Mnemotechne of Design — Ontology and Design Research Theories

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Attestation of Authorship

I hereby declare that this submission is my own work, and that to the best of my knowledge and belief it contains no material previously published by another person except where explicitly defined in the acknowledgements, nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institute of higher learning.

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Dedication

To Benjamin Joseph Cutore

Acknowledgements

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Abstract

This thesis commences with the premise that while design practices may be said to have a very long, perhaps ancient, history, 'Design' as a discipline is of more recent origin, while 'Design Research' as a disciplinary practice emerged mid-way through the twentieth century. This inquiry is concerned with the discipline of design from the perspective of the emergence during the past half century of design research, with particular focus on the development of design research theories. The research sets out from the well-established premise that the discipline of design is heterogeneous, with diverse paradigmatic claims as to its epistemological ground, with a concomitant range of ontological implications for what is considered to be within the disciplinary domain of design. In tracing a genealogy of the emergence of design research theories from the 1960s, the research recognises the early predominance of design science and positivist frameworks in defining the disciplinary boundaries of design. Given the predominance of design science within frameworks of formal attempts to define design research theories, approaches to the heterogeneity of the field were concerned with defining a unified field through meta- or supra- categorisation. The emergence of cybernetics and computational analysis in design processes strengthened this position.

The thesis recognises a fundamental dualism that has tended to define the heterogeneity of the field, dividing it between design science and design aesthetic, with the former more easily engaged in defining formal design research theories and the latter more easily working in atheoretical emphasises on individual expression and intuition. The project adopts a critical hermeneutics in order to approach analyses of design research theories with an aim to maintain a heterogeneity to the field while yet recognising a series of primordial structures that construe relationality across diverse frameworks. In undertaking this, two competing understandings of 'ontology' are engaged with, one opening particularly to ontology as a questioning of the grounding (the meaning of the being) of entities categorised as design, the other emerging from knowledge engineering and computational science, that understands

ontology in the formal and syntactical sense of categorisation and hierarchisation. With a critical hermeneutics of design theories, the former understanding of ontology is foregrounded; with respect to engaging with information hermeneutics and semantic web capabilities for information relationality and retrieval, the latter framework is recognised. A key part of this process has been an investigation through the prototype development of a web deliverable design research resource framework to enable researchers to review and cross-reference at a granulated level the models, structures and key terms of a wide range of design research theories.

In this respect, the thesis deals with comparative analyses of twenty key design research theories that have emerged over the past half century. A second hermeneutical engagement elicits a series of deep structural relations that work across these theories, eschewing a project aimed at meta-theoretical unification. Correlations are then sought with the literature in the broader understanding of theories of research, as well as information hermeneutics. The project recognises that the discipline of design has matured to the extent that it currently seeks to define its foundational frameworks from within an implicit recognition of its disciplinary integrity and identity. A Mnemotechne of Design, envisaged through semantic web technologies, aims to overcome the dualistic thinking that has dominated design discourses in a project that serves design researchers in assaying the plurality of methodological frameworks that have emerged in the discipline's approaches to research theories.

Chapter One

Introduction

Project Focus

This inquiry was motivated by a desire to better understand and explicate the discipline of design and its research, in order to increase awareness of methodological possibilities. It was also sparked by a parallel interest and prior engagement in the development of digital archiving systems as a way to organise information about design history. At the commencement of this project it was thought that the outcome of this research would be a designed artefact in the form of a system that would give access to information about design research methodology through normal search and retrieval processes. However, as the research process unfolded, the project focus changed, which, in turn, affected the methodological approach and the form of research outcomes.

The investigation, as it developed, was recognised as being both ontological – in that it engages with the nature or being of design – and epistemological – in that it is concerned with frameworks of knowing that secure the veracity of design research and the entities we call design. In furthering this research, two competing understandings of 'ontology' were recognised, one opening to ontology as a questioning of the grounding or being of entities categorised as design and its research, the other emerging from knowledge engineering and computational science, as ontology in the formal and syntactical sense of categorisation and structure. The tension between these two ontological positions became a key focus of this inquiry. It was recognised that this issue was implicated in the historical development of design research and with ongoing problems associated with methods and technologies of organising and recalling design knowledge. Thus the 'mnemotechne of design' engages with ontology, memory and technology to represent the pluralism and heterogeneity that is design's potential, rather than entering into the definition of a supposed certainty. It traces a genealogy of theories to arrive at the present moment, but also recognises and recoups the relationality of this history to identify how we can engage design research theory in the present, and become more aware of its changing contexts, opportunities and potential.

In the early stages of this research, a review of theories of design research was undertaken so as to identify a framework from which a metadata structure could be developed. However, it soon became apparent that the heterogeneity of design and the diverse paradigmatic claims made in terms of its epistemological ground, with their related ontological implications for its various practices, research and discourse, made the identification of any singular framework impossible. In further exploring the genealogy of the emergence of design research theories in the 1960s, the emergence of design science in defining the disciplinary boundaries and research focus of design was recognised. Given the development of design science within frameworks of formal attempts to define design theory, early approaches to the problem of heterogeneity were concerned with defining a unified field through meta- or supra- categorisation. The emergence of cybernetics and the project of artificial intelligence to automate design problem-solving processes strengthened this position. This historical framing of design research initiated a fundamental dualism that has tended to define the heterogeneity of the field, dividing it between design science and design aesthetic, with the former engaged in the definition of formal design research theories and the latter with atheoretical emphasises on individual expression and intuition. The repercussions of these issues that emerged some fifty years ago, at the beginning of design's research history, still inform or resonate with many different 'cultures' of design, and contribute to the complexity and 'sub-disciplinary' compartmentalisations of its discourse.

Some commentators have suggested that the purpose of design research and theorisation is to develop a systematic comprehension of design as a science (Freidman, 2003). Others have rejected the idea of a unified science of design, recognising the pluralism and discursive complexity of design as a defining characteristic and strength (Buchanan, 1995). In this thesis, heterogeneity is recognised as a distinguishing feature of design that is vital if design is to be effectively engaged as a trans-discipline, with and across scientific, humanities-based, creative and technological frameworks, to develop alternatives to address complex, contemporary issues. This epistemological diversity places design research in a unique position to harness and foster interdisciplinary understandings and approaches and to support cross-disciplinary teams and diverse stakeholders. However, it is recognised that in order to effectively engage such complexity, design researchers need to be able to understand and draw from different methodological frameworks, to locate those positions and to recognise their implications. Nelson and Stolterman (2003) have noted:

> Every chosen form of inquiry – intuitive, artistic, scientific, logic or a composite thereof – will lead to a specific body of knowledge. The chosen form of inquiry influences both what constitutes knowledge and how knowledge is gained. Each particular approach is based on some fundamental assumptions concerning what it means to create knowledge. (p. 38)

However, methodological selection in design research is often based on prior research experience or institutional conventions. Researchers tend to avoid questioning the fundamental assumptions behind a given methodological approach or to consider possible alternatives that may lead to more effective ways of conducting the research. While bodies of theory have developed in relation to specific forms of design inquiry, there has been less focus on developing relational understanding across different design research areas. This problem has been recognised in the literature. For example, Jonas and Meyer-Veden (2004) have acknowledged the 'Babylonian confusion' of existing design theories. They have also suggested that design needs tools to help manage this discursive complexity. This thesis project attempts to understand and map different theoretical models drawn from across the range of design research frameworks, and to identify patterns of conceptualisation that might inform the development of new relational information frameworks through which information about design research theory could be organised and interpreted. Through this investigation, new relational frameworks are explored. This exploration aims to help design researchers access and relate this theoretical richness and develop greater methodological awareness in order to assist both design specific and interdisciplinary research.

Strategic Approach

The project takes a relational approach, based in hermeneutics, as a way of overcoming the limitations of older dualistic frameworks or more recent and fragmentary models of design as a discipline. Such fundamental ontological perspectives have informed the theories, practices and subjects of design research, and have contributed to the diverse positions taken by design researchers, where each specialised field is often restricted by design genres or design professions that are defined through what it is that is being designed. The project also negotiates another dualism that is part of the ontological basis of information science, that is, between the potential for more intuitive and

interpretive approaches to organising and understanding knowledge and the highly formalised, logic-based schemas that underpin current computational approaches to knowledge representation and organisation.

While hermeneutics was initially engaged as an interpretive approach to understanding design research theories, the central importance of hermeneutics to the wider project became evident as the project developed. Hermeneutics began to inform a wider methodological framework, providing a deeper conceptual underpinning between different aspects of this inquiry. The mnemotechne involves two levels of hermeneutical engagement: critical hermeneutics, which has supported the analysis of design research theories and the development of interpretive models, and information hermeneutics, which has informed the translation of these models into relational information structures and a prototype design research resource to support the interpretive analysis of theories.

