organisational potentials and constraints into account in a designerly way. For example, even through the participants identified the systemic context of their design work and the influence of roles and hierarchy on their interactions, they did not develop practical design approaches to deal with these issues. Furthermore, the mode of integrating knowledge with iterative prototyping is perhaps more closely related to developing aspects of individual products, and is not focussed on using design to address organisational level issues in the same way that the participatory innovation approach uses business model design.

However, combining argumentation and business model design may present a useful approach that can overcome some limitations of simple representational business models. When combined with argumentation, business model design may better support a knowledge creation cycle, since from the perspective of argumentation, a business model is both a theory for how a business’s system of interrelated activities can create value, and a way for people to make strategic judgments about particular courses of action. Within the participatory innovation approach, business model design has been conceptualised as means to represent an organisation’s activity systems to provoke participants to reflect on their positions and reframe their perspectives, rather than as technique for critical inquiry and knowledge creation. A limitation of the participatory innovation approach to business model design may be that reflection does not adequately support moving from representations that describes factors, to a theoretical model that also accounts for how factors interact. Argumentation may be able support the theory construction process since it is strategic rather than reflective, and so may be able to move business model design from simple taxonomy to more complex conceptual frameworks. While the business modelling tools developed by the participatory innovation approach have been effective in producing descriptive business model that produce a useful form of understanding through supporting reflection, they do not explain. For a model to explain it should tell us about what sorts of mechanisms and processes exist, and also something about the systematic relations between underlying factors (Gaspar, 1990, pp. 285-295). A theory rich business model design should illustrate the relationship between interacting factors and activities based on empirical
research rather than through provocation and reflection. Theories progress in terms of their complexity and increasing explanatory power from 1) ad hoc classification systems, 2) systems of categories, 3) conceptual frameworks, and 4) theoretical systems (Parsons & Shils, 1962, p. 50). Theories can be constructed in different ways and are underpinned by philosophical assumptions that influence their theoretical concerns, their empirical content, and their practical use. According to Friedman (2002):

> In its most basic form, a theory is a model. It is an illustration describing how something works by showing its elements in their dynamic relationship to one another. It is the dynamic demonstration of working elements in action as part of a structure that distinguishes a model from a simple taxonomy or catalogue. (p. 12)

However, Webster and Watson (2002) add, “Models and propositions capture relationships between variables, but do not, on their own, represent theory… Rather, the reasoning or justification for these relationships represents the crucial part of the theory-development process” (p. 19). Consequently, we should not restrict our view of theory construction to a form of formal demonstration; rather, we should understand that argumentation is the “engine” of reasoning and judgment that drives theory construction and so also business model design.

### 7.3. Conclusion

The theories of collaborative design that I have discussed in this chapter highlight four important aspects. First, that collaborative design activity is a knowledge intensive process. Second, that there is a common concern with supporting the substance of dialogue, rather than demonstrating necessary truths. Third, in contrast to the model of informal interactions, the S.E.C.I. model and the participatory innovation approach are underpinned by the notion of dialectic as a philosophical system that provokes and synthesises contradictions, particularly regarding the relationship between individual agency and social structure. Fourth, both the S.E.C.I. model and the participatory innovation approach present methods for supporting innovation at the organisational level, while the model of informal interactions is better conceptualised as an approach that supports critical thinking. Considering these four significant aspects helps to contextualise and evaluate the significance and contribution of the model of informal interactions.

The S.E.C.I. model, the participatory innovation approach, and the model of informal interactions emphasise different aspects of a knowledge intensive process. The basic building blocks of the S.E.C.I. model of organisational knowledge creation are experience sharing and
continuous dialogue of cross-functional teams. The spiral process creates organisational knowledge by amplifying individual tacit knowledge and crystalizing it at organisational levels. The participatory innovation approach is centred on provoking conversation to challenge participants to reflect upon their values, intentions, and social positions, leading them to reframe their perspectives and generate new meanings. The model of informal interactions presents a rhetorical process that supports the group to bring the context to bear upon the collaborative design work to develop shared identity concerning the relevance and acceptability of courses of action.