The project methodology also engages with systems thinking, or second-order cybernetics. This approach has underpinned a critique of formal information structures and an exploration of new web-based technologies to support the development of a more flexible approach to the design and agency of an information system that could support interpretation and participation rather than problem solving. A key distinction has been made between the implications of formal approaches to information design using computational ontologies that are characterised by canonicalisation, and the new opportunities offered by semantic web technologies that are based on decentralisation. The mnemotechne project takes an a posteriori approach to knowledge organisation, drawing from conceptualisations developed from the analysis of design research theories, rather than from abstract categorisations drawn from outside the field of design. This approach has resulted in a multilayered and interrelated framework that can present a number of different ways that design research is theorised, and some key nodes and pathways through which different perspectives can be compared, associated or related. There is potential for this system to be expanded to include additional perspectives, information layers and linkages.

Research Questions

There are three key questions that have guided this project:

The first question asks: How might different ways of reflecting on design research be understood in relation to one another? This question is grounded in the heterogeneous nature of the field of design and its research, and is an inquiry into ways this diversity might be better understood and represented. Addressing this question has involved an extensive review of design research theories and an analysis, interpretation and mapping of a selection of different theories to identify particularities and commonalities of approach and conceptualisation. The ontological basis of design has been recognised by Buchanan (1995) as being 'not accidentally but essentially contested' (p. 25). He suggests this is because the subject matter of design is never static and the focus of the discipline is on the development of alternative resolutions and possible worlds, rather than truths or singular solutions. He proposes that this indeterminacy distinguishes design from the natural and social sciences, 'which are directed to the understanding of determinate subject matters' (ibid.), and results in differences of approach and understanding. However, this inherent diversity causes difficulties in attempts to develop overviews or meta-theories that can articulate the breadth of the discipline of design and its research, which in turn makes broader understandings or explications of the field more difficult.

The second question underpinning this inquiry asks: Can the results of an analysis of design research theories be used to inform the development of new conceptualisations or relational approaches to assist the organisation of information about design research methodology? This question is not concerned with the development of a new meta-theory, or a singular framework based on broader ontological considerations, but with a critical engagement and analysis of existing theories about design research and the identification of common or distinctive perspectives across this diverse field. This a posteriori approach to knowledge organisation explores whether concepts and strategies identified 'from the ground up', through analyses of different design research theories, can be used to inform the development of information systems. This approach is quite distinct from traditional 'top-down' or a priori approaches, based on abstract entities and logically predefined relationships, that have dominated the development of computational forms of classification. The process used in this inquiry is both phenomenological, in that it is based on an analysis and interpretation (of design research theories), and relational, in that interpretations of theories are modelled and linked, forming patterns that reveal networks of meanings as part of a prototype information system design. This approach gives rise to further questions about the relevance and value of such a relational information system to design researchers.

The third question asks: Can new computational systems and technologies be used to support a relational modelling of design theories? This question engages with the limitations of traditional information science approaches based on established ontological beliefs and associated epistemological schema. It is addressed in this thesis through a critical consideration of traditional formal approaches using computational ontologies and new opportunities offered by semantic web technologies. This inquiry is underpinned by debates about canonicalisation and decentralisation in relation to the development of new information technologies like the semantic web. The third question is addressed in this thesis through a consideration of the literature and an exploration of semantic web technologies.

Project Context: Mnemotechne

A consideration of the notion of mnemotechne, a term that appears in the title of this thesis, highlights the relationships between information, knowledge, structure, memory and technology. Mnemotechne literally means the *techne* – that is the art or craft – of memory or *mnemos*. The Greek word *techne* also forms the root for the terms technique and technology. Mnemonic practices and technologies are ancient. In *The Art of Memory* (Pimlico, 1992), Frances Yates describes spatial mnemonic techniques, or methods of *loci* or place, as *ars memoriae* or memory arts, these having been developed by rhetoricians in ancient Greece and Rome. Mnemonics involved a mental mapping of the elements of a speech or argument on to the geographic space of a building or environment in order to memorise it. In reconstructing a speech, the passage through the imagined locale was recalled, accessing architectural structures and places with their associated ideas or elements of knowledge. During the Renaissance, this memory system, with a focus on cognitive knowledge and the occult, was extended into forms of memory theatres and w*underkammer* or cabinets of curiosity. These approaches associated information with objects and structures to activate memory and knowledge. The recording and recalling of knowledge are central to the notion of mnemotechne. The philosopher of technology Bernard Stiegler has recognised the development of technologies to aid the transmission of memory beyond the life of an individual as a uniquely human striving. Writing, photography, phonography and cinematography are among the technologies identified by Stiegler (1998) as mnemonic.

Classical memory techniques are considered by some historians of computer science as precursors to computational knowledge systems (Sowa, 2000). In

examining computational forms of database and interface in relation to written and oral traditions, digital theorist Lev Manovich has identified earlier encyclopaedic and narrative forms of recording, systematising and recalling information and the use of spatial metaphors in human mnemonic systems as prescient to navigation and information retrieval within data structures or 'architectures' (Manovich, 2001).

Stiegler suggests there has been a crucial shift from past mnemotechnic systems to current developments enabled by computerisation. He writes:

> Until now, mnemotechnics have always constituted a singular field in relation to the technical systems that followed one another over time. However, this independence of mnemotechnics from the technical system of production no longer exists today: in becoming planetary, the technical system is now also, and even foremost, a global mnemotechnical system. In a sense, a fusion between the technical system, the mnemotechnical system and globalisation has occurred. (Stiegler, 2003, unpaged)

Stiegler traces a shift from artisanal and industrial systems of production – which produced manuscripts and paintings, then printed books and images, records, films and videos – and their related forms of access and/or distribution, for example through libraries, museums, galleries, bookshops or movie theatres. The new globalised convergences that Stiegler identifies are due to computerisation and the development of the internet. These recent technological developments have led to the creation and access to a vast diversity of forms and types of information and have involved a profound shift in the way different bodies and forms of information can be created, organised, related and used. This situation presents enormous challenges and opportunities for the field of design research in terms of its heterogeneous body of knowledge and for traditional information science approaches in terms of the ways information is organised, accessed and activated.

The title of this thesis is intended to emphasise the potential of these new technologies of collective memory to collect and relate information, engaging both with an architecture of knowing and more specific understandings of design and research, to create a 'mnemotechne of design'. There is recognition in this title of the potential of the technologies of computer-based systems to support the development of networked, relational resources. There is also an acknowledgement of the need to remember the history of design research and

its various positions and framings. Given the particular modes and specific qualities or defining characteristics of earlier mnemotechnologies, an understanding of the conceptual basis and effects of computer-based information systems is vital to understanding their limitations and exploring their potentials as mnemonic technologies.

Academic Contexts of Design Research

While the roots of design research, as a drive to 'scientise' design, have been traced to early twentieth-century European and American developments (Bayazit, 2004), the beginnings of the formal articulation of design research as part of the emerging discipline of design are generally associated with the Design Methods movement in the 1960s (Cross, 1993; Bayazit, 2004; Margolin, 2002, 2010; Luck, 2006). The development of research into systematic design processes and methods has continued from this period on, particularly within university departments of engineering and architecture. Another critical shift took place in the late 1980s in the UK with the move of industry oriented art and design schools from polytechnics into university systems. These moves were followed by similar changes in Australian and New Zealand tertiary education design provisions, leading to the introduction of bachelor-level degrees in design and the development of post-graduate design qualifications, in particular PhD programmes in design.

These institutional changes were paralleled by the development of national research evaluation programmes for universities in the UK, Australia and New Zealand during the 1990s.[1] Within universities, design is located across several different disciplinary registers: it can be found within traditional university fields such as architecture and engineering, but more recently design has emerged as an area in computer and information sciences, in business studies and even education. These areas often exist quite separately from art and design departments transferred from the polytechnic sector. The effect of these educational systems and research-evaluation regimes on the development of design research and discourse has been significant. In particular, the debate concerning the relationship between academic research approaches and creative or professional design practices has called into question both the nature and role of design, and the forms, criteria and relevance of established research practices

[1] A more detailed discussion of the development of design education and university research evaluation schemes is presented in Chapter Two.

from other disciplines in relation to more discipline-specific 'designerly' approaches.

The discourse that has been generated through subsequent developments of postgraduate programmes, academic journals, design-related conferences, online discussion groups and publications has been dynamic and productive. However, it has also been divisive, often fracturing along the lines of professional demarcations or academic disciplines. The field is also challenged by the emergence of new conceptual frameworks, new modes of working and new technologies within the context of complex social and environmental problems. While it is recognised that many design–led companies and commercial organisations are also involved in design research, for example the international design company IDEO, these tend to use research as a way of better understanding the context of a design problem or the experience of users of systems or products being developed by companies or to test the development of better design solutions or practices.

Such human-centred or strategic design approaches also constitute an important part of the academic sphere of design research, and most design research and discourse that is concerned with the ontological and epistemological dimensions of design and design knowledge is located within academia. The re-orientation of design from the practical training regimes of industry-focussed polytechnics to the research focus of the university has occurred in parallel with significant shifts in the practices and forms of design and other disciplines as a result of rapid technological, economic and social changes. Within university art and design departments, academics and researchers have struggled to keep pace with these shifts, not just in terms of mastering or at least keeping some currency with new technologies, but, more particularly, in understanding the radical effects these developments are having on traditional forms of design practice and the new opportunities they offer to design research.

Design has been recognised as an 'integrative discipline' (Friedman, 2000), a 'trans- discipline' (Buchanan, 1998b) and as an 'expert discipline for relating and connecting floating fields' (Jonas, 2000, unpaged). This connective location means that design is well positioned to help negotiate complex problems that require different disciplinary perspectives. In order to realise this potential, however, design researchers need to develop greater relational understanding of different methodological approaches alongside their own particular design specialisations. This need underpins the aim, approach and outcomes of this thesis inquiry.

While the outcomes of design have been identified as new or better solutions (Friedman, 2000), artefacts (Krippendorff, 2006) or possibilities (Buchanan, 1995), the outcome of research, including design research, is the extension of knowledge. The development of design research and its associated discourse has seen a significant growth in the publication of design-related research. While the focus of much design research has been on processes of designing and the development of methods and tools to enhance the efficacy of design processes (Dorst, 2007, p. 2), inquiry into other aspects of design is increasing. However, research and the development of a broader and more reflexive discourse concerning the nature and scope of design research is still fragmented. This has made it difficult to organise, access and articulate the growing body of design knowledge generated through design research, beyond specific professional, thematic or methodological frameworks. The difficulty here is not just that a singular framework can't adequately represent the diversity of design research approaches and understandings, but that there is inconsistency and disagreement even within specified areas. The field of 'design science' is one example, which is discussed in more detail in Chapter Four of this thesis.

It has to be recognised that theories of design research are historically contingent. The 'sediment' of these theories (Jonas, 2000) is not compressed or petrified, like geological layers of a subterranean past, but is more like silt: readily disturbed, and easily remixing with other material to reform as new layers. Thus any system for organising design information needs to be dynamic and able to change over time so as to accommodate new perspectives and relationships, as well as recognising the various genealogies that have influenced the development of design research. This thesis investigates conceptual approaches to the theorisation of design research and the development of a relational framework that can assist with the organisation and access to information about design research through an analysis and interpretation of design theories and a testing of this model through comparison with other research models and a prototype application.

Approaches to the organisation of information within computerised systems, built on forms of structuring developed from scientific approaches where information is logically ordered into categories and subcategories to form taxonomies, metadata schema or ontologies, are another critical consideration in this project. The ability of computers to process information for query, selection, optimisation, randomisation, prediction and other 'functions' requires this formalisation so that information can be treated abstractly in mathematically

based computational languages (Sowa, 2000). While forms of computational processing languages have now extended far beyond traditional linear approaches like calculation to include complex, 'soft' computing methods like 'fuzzy logic', optimisation, genetic algorithms and quantum-like computing (Kasabov, 2005), they still require that the data or information on which they operate is formally structured. Such structures are built from 'high level' abstract concepts, which, in the case of formal computational ontologies, are based on 'universal' constructs or principals that, in theory at least, should be applicable across, or relatable to, any subject domain or area of application.

This is not such a problem in scientific, economic or commercial spheres – which have been the main arenas of computational application – where data is treated objectively and can more easily be formally structured. It is problematic in cultural domains like design, however, where information is heterogeneous and can be interpreted and understood from a number of different perspectives. That is, information has a hermeneutical dimension that cannot be represented in formal systems.

Thesis Structure

The thesis is presented in eight chapters, followed by a conclusion. This first chapter introduces the project, discussing the focus, strategy, outcomes and context of the research. Chapter Two, 'Design Research: Paradigms, Theories and Practices: A Literature Review', presents an analysis of relevant literature to articulate key issues associated with the research context and project rationale. The third chapter, 'Design Research Theories and Methods: Ways of Researching', outlines and discusses the research design and methodological approach taken in conducting this project. Chapters Four and Five present the critical analysis and interpretive mapping of twenty design research theories. Chapter Four, 'Design Research the Early Frameworks,' is historically focussed and considers theories based on frameworks that were drawn from, or articulated in response to, other disciplinary perspectives. The theories analysed in Chapter Five, 'Designerly Research Frameworks,' have been drawn from more recent 'designerly' frameworks of research or have attempted to model broader overviews of the field. While the main focus in both these chapters is on the analysis and interpretive modelling of individual theories, some comparative analysis of different theories is introduced.

Chapter Six, 'Design Research Models: A Relational Analysis', is focussed on determining relational structures as well as on the identification of shared conceptualisations across groupings of different theories. Chapters Seven and Eight present two different approaches to testing the conceptualisations and models developed through this analysis. Chapter Seven, 'Recent Research Frameworks: Typologies of Method', engages in a comparative analysis with other disciplinary models and theories concerning research and researchers. Chapter Eight, 'An Information Framework for a Design Research Resource' presents a discussion and analysis of the experimental development undertaken to produce a prototype design research resource using semantic web technologies. This application is rudimentary, but indicates some of the potential for application of the conceptual model developed through this research. This process of prototype development suggests that emerging semantic web technologies can be used to support approaches to information organisation based on information hermeneutics and relational, rather than formal, information structures. Appendices include a full list of theoretical texts initially considered for analysis, more detailed exploratory mappings of each of the twenty theories analysed in this research, and documentation of the prototype design research resource.

Research Outcomes

The outcomes of this research are theoretical insights and new relational models, which have been interrogated through the experimental development of a prototype system. The analysis, interpretation and mapping of a selected group of design research theories have led to some new insights within specific theories and across groups of theories. This analysis of design research theories has engaged with several different perspectives, and challenges fundamental and longstanding ontological schisms based on binary models that have long influenced understandings of the field of design research.

A series of deeper structural relations that work across these theories have also been identified. This relational identification eschews a project aimed at meta-theoretical unification. Correlations of these structural perspectives with some findings in recent literature about academic perspectives on research, has led to the identification of some parallel forms of conceptualisation, opening up the possibility of these groupings being used to support a range of interpretive pathways in a more relational information system. These perspectives would seem to indicate that individual sensibilities or contexts influence the way

researchers understand research, and that such understandings or orientations to research are distinct from disciplinary perspectives and conventions. These frameworks have grounded the development of a prototype design for an information system based on multiplicity, interpretation and relationality, rather than formalism. A key thesis outcome is the development, to proof-of-concept, of a web deliverable design research resource framework that can enable researchers to review and cross-reference at a granulated level the models, structures and key terms of a range of design research theories.

Chapter Two

Design Research: Paradigms, Theories and Practices

A Literature Review

Introduction

'Design Research: Paradigms, Theories and Practices' engages with key references and ideas that have informed the research questions, rationale and development of this project. While concerned with design research methodology, this project has developed from a consideration of relevant concepts from literature drawn from a number of distinct disciplinary fields including the areas of design theory, research theory, information science, design philosophy and the philosophy of technology. The subheadings used in this chapter are based on issues relevant to this thesis and are identified through a consideration of writings across these fields. A major focus of the literature review has been on writing about the discipline of design, in particular the theories and practices of design research. Reading in this area has drawn on texts from design's many different genres or professional specialisations, such as engineering design (for example, Hubka and Eder, 2003), art and design (Scrivener, 2000; Niedderer and Roworth-Stokes, 2007; Rust, 2008), graphic communication (Poggenpohl, 2000) and information design (Cao and Protzen, 1999; Vaishnavi and Kuechler, 2004/2005), as well as from sub-disciplinary fields and/or methodologically distinct areas of design such as design philosophy (Buchanan, 1995, 1998, 2001, 2007), design studies (Margolin, 1995, 2002), design science (Gregory, 1966) and human-centred design (Krippendorff, 2006).[2] This engagement with readings from across the design domain was undertaken in order to gain an overview of the field, to better understand issues and theorisations of design research and to more fully comprehend the

[2] For a full list of design research texts reviewed for this thesis see Appendix Two.

heterogeneity of the domain. This review also provided some insight into methodological approaches that might inform and guide in research for this thesis.[3]

The first part of this chapter considers the theories and practices of design research, beginning with the identification and discussion of key texts that address the nature of design research and issues of pluralism and duality that have shaped the development of its disciplinary identity. Ontological debates concerned with the nature of design research are critical to this inquiry, as various beliefs or understandings about what design is inform different perspectives and theories about design research. This section is followed by an analysis of literature that considers different methodological frameworks and approaches taken to categorising various approaches to design research. The next section of this chapter considers some theoretical inconsistencies identified in and between different frameworks and their effects on design discourse, for example the problem of terminological variation. The issue of inconsistent terminological definition highlights underlying dualistic tensions between scientific approaches to design, which demand fixed definition and consistency, and constructivist approaches, which recognise the inevitability and cultural richness of terminological relativism.