Conversation and dialogue are key aspects of the three models, and furthermore, the three models are concerned with the substance of the dialogue rather than demonstrating the validity of the expressions. The S.E.C.I. model of organisational knowledge creation addresses the substance of dialogue through the notion of knowledge conversion. By converting knowledge through the modes of socialization, externalization, combination, and internalization, the team generates potential for innovation through a social learning process rather than demonstration of truths. Within the participatory innovation approach, the participants gain new awareness of their organisational relationships and ascertain opportunities for change through conversational interactions that provoke them to reflect on their positions and reframe their perspectives. Innovation and new meanings are generated within the conversation through crossing intentions, values, and identities, rather than verifying accounts of the organisation’s structure. The model of informal interactions addresses the substance of the participants’ communication through modes of interactions that bring the context to bear upon the collaborative work. Through situating the design work within the locality and background of the issue, adapting expression to the qualities of the group, and encouraging identification with the community, the model of informal interactions supports the team to adopt courses of action based on their relevance and acceptability rather than technical rationality.

In contrast to the model of informal interactions, the S.E.C.I. model and the participatory innovation approach are more strongly underpinned by a process of dialectical change that is centred on the political relationship between individual agency and social structure. Both models posit dialectical theories of development where a thesis gives rise to an antithesis and the resulting contradiction is resolved by means of a synthesis. This process is, in part, driven by contradictions between individuals’ relations and the social system. Although the model of informal interactions takes controversy rather than objectivity as a
point of departure, from this perspective the formation of communion surrounding a course of action is not necessarily driven by synthesis of opposing positions.

The S.E.C.I. model and the participatory innovation approach present methods for supporting innovation at the organisational level, however, the model of informal interactions does not indicate specific organisational level approaches. Nonaka’s S.E.C.I. model of social learning shifts and amplifies knowledge organisationally through a spiral process that supports the individuals to develop critical comprehension that can guide their perception and action. The participatory innovation approach utilises business model design methods to provoke individuals’ awareness of their position in the organisation’s activity system and so reframe their perspectives. In contest, the modes of informal interactions do not specifically address organisational level innovation, however, since argumentation can support critical thinking techniques that can drive theory construction, then the model holds potential for additional refinement that may lead to methods for organisational knowledge creation.

The model of informal interactions that I developed identified ways that design teams integrate rhetorical and dialectical argumentation to bring aspects of context to bear upon the collaborative design process. In this chapter I have compared and contrasted the model of informal interactions with two similar theories of collaborative design that take the context of innovation as a crucial aspect of their approaches. By considering these theories, I have provided some contextualisation and evaluation of the significance and limitations of the model of informal interactions.
Conclusion

This dissertation is situated within the tradition of design methodology. It aims to generate knowledge about design and for design to contribute to building a progressive research programme within the design field. The investigation rests upon the notion that systematic design methods have changed from working by a scientific method of linear reduction to and combination of basic forms, to human-centred collaborative design that takes an argumentative approach. This change means that designers must now work collaboratively to understand the milieu of people’s lives; their experiences, their stories, how they organise themselves, their relationships between individuals, relationships in their communities, and their social and physical environments. This research project makes an original contribution to the knowledge of the field of design through generating theory about design by identifying modes of collaborative design activity that can be addressed to develop support for the practice of design. A key insight from the investigation is that designers may employ informal interactions within these modes that integrate rhetorical argumentation to bring the context to bear upon the design work. This insight contributes to refining the argumentative model of design.

8.1. Conclusions

Rittel (1984, pp. 323-324) mapped out three paths for further research in design methodology:

- Refinement of the argumentative model of the design process and the study of logic of the reasoning of the designer in terms of the rules for asking questions, generating information and making decisions.
• Practical procedures for implementing the argumentative model, such as how to foster the process of group argumentation, how to select the group, and problems of the decision rules.
• The technical manner of supporting the instrumental version of the model through administrative and computer based aids.

This research project specifically contributes to the first path of research identified by Rittel. To address this path of research, I investigated two research questions:
• How do people in collaborative design teams interact?
• What is the significance of informal interactions in collaborative design activity?