The next section of the review draws from literature about the relationship between research and knowledge, from both design and other disciplinary perspectives. In particular, there has been a consideration of literature concerned with the nature of research and the ways research is understood and organised. This literature addresses the historical and institutional frameworks that have shaped the development of design and research. Some of this literature has been drawn from writings about the history and philosophy of science (for example, Kuhn, 1962), and some from the area of research education (Brew, 2001; Akerlind, 2008). As this thesis is concerned with design research, theoretical perspectives about knowledge and research, both from within and outside the discipline of design, have been fundamental to this project. The development of design research has led to a growth in design knowledge across a range of different areas, using diverse approaches and presented and published in a range of different locations and media. This proliferation of information has led to a need for better organisational structures to manage design knowledge. The organisation of information is considered in this project through a review of texts that address the nature of information, approaches to the ways information can be organised, and the relationship between

[3] The methodological approach taken in this project is discussed in Chapter Three.

information and knowledge. This area of focus grew from the recognition and primary impetus of this project: the need to find ways that information, as presented in models and theories about the heterogeneous field of design research, might be better represented and better navigated to support greater relational understanding and encourage greater methodological awareness by design researchers. The relationship between the development of design research and computing is addressed; in particular, approaches by the Artificial Intelligence in Design movement to the organisation of design knowledge are considered in light of the failure of such approaches and the difficult legacy they have bequeathed to the future development of any computer-based design knowledge management systems.

In the sections of this chapter titled 'Information and Technology' and 'Semantic Variations and Meta-theoretical Structures' technological and conceptual shifts in the way information is defined, organised and managed are considered in relation to both formal and non-traditional methods of categorisation. The value and limitations of traditional information systems' approaches, based on top-down, hierarchical categorisations, are compared to interpretative approaches based on information hermeneutics. In particular, the development of semantically-based web approaches are considered in relation to the ways information can be structured. This discussion contextualises and has informed part of the methodological approach taken to this research inquiry. Finally, a selection of online design resources is reviewed to ascertain the range and capability of existing resources. This review covers a range of web-based material and has been useful in understanding what currently exists in terms of design research resources and in helping draw out and refine the research problem and the focus of the inquiry.

Pluralism and Dualities

Heterogeneity is regarded as an inherent and significant feature of the emergent field of design research (Buchanan 2007; Margolin, 2002; Heskett, 2002; Dilnot, 1984, 1984b; Jonas, 2000; Jonas and Meyer-Velden, 2004; Roth, 2000). Richard Buchanan writes: 'The pluralism of design and design research is one of the fundamental characteristics of the field. It is a characteristic we may ignore at the peril of gross misunderstanding of the richness and complexity of the field' (2007, p. 56). This diversity of approach is recognised as both a limitation and a potential strength for the discipline. The value of such multiplicity is seen to lie in design's position as an integrative (Buchanan, 1996) or interface (Jonas, 1999)

discipline that has the potential or need to bridge traditional divisions such as the 'natural' orientation of sciences and the 'social' orientation of the humanities through a 'third culture' concerned with the artificial (Simon, 1969; Cross, 2000; Jonas, 2000). In spite of sometimes heated disagreement and resulting disciplinary fragmentation across the field, this 'undisciplined' pluralism is also recognised as contributing to the increasing articulation and vibrancy of design discourse (Krippendorff, 2006).[4] Buchanan goes further, claiming this diversity and discursive vibrancy is critical to the discipline and its activities: 'The implications of this are immense, because it reveals the domain of design to be not accidently but essentially contested. The essential nature of design calls for both process and the results of designing to be open to debate and disagreement' (1995, p. 25).

However, a number of limitations associated with this pluralism have been recognised. They include: the difficulty of representing this complex field of seemingly contradictory positions to people outside the discipline (Buchanan, 2007); the resulting tendency to represent and practice design research through the ill-fitting frameworks of other disciplines (Jonas, 2007); the widespread lack of understanding across the broad scope of the field and the limited appreciation of the potential range of available methodological approaches among design researchers (Chow, 2003; Margolin, 2002; Cross, 2006); inhibition of the development of the discourse of design across different design research communities and approaches (Margolin, 2002); and, perhaps most importantly, the limitation of the development of new approaches that are needed to address complex contemporary problems that draw from multiple perspectives (Navarez and Feher, 2000; Roth, 2000; Buchanan, 2001). Such limitations indicate a more widespread problem related to a lack of understanding of broader frameworks and relational articulation across the field.

Issues that underpin and contribute to this situation include: longstanding professional divisions within the discipline itself (Margolin, 2002); the trajectory and implications of design's historic development, first as craft, then as a number of distinct professions until its inclusion as an academic discipline within the university (Buchanan, 2007); the introduction of PhDs in design in the latter part of the twentieth century, and the consequent development of a design research culture (Friedman, 2000); and the resulting divisions and limitations of theoretical discourse (Margolin, 2002; Krippendorff 2006; Jonas 2007; Love, 2002). The associated problems that arise from this diversity have

[4] Undisciplined was the title of the 2008 Design Research Society Conference, held at Sheffield Hallam University, UK.

led to an acknowledgement of the need for more dialogue between different theories and approaches (Archer, 1981; Margolin, Doordan and Buchanan, 1998: Krippendorff, 2006). While many design researchers use or advocate specific positions and associated methodological approaches, few are engaged with the problem of addressing or researching this complex situation. The need for better relational understanding across the field of design research underpins the purpose and rationale of this thesis.

Many theories of design research draw from overarching binary knowledge models to explain design knowledge frameworks. Historically this epistemological division in the discipline of design can be linked with the rational, problem-solving paradigm of design based on a techno-positivist framework developed by Herbert Simon (1969) and members of the Artificial Intelligence Movement, which had, and continue to have, a profound effect on the development of design methodology, and the alternative constructivist epistemology, proposed by Donald Schön (1983), based on human perception and 'reflection-in-action'. While the fundamental tensions in these framings emerged in classical philosophy, the limitations of this originary model have been recognised and challenged by Richard Coyne and Adrian Snodgrass (1991), Kees Dorst and Judith Dijkhuis (1995) and more recently by Rosanne Chow and Wolfgang Jonas (2008). In particular, the polarity between the rational, systematic approach of design science and that of intuitive, tacit, practice-led approaches, described by Coyne and Snodgrass as 'design's dual knowledge thesis', has underpinned much of the discourse about design research over the last forty years. Ken Friedman (2003) has recognised a distinction between the intuitive but unpredictable processes of art and craft, which have informed one approach to design, and scientifically based approaches, which focus on understanding 'how things are and how they work' (p. 513). He identifies this focus on predictability with industrial and digital forms of production, that is, with scientific and technical frameworks. Victor Margolin (2002) recognises that such divisions are part of the history of institutionalisations and disciplines. They occur 'between those practices that have traditionally been recognised as intuitive and aesthetic and hence located in schools of art, and those seen as technical and thus founded in colleges of engineering and computer science departments' (p. 29). He suggests that these divisions are cultural rather than epistemological, and that 'the different ways of valuing aesthetics and technical knowledge are deeply embedded in the culture at large and have prevented greater communication among designers' (p. 31). The need to interrogate and understand this fundamental dualistic underpinning and find new ways of articulating and researching design outside

the confines of these historical divisions has been recognised by certain design theorists, leading to the development of a number of more complex interpretations and theories of what design research is and the ways it can be conducted.

However, the dualistic divide still prevails. Jonas (1999, 2000, 2007) and Chow and Jonas (2008), have criticised design's historic but still evident divisionism as counterproductive, suggesting that it ignores the uniqueness of design as a third culture, with its own distinct ways of working, research processes, methods and outcomes:

> The problems of design and innovation in industrial, organisational and social contexts are characterised by complexity on the problem side and contingency on the solution side. The current methodological dualisms fail to address these issues as a whole. Resolving the dualisms is a must if design research is to proceed to fulfil its potential. (Chow and Jonas, 2008, p. 047/2)

Margolin (2002) also recognises the limitations of this divisionism in relation to the capacity of design research to address complex contemporary problems and to the transfer of new knowledge across specialist divides (p. 237). Here the issue of complexity should be recognised not only in relation to the social and technological complexities of human society, but also in relation to the changing role of design and the re-conceptualisations of the nature of designed artefacts that such interdisciplinary approaches require.