The insights from this investigation answer the first research question *How do people in collaborative design teams interact?* through disclosing that we can probably account for how people in collaborative design teams interact through nine modes: system, participation, co-experience, integration, continuity, mediation, understanding, dialogue, and contribution. The research answers the second research question *What is the significance of informal interactions in collaborative design activity?* by revealing how informal interactions in collaborative design activity support the design teams to utilise aspects of context within their reasoning. By generating answers to these research questions, I conclude that this research project has achieved its specific intention of contributing to the path of research outlined by Rittel that aims to refine the argumentative model of design. Furthermore, the insights from the investigation may be used in the future to improve design practice through contributing to the formulation and validation of more advanced models and theories about the practice of collaborative design and, in turn, the development and validation of support founded on those models and theories.

### 8.2. Contributions

In chapter two I outlined a history of design methodology that began with the early 20th century Modern Movement and continued through the 1960s with the Design Methods Movement. While recent research has greatly expanded scope of design methodology beyond the concerns of the Bauhaus or ‘the sciences of the artificial’, and has criticised some of its basic assumptions, in this dissertation I have taken the position that there are ideas that maintain the consistency of design methodology as a coherent tradition of intellectual inquiry. One of these ideas is that there are ways of thinking and acting that are special to the capabilities of a designer. Consequently, doing research within the tradition of design
methodology means generating knowledge about design as a process of thinking and acting. The tools of research allow us to develop, articulate, and communicate design knowledge through systematic inquiry and critical thinking (Friedman, 2003, p. 512). Cross (2000a, p. 98) states that examples of ‘best practice’ in design research display the following characteristics:

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

To do design research and generate knowledge following these characteristics of best practice, the type of systematic inquiry that framed this investigation consisted of four basic elements: epistemology, theoretical perspective, methodology, and methods (Crotty, 1998, p. 5). To clearly articulate the design knowledge that this dissertation contributes to the tradition of design methodology, I will outline the contributions of this investigation in terms of these four elements.

The first element is epistemology. Crotty (1998) defines the meaning of epistemology as “the theory of knowledge that defines what kind of knowledge is possible and legitimate” (p. 5). The epistemology that underpins this research project is objectivism. According to Crotty (1998) “objectivist epistemology holds that a meaningful reality exists independently of consciousness and experience, that entities carry intrinsic meaning within them as objects and that we can discover this objective truth if we carefully go about it in right way” (p. 7). In this view, research generates knowledge that tells us about what sorts of mechanisms and processes exist in the world, and the relations between them (Gaspar, 1990, pp. 292-293). Following Friedman (2003, p. 512), knowledge is articulated through systematic inquiry organised in theory and research provides the tools that allows us to bring experience into critical comprehension and organise it in theory. Friedman (2002, p. 12) states that at its most simple a theory is a model that shows how something works and why. This dissertation has made an epistemological contribution since it has generated emergent theory about the phenomena of collaborative design activity. Through the investigation I brought experience out of practice and organised it in a model as summarised in Table 5. The model describes patterns of relationships between factors that may affect collaborative design activity and explains how designers may interact to bring context to bear upon their collaborative work. Furthermore, the model brings new insights about the influence of informal interactions in
collaborative design activity and it also refines the argumentative model of design. In addition, because I generated a theory from social facts, I could then consider, share, and reflect on the insights through comparison with existing theories of collaborative design that take the context of innovation as a crucial aspect of their approaches. In chapter seven I compared and contrasted the model of informal interactions with Nonaka's theory of organisational knowledge creation and Buur's participatory innovation approach to contextualise and evaluate the significance and limitations of the model. Nonaka's theory of organisational knowledge creation, Buur's participatory innovation approach, and the model of informal interactions all emphasise different aspects of a knowledge intensive process. However, in contrast to Nonaka’s or Buur’s approaches, the model of informal interactions is not driven by contradictions between individuals’ relations and the social system, but through a rhetorical process that supports the group to bring the context to bear upon the collaborative design work to develop shared identity concerning the relevance and acceptability of courses of action. Moreover, while Nonaka’s or Buur’s approaches present models for supporting innovation at the organisational level, the model of informal interactions is comparatively more focused on generating meaning, and so it does not specifically address innovation at organisational levels. This evaluation improves the validity of the model of informal interactions since finding similarities in findings in different contexts through comparison with extant literature strengthens our confidence in the internal validity and generalizability of the model since the potential impact of bias is reduced (Eisenhardt, 1989, pp. 544-545).

The second element is theoretical perspective. Crotty (1998) defines the meaning of theoretical perspective as “the philosophical stance informing the methodology and thus providing a context for the process and grounding its logic and criteria” (p. 5). The theoretical perspective that underpins this research project is post-positivism. As I described in chapter four, the post-positivist theoretical perspective is usually associated with Popper's logic of scientific discovery and in particular his theory of falsification. However, in this project I have used Lakatos’s (1970) methodology of scientific research programmes, since I believe Lakatos’s theory better addresses some of Kuhn’s criticisms of Popper’s approach. Because I use Lakatos’s post-positivist theoretical perspective, then the epistemological commitment that underpins this investigation is better described as a weak version of objectivism. The key concept of Lakatos’s theoretical perspective is his notion of the research programme (Lakatos, 1970). A research programme provides a framework for investigations
within a domain. The content of a research programme is a sequence of theories within a domain of inquiry. A research programme has a set of hard-core principle assumptions and then a protective belt of auxiliary theories. The move from one theory to its successor, within a research programme, is called a problem shift. There is a negative heuristic that guides what researchers should not do, such as changing the hard-core assumptions of the research programme, and there is a positive heuristic that specifies what researchers should do, these are ways that researchers should work to contribute within the research programme. The merit of an investigation is indicated to the extent that it leads to novel ideas while maintaining a coherent programme of research. A progressive research programme is one that maintains its coherence and sometimes leads to novel ideas, while a degenerating research programme loses its coherence and fails to innovate. The idea of a progressive research programme has also been taken up within the design research literature, for example, Friedman (2001, p. 24) identifies eight characteristics of a progressive research program:

1. Building a body of generalized knowledge
2. Improving problem solving capacity
3. Generalizing knowledge into new areas
4. Identifying value creation and cost effects
5. Explaining differences in design strategies and their risks or benefits
6. Learning on the individual level
7. Collective learning

Using this post-positivist theoretical perspective as a lens through which to study collaborative design, I take the tradition of design methodology as a research programme in the Lakatosian sense. The hard-core of the design methodology research programme takes design activity as a knowledge intensive process rather than the crafting of objects. The domain of inquiry that concerns design methodology is the study of the thinking and action of designers. This investigation has contributed to the research programme of design methodology by refining the argumentative model of design. In chapter three I articulated a sequence of problem shifts that describe a transition from justifying the features of designed products, to regulating the procedure of design activities, to accounting for the interactions within the design process. This sequence of problem shifts, as I see it, describes a broadening out the argumentative model of design from logic to dialectic to rhetoric. Furthermore, this investigation of the thinking and action of designers has indicated new subject matters of design. The refinement of the argumentative model of design conceptualises logical
approaches as leading to instrumental design methods, dialectical approaches as leading to understanding the designer as a facilitator who regulates group work, and rhetorical approaches as leading to understanding the designer as a knowledge worker with socially responsible design capabilities. According to Friedman’s (2001, p. 24) eight characteristics of a progressive research program, these insights have contributed first to building a body of generalized knowledge through improving our understanding of collaborative design activity, second to improving problem solving capacity by indicating new subject matters of design, and third to generalizing knowledge into new areas through utilising the theory and philosophy of argumentation to refine the argumentative model of design by explaining logical, dialectical, rhetorical models of design activity.