This thesis project recognises and engages with the fundamental problematic of design's dual knowledge thesis. While the context of this dualism is an important factor in design's history, and an ongoing issue in terms of the constitution of design's identity, this situation has been challenged by more urgent needs that demand new understandings and approaches. The discipline of design has begun to develop its own 'designerly ways of thinking' (Cross, 2001, 2006) that have grown from developments in the knowledge and understanding of design practice, design research and design discourse, rather than being drawn directly or adapted from the epistemological frameworks of other disciplines, for example from the earlier scientific and artistic traditions from which design's dualistic positioning was derived. Literature about design research reflects these developments and shifts, from positions that borrow strongly from other disciplinary approaches to theories based in newer, 'designerly' ways of thinking. The analysis, interpretation and relating of a

number of design research theories, proposed by different investigators and authors over the past forty years, is a core focus of this thesis. This relational approach is different from scientific attempts to develop unified theories of design based on a stable disciplinary core, fixed vocabularies and formal taxonomies (Hubka, 1987; Love, 1999). The impossibility of such totalising approaches, which seek to create singular, all-encompassing theories that define and categorise all aspects of design, have been recognised and discussed by a number of writers, including Jonas (2000) and Margolin (2002). Richard Buchanan (2007) writes:

> Many investigators are tempted with the prospect of a single monistic vision of design, but the diversity of potential monisms suggests that pluralism is an unavoidable reality. The pluralism of design research suggests that design is a field comprised of many fields, each shaped by its own problems and lines of investigation. (p. 56)

This diversity has caused the development of a number of research groups and design research conferences that have sought to engage with, solve or dismiss this problem of heterogeneity. For example, the AI in Design group sought to develop formal design ontologies as ways of systematising and generalising design knowledge (Brown and Birmingham, 1997: Gero and Kannengiesser, 2004); Jonas's online event 'Paradox endeavour to design a foundation for a groundless field' (2000) was based on the premise that design 'is a groundless field, there cannot be eternal basics but rather arbitrary entry points' (unpaged); the 2008 Undisciplined Conference by the International Design Research Society recognised the dynamic shifts in the field, claiming that: 'Designing seems to be moving into a new era, the disciplines that have framed our work are reshaping themselves, new kinds of designing are emerging and we are not yet able to define these new and hybrid professions, some created by people not previously thought of as designers'
(http://digitalcommons.shu.ac.uk/drs2008/DRS2008_About_The_Conference.pdf).

This pluralism is linked to issues – described by some as problems – of language and terminological variation. Even within longstanding and established fields like design science there are particular terms denoting different understandings, practices and approaches. What are often proposed as unproblematic terms or concepts are, in reality, more complex and contested entities. The very term 'design science' elicits a number of diverse definitions or categorisations used to describe a number of different approaches within distinctive cultural and professional contexts. Please refer to Chapter Four for a more detailed

discussion of concepts of design science in the theories of Gasparski et al. (1995), Cross (2006) and Krippendorff (2006). Kristine Niedderer and Seymour Roworth-Stokes (2007) have considered variations of terminology used in the field of 'practice-based, practice-led, studio-based' design research (p. 2). They define so-called 'art and design' research as an area with a common problematic, defined by particular institutional structures (within Schools of Art and Design) and their common, associated 'research regulations and requirements' (p. 2). Niedderer and Roworth-Stokes recognise the problems that the confusion of terminology causes for the developing discourse of 'art and design' research and address the problem by identifying, comparing and mapping different terms used in texts about practice-based research.

The terminology used in different areas of design research, be they scientific, practice-based or otherwise oriented, is difficult to correlate. The overlaps, linkages and distinctions between terms within a specified field or associated with other design strategies or disciplines are rarely explored. The history of design research, its various institutionalisations, and the ideas that have informed its different methodological and conceptual developments underpin this current situation. However, the history of design research is unevenly chronicled and scholarship in the area is still limited (Buchanan, 1998; Bayazit, 2004).

Jonas (2000) describes this historical perspective as a 'temporalisation of theory in design' (unpaged). He recognises a tendency to dismiss older theories as useless or irrelevant, when 'nothing is really entirely new, everything is based on archaeological sediments. None of the many branches ever "dies". Instead they "sleep" for a while and differentiate according to new impulses/fluctuations from inside/outside the discipline' (unpaged). Jonas recognises a dynamic relationship and recycling of ideas and approaches in regard to design research. He suggests that design discourse reacts, reclaims and regenerates, and so old ideas are never completely disregarded: 'We have "theory generations" which are not "true" or "false" but "fashionable" and "appropriate" or "outdated" and "inappropriate"' (2000, unpaged). Jonas recognises the basis of the discipline through a history of theories or discourses about design (rather than a history of objects, famous designers or styles), and describes this as a 'growing sediment of past discourse that creates the stable intellectual foundation for essentially unstable and risky and explorative action' (ibid.). This perspective recognises the field of design research and its discourse as unstable, but productive because of this dynamic. Buchanan (2007) has also recognised a cyclical process of design research theory building: 'They have

risen and declined in popularity but they have all persisted and been available when one or another embodiment of a strategy has temporarily run dry or has suggested further problems for which a different strategy was needed. Their interplay accounts for much of the vitality of the field '(pp. 56 and 57).

This temporal and theoretical fluidity is generally overlooked in accounts of design research history and methodology, where firm distinctions are often made between new positions and older, more established frameworks. Such accounts are linear, and demarcations between approaches and movements are described and defined. There appears to be an assumption that earlier approaches cease or loose relevance when in fact they tend to continue to be used or are taken up, at least in part, in other areas, for example the uptake of design science approaches in the area of information systems design (March and Smith, 1995; Vaishnavi and Kuechler, 2004).

Historical divisionism cannot adequately represent or explain design's complex and multi-stranded development. There is a need for a better relational understanding of how and why different design research frameworks have developed, and for further investigation into the ways these different understandings can be related as a more dynamic and distributed framework for the benefit of design researchers.

Design's Methodological Frameworks

Any deeper understanding of this process of cycling, with re-emerging ideas and shifting interpretations, requires an historical perspective. However, narratives charting the historical development of design research are recognised as being limited (Buchanan, 2007). This may in part be due to the relatively short timeframe, of approximately half a century, over which design research has emerged. There are also difficulties in researching and writing a history that has developed from a number of different starting points, in different research communities that have posed very different questions about design and the ways it is studied and researched (Margolin, 2002). This heterogeneity and fluidity of ideas has made it difficult for people, both within and outside of the discipline, to understand or contribute to design's emerging discourse. Design historians have tended to focus on the histories of design production through studies of designed objects, designers' biographies or design companies (Woodham, 2001) rather than on the less tangible conceptual developments within the history of design research itself, which, as Margolin has recognised,

can be complex, multi-stranded and spread across a number of geographical locations. This is reflected in the limited writing available about the history and theory of design research from outside Western Europe and North America (Gasparski, 1995b; Woodham, 2001).

Another significant and related problem concerns the lack of agreement about the value of and approach to organisational frameworks that might help identify, store and give better access to the growing body of information about this pluralistic field. This issue has been addressed by a number of theorists and educators who have identified several effects of this situation (Archer, 1979; Margolin, 2002; Love, 2001; Krippendorff, 2000). Margolin recognises that the lack of overarching frameworks is evident in the scope of most design research teaching and curricula in programmes that teach postgraduate researchers about research, sometimes described as research methodology programmes. He acknowledges the restriction of conceptual and methodological specialisation evident in most design research training programmes:

> Unlike most advanced degree programs where students are introduced to the debates and conflicts in their field, no degree program in design at the master's or doctoral level has ever acquainted students with all the existing design research areas. Hence academic programs in design have remained limited in subject matter. (Margolin, 2002, p. 246)

Margolin does not propose a normative approach to systematise all knowledge about design research, but seems to suggest a more expansive approach that would provide students with a greater understanding through an overview of the broader disciplinary field and its range of methodological approaches. Dorst (2007) recognises a need for an 'anatomy of design research' (p. 1) and suggests this would initially require an identification of core assumptions that underpin existing ways of working. From this point, he suggests, anomalies could be identified and 'footholds for a further development recognised' (ibid.).

A contrasting position and approach is evident in Terrence Love's 'meta-theoretical structure for design' (2000, 2000b, 2001, 2002). This takes a scientific approach and is posited as a way of underpinning the development of a 'unified body of knowledge' (Love, 2002, p. 345). Love's framework seeks to establish a set of higher order categories for organising design knowledge, drawing from an ontological schema developed by the philosopher of science Karl Popper (1976). Described as the 'three world' model, this approach was based on a distinction among concepts from the physical, material world and those of the

subjective world of the mind and its contents, and, thirdly, from the objective world of theories, knowledge and problems (Love, 2000, p. 301). The stated purpose of Love's rational approach is to enable clarity by creating distinct categorisations and to minimise the conflation of concepts that he recognises as inevitable across seemingly incommensurate worlds. That is, Love seeks to develop a concise, certain and well-defined ontological structure in terms of which, he claims, all design knowledge can be organised.

While the divisions between different forms of professional design practice are still maintained in many tertiary institutions, these boundaries have been challenged by a number of theorists and educators in response to social, economic and technological shifts that have affected the discourse, practices and understandings of design over the past twenty years. Margolin (2002) suggests that designers and educators need to look beyond the old boundaries of established professional design practices: 'At the university where much professional design training takes place the different practices are separated into distinct academic programs that serve to obstruct productive dialogue' (p. 29).[5] Krippendorff (2006) suggests that the limitations of older, institutionalised design genres restrict the re-conceptualisation of design beyond old industrial categories of products, brands and services. Such re-conceptualisation entails a conceptual shift from the industrial to the electronic age and recognition of the challenge this poses to earlier notions and outcomes of design (Roth, 1999).