The third element is methodology. Crotty (1998) defines the meaning of methodology as “the strategy, plan of action, process or design lying behind the choice and use of particular methods and linking the choice and use of methods to the desired outcomes” (p. 5). The methodology that guides the selection of methods in this investigation has been DRM Design Research Methodology (Blessing & Chakrabarti, 2009). The DRM methodology maps onto the concerns of the tradition of design methodology by distinguishing between descriptive studies that generate knowledge about design activity, and prescriptive studies that generate knowledge for design activity. In the descriptive study stage the researcher conducts empirical research to understand the influencing factors and to accurately describe the existing situation. In the prescriptive study stage the researcher uses their increased understanding of the existing situation to elaborate a description of a desired situation. They identify which factors are most likely to lead to changing the existing situation into the desired situation and develop initial support to do this. In chapter five I reported a comprehensive descriptive study that investigates the interactions that participants in design teams may employ during collaborative design activity. Then, in chapter six, I analysed the modes of interactions to generate an initial prescriptive model, shown in Table 5, that indicates that informal interactions may influence the design team to bring aspects of the context to bear upon their reasoning within collaborative design activity. This strategy of linking descriptive studies and prescriptive studies is consistent with the type 2 variation of the DRM approach. Furthermore, since I conducted empirical fieldwork to investigate collaborative design activity in its naturalistic environment, then this investigation contributes to the trend in design research that focuses on industry based investigations of multidisciplinary teams working on complex design issues rather than the study of design.
activity in laboratory based investigations of individual designers working on simple design problems. The insights from the investigation corroborate and extend existing research that identifies that design activity in industry is often interdisciplinary and strongly affected by social factors. This conclusion implies that it is likely that existing design support that has been developed from reports of design activity from laboratory based investigations of individual designers may not fully address the factors that influence the social and collaborative reality of contemporary design practice. This also implies that the knowledge creation cycle between professional practice and research may perhaps be impaired.

The fourth element is methods. Crotty (1998) defines the meaning of methods as “the techniques or procedures used to gather and analyse data related to a research question or hypothesis” (p. 5). I developed research instruments to collect data through semi-structured interviews with professionals involved in collaborative design work, and to conduct participant observation at organisations working within the design profession. The Swinburne University Human Research Ethics Committee approved these research instruments and the data collection was conducted appropriately. I investigated three companies: a small industrial design company, a small architectural practice, and the design research team within a large market research agency. I analysed the data using constant comparative method to explore similarities and differences within the data. Through comparing all the codes and categories with each other, I crafted a holistic understanding of the patterns of influence that each factor generated and their relationships within each mode of interaction. The field notes from the observations triangulate the insights from the reports given the interview data, which supports validity by reducing bias. The rich descriptions of the qualitative data give a sound understanding of the phenomena, which supports the validity to the insights. Furthermore, by using NVivo CSQDAS to support the data analysis process, I was able to perform simple quantitative analyses of the data, which in turn provided some indication of the distribution of the coding references between the data collection methods and the cases. By showing the distribution of the insights in terms of the methods and the cases that they were drawn from, I was able to give an indication the reliability of the findings.

This investigation contributes by improving our understanding of the factors that underpin collaborative design work that could lead to the development of support for collaborative design work. Furthermore, this research contributes new facts about collaborative design activity that may lead other researchers to develop new experimental
techniques that could make more precise predictions about design activity. This study also provides new data that improves our understanding of how collaborative work is actually done in industry today. In addition, this research project is useful to designers because it improves understanding of pre-production design methods to better deal with the complex combinations of interacting activities, behaviours, and relationships of people working together to generate an industrial design product. Also, because the research topic is interdisciplinary, and design an integrative discipline, I hope that researchers outside design, for example disciplines such as management and social policy, could also use the theoretical contributions.

8.3. Limitations

The first limitation of this research project is derived from the nature of the phenomena being investigated and the level of knowledge already known. Interdisciplinary collaborative design activity involves many interacting factors and there are few existing theories already established to test. Consequently an explorative, naturalistic research design was required, and the intensity of this type of research limited the sample size of the study and consequently the generalizability of the findings. Furthermore, conducting fieldwork in industry had implications for this study. Design work in industry is affected at a market level through economic factors and at the project level through particular clients. This study was affected by both these factors. First, the project was affected by the impact of the Global Financial Crisis of late 2007 and the 2008-2012 Global Recession since one of the companies I had organised as a case study went into receivership just weeks prior to when the fieldwork was planned to begin, consequently I had to organise alternative case studies and gain additional ethics approvals within a very short timeframe. In addition, these alternative case studies introduced new limitations since they involved small numbers of employees, had a comparatively more single discipline focus, and shortened the possible duration of the fieldwork. The third case study was affected by limitation due to particular clients. This case study was intended to provide access to participant observation of interdisciplinary work between design researchers and industrial designers during immersion projects in developing markets. However, within the duration I spent at the company there were no immersion projects initiated by their clients. I addressed this limitation by refocusing the case study to the agency’s work with local clients.
A limitation I should have foreseen was restricting my observation method to participant observation and not conducting systematic shadowing of particular participants. The significance of informal interactions that has been revealed through this study highlights that, in retrospect, a series of shadowing observations where I could have observed the interactions of participants over a sustained period would have been useful. Consequently, this may have limited the number and types of informal interactions I observed.