Design Research Literature

These shifts in the conceptualisation and approach to design not only affect the education and professional practices of designers, but challenge more traditional understandings and approaches to design research. Such contextual and methodological limitations are further exacerbated by institutional and discursive boundaries. Noella Mackenzie and Sally Knipe (2006) recognise a number of problems faced by most early career researchers in making 'considered decisions' about the type of study they might undertake. Among them is the need to locate a research project in terms of the 'debates in the

[5] New approaches are evident at the School of Design Strategies**,** Parsons New School of Design, New York, and at the Institute of Design at the Illinois Institute of Technology, Chicago, with its areas of Design Planning, Interaction Design and Systems Design. These approaches can be contrasted with design areas at the University of Technology, Sydney, which include Fashion and Textiles, Industrial, Interior and Visual Communication Design, or the Auckland University of Technology's School of Art and Design with its departments of Graphic Communication, Digital Design, Spatial Design, Fashion and Textiles, Product Design and Visual Arts.

literature surrounding theoretical frameworks underpinning the research' (p. 1). Within the emergent and contested domain of design research this can be difficult. Cross (2006) has recognised that many design researchers do not properly understand the frameworks in which they are working: 'the danger is that researchers adhere to underlying paradigms of which they are only vaguely aware. We need to develop this intellectual awareness in our community' (Cross, 2006, p. 102). Rosanne Chow (2003) has written about the problems she encountered as a doctoral student trying to locate and make sense of design research theory (p. 4). She has noted that unlike most other disciplinary fields there were (some seven years ago) few general introductory texts to theories of design, at undergraduate or postgraduate level. While recognising that there were some specialised texts about design methods and 'a number of how to do technical books', she identified a 'general neglect' of theories in design practice, research and education (ibid.).

The situation has improved somewhat since then, with the publication of a number of monographs by prominent design academics (for example, Margolin, 2002; Nelson and Stolterman, 2003; Jonas, 2004; Cross, 2006; Krippendorff, 2006), although the field and practices of design, rather than design research, have been the focus of most of these books. There has been significant growth in the number of conferences and published proceedings concerned with design research, associated in part with the development of PhDs in design and the rise in research evaluation processes at universities, with their expectation of staff being involved in developing papers and publications.[6] However, much design research tends to focus on specific projects and design methods, rather than on broader theoretical or methodological perspectives (Friedman, 2000; Dorst, 2007). There are a growing number of design-research focussed papers in an expanding range of academic design journals and volumes of selected essays focussed on design research, such as *Design Research Now (*Birkhäuser, 2007) edited by Ralph Michel. However, access to overviews of such literature and the wide diversity of approaches it presents remains a problem for many design researchers and students. Margolin (2002) recognises that literature which attempts to relate, critique or systematically analyse design research theories is still limited. Krippendorff (2006) has also noted that approaches to synthesising

[6] The UK's Higher Education Funding Council for England (HEFCE), the Scottish Funding Council (SFC), the Higher Education Funding Council for Wales (HEFCW) and the Department for Employment and Learning, Northern Ireland (DEL), the Research Evaluation Exercise (REA), initiated in 1986, the New Zealand Tertiary Education Commission's Performance Based Research Fund (PBRF), initiated in 2003, and the Australian Research Council's Excellence for Research in Australia (ERA) program, announced in 2008, are examples of this tendency to the quantification of university research through external benchmarks such as the rating and counting of articles published in qualified academic journals.

design literature, identifying exemplars and codifying design methods for use in information systems are limited as well. This lack of analysis and synthesis is particularly evident in the literature about design research, and indicates the need for the type of critical analysis of design research theories undertaken in this thesis.

Friedman (2003) has written that theory enables people to frame and organise observations, and to question and better understand what they do. It supports the development of more generalisable answers that allow knowledge to be passed on to other people and to be used by them. He suggests that every carefully defined and logically integrated conceptual scheme or theory constitutes, in some respects, a system, and cites the work of Talcott Parsons and Edward A. Shils (1951), who identified four levels of theoretical systems, based on an analysis of levels of generality and complexity, the degree to which a system is self consistent and the degree to which one part of a theory is supported or contradicted by other parts. They also take into account the level of systematisation or degree to which a theory moves towards general scientific goals. While the project of design science strove to develop formal, generalisable theories, many theorists working after this period recognised the impossibility of this endeavour in the heterogeneous field of design and shifted their focus and approach. However, there is scant recent literature that attempts to review or differentiate approaches or types of design research theories. The levels and categories of theories identified by Parsons and Shils, though, have been useful in helping to identify strategies and analysing conceptual approaches in particular design research theories analysed in this thesis.

While a number of researchers have developed and articulated theoretical frameworks identifying different types of design research approaches, there is significant diversity and inconsistency across these various models. Love (2002) suggests that 'paradigmatic factors related to cultural influence and the existence of prior theory have also limited the development of coherent cross-disciplinary design theories' (p. 352). Such incompatibilities across different theoretical models, he suggests, are not only caused by different paradigmatic underpinnings but by different conceptualisations of research and approaches to theory development. They sit at different levels of conceptual abstraction, located across different levels of categorisation. Love (2000) notes: 'the semantic and conceptual confusion in design research is compounded by theoretical constructs at different levels of abstraction having many similarities' (p. 300). He proposes a different basis for distinction between theoretical abstractions than that of Parsons and Shils, suggesting that abstractions are 'grounded in human

experience and conceived on the basis of our ontological assumptions about existence' (p. 303). He identifies a range of levels of abstractions from 'the sensual "concrete" world as experienced through our senses, and the most abstract higher levels refer to the ontological world of assumptions about reality, personal values and value systems' (ibid.). Love's levels of abstraction sit along a scale of relative values that range from empirical, embodied and material experience at one end of the scale, to broader cultural and intellectual concepts at the other.[7]

The lack of consistency of design terminology and its effect on the development of a cohesive disciplinary body of knowledge is another issue that has been the focus of much debate. There is no agreement on key terms and their meaning (Poggenpohl, 2004). The importance of terminological consistency is – like other areas of design discourse – interpreted from a number of different perspectives. Love (2002) suggests this is a significant problem to the project of building a unified structure for design:

> Currently it is difficult or impossible to build a coherent cross-disciplinary body of theory because key terms are: too broad, too narrow, inappropriate, ambiguous, multiple, inconsistent and different in different areas of study or practice. Resolving the problem requires tightening the definitions of core concepts specific to theory making about designing and designs, so that a common foundation can be established across and independent of domains of practice. (Love 2002, pp. 354–55)

Any such terminological homogeneity, however, could limit cross-disciplinary approaches, where the linguistic specificity of particular disciplinary frameworks and cultures implies a particular way of thinking and working with things. Specified vocabularies with fixed definitions, which are fundamental to traditional computer-based knowledge systems, and are akin to those proposed by Love, are also very different from the dynamic, culturally inflected ways that designers and researchers describe and understand the field. Krippendorff (2006) has argued for the inevitable contextualisation of terms and the impossibility of developing a universal terminology for design. He likens words to artefacts, which 'change their meaning as they travel through different uses, situations, times and different people's lives' (p. 7). Liddament (1999) has addressed this tension between computational requirements to standardise

[7] Love's model is discussed and analysed further in Chapter Five of this thesis

design language and the linguistic indeterminacy he also sees as being important for a socially mediated activity such as design:

> When we examine the complex concepts typically employed in design vocabularies (as elsewhere in our culture) we do not find 'fixed' usages, but rather, constantly evolving patterns of usage. We also see that the 'rules' governing these modes of discourse are not generally fixed a priori according to a calculus strictly determining their employment, although of course we do see strict 'rules' in some specific modes of language, particularly those employed in the logical calculi of computational methods where they become, in those very specific contexts, vital determinants of appropriate usage. Patterns of usage have their being, essentially so, in the specific contexts that give them their life. What we see, when we survey the vocabulary(s) actually employed in design contexts, is a rich interdependency; language structures are essentially holistic. (1999, p. 54)

The careful analysis of different terms related to creative practice in research conducted by Kristina Niedderer and Seymour Roworth-Stokes (2007) offers a more detailed analysis of terminological variety and meaning.[8] While recognising that 'many of these terms are not clearly defined and have multiple uses and interpretations,' (p. 9) Niedderer and Roworth-Stokes identify 'three categories that make sense of the context, purpose and outcomes associated with these terms' (ibid.). These are, firstly, terms related to research involving practice; secondly, terms related to practice by research or reflection; and, thirdly, terms related to critical inquiry (p. 10). This analysis helps clarify concepts and strategies associated with certain terminological groupings that are often confused because terms are sometimes used synonymously or to describe overlapping phenomena or are even used to denote quite different approaches. While Niedderer and Roworth-Stokes recognise 'the difficulties of interpretation and utilisation of such terms in any consistent and rigorous manner' (p.9), their analysis is valuable in examining the way design terminology is used in specific arenas and in differentiating frameworks, associated with certain terms, through which creative practice and design research are understood.