8.4. Further Research

Future paths that this research project identifies are the refinement of the model of informal interactions, the validation of the influence of informal interactions in collaborative design activity, and subsequently, the development of support for collaborative design work in interdisciplinary teams based on those informal interactions. Extensive systematic research is needed to evaluate the influence of the nine modes of interactions in collaborative design activity that I describe and analyse in chapters five and six. The triangulation of the fieldwork data does provide some indication of the strength of the impact of these interactions, however, rigorous testing of precisely defined hypotheses for each factor is required to more systematically validate their influence in collaborative design activity.

On a philosophical level, a conclusion of this research has been that Rittel's argumentative model of design proposes an account of design activity that is fundamentally different from the prevailing theories of rational problem solving and reflective practice. However, Rittel's argumentative model of design has historically been labelled as an extension of the rational problem solving approach of the design methods movement. Further research should be undertaken to understand whether the argumentative model of design constitutes a decisive break with rational problem solving approaches.

8.5. Conclusion

Knowledge about how designers reason, interact, generate information, and make decisions, is needed so that the argumentative approach can be understood and supported. I claim that much of the research that has addressed Rittel’s argumentative model of design has either focussed on developing software tools for objectifying designers’ explicit communication in formal meetings, developing participatory design games for reflective practice, or has tried to absorb Rittel's theory of wicked problems into the technical rational problem solving
paradigm of engineering design. My thesis is that these approaches do not address the fundamental implications of a shift toward an argumentative approach to design, because they do not accommodate the influence of informal interactions and ethico-political judgement within human-centred collaborative design activity. Consequently, this research project has generated knowledge about how people in interdisciplinary collaborative design teams interact and how informal interactions may support the design teams to utilise aspects of context within their reasoning.
References


Guinan, P. (1986). Specialist-generalist communication competence: A field experiment investigating the communication behavior of information systems developers. (Ph.D.), Indiana University, Bloomington.


NHMRC. (2007). Australian code for the responsible conduct of research. Commonwealth of Australia, Canberra.: The National Health and Medical Research Council, the Australian Research Council and the Australian Vice-Chancellors’ Committee.


Appendix

Ethics Clearance

3/03/2011

To: Dr Gavin Melles/Mr Luke Feast, Design
CC: Ms Rachel Mosel, Research Admin. Co-ordinator, Design

Dear Gavin and Luke

SUHREC Project 2010/309 Investigating Collaboration in Interdisciplinary Design Teams
Dr Gavin Melles Design Mr Luke Feast
Approved Duration: 03/03/2011 To 03/03/2012 [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 (SHESC2) at a meeting held on 13 December 2010. Your response to the review as e-mailed on 6 February 2011 was put to a nominated SHESC2 delegate for review.

The delegate wished to thank you for your detailed response and patience in awaiting the resolution of the review process.

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, SHESC2

Kaye Goldenberg
Administrative Officer (Research Ethics)
Swinburne Research (H68)
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Interview Protocol

Thank you for agreeing to take part in our interviews on collaborative design work. We are very grateful that we can draw on your experiences and expertise. Please be assured that your responses will remain anonymous.

We will be recording this session, please tell us if you want us to stop the audio recorder, otherwise it will run for the duration. Please feel free to use examples and illustrations in the knowledge that identifying information will be deleted from the transcripts and specific comments will not be attributed to individuals.

Do you have any questions or queries about this interview and its use?

The interview will now commence and we are switching on the audio recorder.

First, can you please broadly describe your background?
Can you please tell me about your experiences of working with other designers or other professionals?
Would you describe these situations as collaborative?
Who participated in the collaborative work?
What did they do?
At what stage of the project were they involved?
How was knowledge shared or negotiated?
What was actually produced during collaborative work?
What roles did intermediary objects diagrams, plans, models play?
When collaboration was working well, what kinds of benefits did you experience?
What were the toughest aspects of working in collaborative situations?
How does working with others differ from working alone?
Is there anything else you would like to add?
Publications