[8] Terms identified by Niedderer and Roworth-Stokes include: practice-led research, practice-based research, arts-based research, design-based research, studio-based research, practice-centred research, critical inquiry, investigative practice, reflective practice, evidence-based practice, research-informed practice and research-led practice.

Concerns about the standardisation of terminology are also recognised in critiques of information science, culture and new approaches to the organisation of information enabled by semantic web technologies. Kim Veltman writes:

> Cultural terms have local, regional, national and international variants, which change over time. Data structures and databases of static terms are therefore not useful to the cultural community. We need databases to reflect that meaning changes both temporally (whence etymology) and spatially, even within a culture (e.g. national, regional and local difference) and especially between cultures. (2004, p. 7)

Traditional information science approaches require standardised vocabularies. These have come to be regarded as problematic in a number of respects. For example, the use of standardised terminologies can be difficult for 'domain experts' – such as design theorists and design educators – to use, because specified vocabularies are often very different from the dynamic, culturally inflected ways different specialists and practitioners describe and understand the field. The focus on identifying 'one unequivocal, logical, static definition for each term' (Veltman, ibid.) may be feasible within scientific fields but is at odds with the changing and diverse culture of design.

Discourses of Knowledge

Design research must be contextualised within the fields of design discourse. Krippendorff (2006) defines discourse as organised ways of talking and writing that reside in communities of people. Such discourse needs to extend beyond the barriers of specific design genres and associated research methods, to engage with and extend new practices and understandings of design through research. The development of design research and the growth of design discourse have led to a growing body of design knowledge. However, attempts to build information resources and systems that might assist this process are limited. New approaches that could allow better identification of material through enhanced searching and questioning of information could be improved by the documenting and archiving of relevant commentary, analysis and critique of theories, the association of relevant examples (such as practices, case studies or projects) with particular theoretical positions, and the identification and discussion of terminological differences, overlaps and shifts of meaning.

Research, according to the definition provided in the New Zealand Government's Performance Based Research Fund, is concerned with making a contribution to knowledge and understanding.[9] As the discipline of design has developed, the discourse and body of knowledge across its various fields has grown. The problem of organising and accessing such a growing and 'undisciplined' body of knowledge is of concern for designers, educators and researchers.[10] Design lacks an agreed information structure. Even within traditional information systems like libraries, design lacks proper representation, with material being dispersed across other typologies. Praima Chayutsahakij writes:

> There is no database and/or Library of Congress (LC) classification: Design. Design literature resources are organized under databases of related fields such as architecture, psychology, business and economics, marketing, humanities and engineering. For example the sub-category 'industrial design' is organized under the LC classification of 'technology' while graphic design is under 'art' (Chayutsahakij, 2002, p. 7).

The difficulty with any endeavour that attempts to organise or classify knowledge within the contested domain of design is the complexity of design itself. There is a lack of agreement about the nature and scope of the field. This means that there are no basic taxonomic or terminological agreements: 'Design lacks a reasonable infrastructure including agreement on key terms and their meaning, on what constitutes core knowledge, on structures that support research, and on a discourse that transcends the ephemera' (Poggenpohl, 2004, p. 579). The development, access and application of design research knowledge and discourse have been limited by this problem. Despite the growth of publications, conferences and the development of the internet and online resources, specialist design areas often remain separated and their respective discourses isolated from the broader community of design. While the enormous growth of research and literature about design is evident (Cross, 2001, p. 50), the need for greater synthesis and relationality between different design approaches and bodies of knowledge remains a problem. Love (2002) identifies a lack of

[9] See http://www.auckland.ac.nz/uoa/home/about/research/re-performance-based-research-fund/PBRF-definition-of-research-2006

[10] The 2008 Design Research Society Conference was titled Undisciplined, reflecting the position that 'the disciplines that have framed our work are reshaping themselves, new kinds of designing are emerging and we are not yet able to define these new and hybrid professions.' See http://drs2008.designinquiry.wikispaces.net/Conference+Theme

supporting literature that could guide researchers in choosing between different traditional or alternative research paradigms (p. 354). The ability to make 'considered decisions' (Mackenzie and Knipe, 2006, p. 1) about the most effective type of research study, and the need to locate a project in terms of the theoretical frameworks underpinning the research, is limited by the heterogeneity of the field and a lack of relational understanding and theorisation across different design research approaches. Above all, this fragmentation limits possibilities for the development of new ways of conducting design research or of developing insights that might lead to valuable new interdisciplinary approaches. For example, it has been recognised that the emergent area of smart textile and clothing design demands multidisciplinary collaboration (Ariyatum, Holland, Harrison and Kazi, 2005), involving electrical engineers, computer scientists, textile designers and apparel designers as well as specialist input depending on areas of application, such as sports scientists for smart sportswear or medical specialists for health applications. There are difficulties in developing hybrid approaches or new interdisciplinary methodologies when research frameworks are seemingly incommensurate. If design researchers can develop or access greater relational understandings across different methodological frameworks and their associated conceptual, terminological and procedural issues, they might be able to better guide and participate in such interdisciplinary research.

Krippendorff (2006) has recognised that new information technologies may offer potential for supporting greater relationality. However, he suggests that this will first require more research and synthesis of existing literature:

> While major advances have been made in the automatic retrieval of texts and images from the World Wide Web they have not reached a level of synthesis of interest to a science for design. Textbooks and dissertations that can synthesize the design literature, extract recommendations, codify design methods and identify important exemplars await to be written. (Krippendorff, 2006, pp. 269–70)

Here the term synthesis should not be taken to mean the creation of unified theories or homogenised approaches. Rather, in the broader context of Krippendorff's writings on design, it suggests a need for deeper understandings of design research's different historical trajectories, contexts, theories and outcomes through critical analysis, exploring relationships between different discourses, conceptualisations and approaches to design research. This would enable the development of more inclusive perspectives that recognised the

importance of particular approaches for different types of research undertakings and valued distinction as well as commonality. This deeper relational understanding of the field, which is synthetic in approach, could lead to better ways of organising and retrieving information about design research. This concern is fundamental to the purpose and approach taken in this thesis research.

Margolin has also recognised that 'designers need to think in a more integrated way about how they work and they need to find better ways to navigate the intersections of domain knowledge and shared knowledge' (2002, p. 4). This, he suggests, would enhance the expression of the tacit knowledge of design practitioners into more explicit forms of knowledge to assist design education and the design professions, and support the role of design as a significant interdisciplinary discourse that could bring together human, scientific, technical and creative approaches. Margolin also emphasises the importance of design discourse as 'different arguments about what design is and might be as these are embodied in the literature of design' (p. 253), and suggests that studies on the literature of design are needed in this area. He also acknowledges that the worldwide development of doctoral programmes in design has given some urgency to building a serious academic research culture for the subject:

> It is important to frame a debate on the nature of design activity such that it can eventually lead to a greater understanding of the nature of design activity and what types of design research will be deemed valuable, even if these research tendencies are at odds with one another. (Margolin, 2003, p. 237)

Acknowledging the limitations of rational approaches like design science, Margolin suggests that the solution is not about an academic field agreeing on a single goal or approach to design, but lies in the recognition and appreciation of the 'plurality of research methods and goals that bear some shared relation to the larger profession to which they relate' (2002, p. 238).

Design Research and Computation

The history of design research has been temporally and conceptually intertwined with the development of computing. Herbert Simon's interest in design developed through his engagement with artificial intelligence. The context and main focus of his book *The Sciences of the Artificial* (MIT Press, 1969)

was the development of artificial intelligence (AI). Ideas of AI informed his belief that design processes could be generalised and reproduced in 'running computer programs, optimising algorithms, search procedures, and special purpose programs for designing motors, balancing assembly lines selecting investment portfolios, locating warehouses, designing highways, diagnosing and treating diseases and so forth' (Margolin, 2002, p. 236). Margolin recognises Simon's theory of design as an operational one, where design problems and strategies of decision making are to be resolved through logically based procedures concerned with generalised methods rather than outcomes.

Given the original purpose of computers was the computation of numbers, the mathematical and logical basis of computing was fundamental to its development. The expansion of 'computers as memory devices' (Veltman, 2004, p. 43), which can contain texts, images, media and multimedia, was supported by this original conception and application of computing. However, as Veltman suggests, there are dangers that 'the tools designed to help us become an end in themselves: merely providing solutions for the problems which they create' (p. 43). That is, the logical and formal basis of computing becomes the framework through which all human knowledge and thinking must be structured and operationalised. Implicit in this approach is the notion that principles of logic are reflected in the functions of language through grammar or syntax (ibid., p. 12). The development of the Design Methods movement in the 1960s, with its focus on the systematisation of design knowledge and computer-aided systems of designing, informed by rationalism, cognitive science and computer systems, was characterised and limited by such prescriptions (Buchanan, 1995; Margolin, 2002; Cross, 2006). The notion of objective information underpinned a key focus of design science and aimed to create a totalised system of logically related knowledge that would 'contain and organize the complete knowledge about and for designing' (Hubka and Eder, 1996, Section 4.2). Cross recognises that a number of different relationships between design and science exist under the term 'design science'. He describes Hubka's project as being about the development of 'systematic knowledge of design process and methodology as well as the scientific/technological underpinnings of design artefacts' (2006, p. 98) through the formal organisation of design knowledge.

The Artificial Intelligence in Design Group (AIDG) was motivated by developments in cognitive science and the desire to organise design information into formal, machine-readable systems and to replicate decision making, problem solving and even creative design processes via computing (Brown,

1997; Gero, 2002).[11] Such systems involved information structuring and computational agency. Structuring enables read-ability to support data identification and search, while computational agency supports action-ability, allowing more complex processes and associations to be made, for example through queries, optimisation or combinatorics (Bezerra and Wakes, 2005). Thus the significance of computational ontologies is that they are not only machine readable, but are actionable by computers. The main focus of AI has been located in fields of engineering design and to a lesser extent architecture, where formal taxonomies to describe artefacts, developed to support normative procedures as methods, have been the main subjects of focus (Gero and Kannengiesser, 2004; Gero, 2007b). Liddament (1999) recognised that the computationalist paradigm offered a promising way of conceptualising design activity through 'a systematic treatment of a hitherto messy and rather disparate domain, a scientific approach with a correspondingly rigorous methodology' (p. 44), but he questioned a number of assumptions behind this approach. These concerns stemmed from the basis of computation being founded on the belief 'that human cognitive ability must be encodable in some specifiable set of explicit, unambiguous instructions of the type that could be produced in the form of a program to be run on a serial computer' (ibid.). The conceptualisation of a mechanical process as cognitive activity assumes that cognitive activity can be reduced to specifiable sets that, he suggests, threatens to collapse distinctions between human and machine cognition. Liddament understood that design processes cover a broad spectrum of skills and approaches, ranging from calculus through to the application of 'critical thinking' leading to insight, originality and creativity in the development of possibilities. His criticism of the mechanical application of problem-solving processes, particularly to high level problem solving skills such as organisation, analysis, definition, development, refinement and evaluation, was that it led to a sort of scientific reductionism that works against the generative character of design activity.

Design science sought to build a comprehensive knowledge base that relied on fixed terminology, classes and formalised relationships that would serve as the basis for rationally guided and generalisable design activity. While this approach may be feasible in relation to some technically based areas of engineering design, the notion that consciously based design activity can only be realised through logical processes of systematisation has been strongly contested in areas of design where different perspectives on human problems may be needed in order to generate new approaches resulting in better design

[11] See the AIDG website at Worchester Polytechnic Institute: http://web.cs.wpi.edu/Research/aidg/

solutions. The realisation here is that in design there is no right answer; rather there are improved or new solutions. Buchanan (1996) claims this radical indeterminacy is fundamental to the nature of design.

The limitations of the design science approach have fuelled a level of scepticism within the design research community towards computer-based approaches to the organisation and agency of design knowledge. The problematic of such projects was explained by Liddament (1996) as being related to the inability of the machine to replicate human thinking and behaviour: 'Can computational programs simulate the vocabulary(s) (syntactical and semantical) used by human designers; and to what extent (and in what sense) might the machines on which such programs can be run resemble the biological "hardware" we think of as (partly at least) comprising human designers?' (p. 43.) This recognition parallels the basic assumptions on which the project of artificial intelligence was based, identified by the phenomenologist and critic of AI, Hubert Dreyfus, firstly as a biological assumption that the human brain processes information in a particular way akin to on/off switches; secondly, as a psychological assumption based on a conceptualisation of the mind as a device which works on pieces of information according to formal rules; thirdly, as an epistemological function whereby all information can be formalised; and, fourthly, as an ontological assumption that the world is made up of facts that can be represented by discreet symbols (Dreyfus and Dreyfus, 1986). The philosopher Bernard Stiegler has also questioned the tendency to conflate human capabilities with machine abilities. He writes: 'the brain is not a machine, on the one hand because 'abstract machines' do not exist, and on the other, because this organ is in no respect a machine: a machine is not a living organism and therein lies its force' (2004, p. 1).

Different ways of approaching the organisation of information within computers are underpinned by earlier historic conceptualisations of structure and human knowledge. Information scientist John Sowa (2006) recognises that Aristotelian notions of classification underpin all branches of cognitive computer science. These fall into two broad approaches, the first being top-down logic-based approaches, which define concepts based on genus or supra-type as universals. The second approach (drawn from biological study) begins with the description of particulars, leading to classifying and then identifying related groupings as genera. This is described by Sowa as a bottom-up approach. While many design ontologies purport to be generalisable into other fields of design (Gero and Kannengiesser, 1994), they are inevitably limited and partial conceptualisations, restricted to specific theorisations, contexts,

terminologies and areas of application. Design science sought to use a top-down, logic-based approach to organising design knowledge, but failed to realise a universal system. Sowa recognises the impossibility of defining such empirical concepts: 'For any particular application a top-down hierarchy of concepts can be legislated but attempts to force all concepts into a universal globally consistent hierarchy have failed' (Section 2). One significant limitation of formalised knowledge structures, such as computer ontologies, lies in this assumption of a single world-view. Veltman (2004) also recognises the limitations of fixed information schema, which are generally developed by information scientists rather than subject specialists and are based on abstract, logically-based knowledge concepts:

> Everything is presented as if this is the way 'it is' ontologically, rather than providing frameworks whereby what a thing 'is', what it means, and how it relates to other things, change as the framework changes. This dimension is needed a) to explore the interplay between facts and frameworks or world-views used to explain them and b) to explain an historical shift from a quest for a single ontology to a need for multiple ontologies. Needed is an approach where entities can evolve meaning. (Veltman, 2004, p. 7)

New contexts for organising strategies and ways of engaging technologies are critical to the representation of cultural domains like design. However, these issues are generally ignored in design research literature, in part because of associations with earlier AI in Design projects and also because they are seen to sit outside traditional fields of design research activity, which authors like Dorst (2007) have recognised as being predominantly focussed on studies of designing. Nelson and Stolterman suggest that analytic or scientific thinking is limited by reductionism or 'the effect of logical dissection as a means of studying the elements, components or qualities of things in isolation from their intact whole' (2003, p. 72). They recognise that the benefits of a scientific approach have been enormous, but have also given rise to other problems. These problems, they suggest, arise from a focus on reductive observation and analysis, which, while providing powerful insights helpful in predicting and controlling nature, also limit understanding of complex systems and relationships:

> Nature is not merely a collection of organic and inorganic elements or compounds, possessing attendant qualities and attributes, which exist in isolation. Nor is humanity merely a collection of individuals in isolated

> proximity to one another. Everything is in relationship to everything else with varying levels of criticality and intensity. These attributes produce qualities and attributes at multiple levels of resolution. Complexity, a distinctive attribute arising as a consequence of the dynamic interactivity of relationships, is the rule in the real world, while simplification or reductionist thinking, such as ignoring relationships and concomitant emergent qualities, is a dangerous distraction. Analytic, reductionist thinking […] can create knowledge that is powerful only when brought back into a context of inquiry that takes into account the existence of complex relationships and the phenomenon of emergence. (Nelson and Stolterman, 2003, pp. 72–73)

The scientific approach towards ordering information has followed a reductionist approach that has proven to be inadequate for representing knowledge in a cultural domain like design. New conceptualisations are leading to different understandings, approaches and metaphors, such as Felix Guattari's notion of ecologies of knowledge (1989), second-order cybernetics (Jonas, 2006) and systems thinking (Nelson and Stolterman, 2003), which emphasise complexity, emergence and relationality rather than reductionism. These approaches parallel new conceptual and technological developments in computing and information sciences.

Information and Technology

Some thirty years ago Bruce Archer (1981) noted that the searchability of design-related databases was limited to and by titles and word searches. He recognised that 'the establishment of recognisable markers for centres of interest in design research is a matter of some importance' (p. 35). Traditionally, the organisation of information in databases has been through taxonomic structures such as metadata schema and, more recently, computational ontologies. Such structures have been developed either to conform to broader universal categories as formal ontologies, or as isolated frameworks pertaining to a specific domain of application (as applied ontologies). In domains like medicine, where there is a high level of consensus and explicit relevance criteria, complex ontologies have been developed to support knowledge engineering through computation.[12]

[12] The Brain Gene Ontology, for example, was developed at KEDRI (The Knowledge Engineering Research Institute at AUT University) to support the organisation and use of biomedical data (Kasabov, Jain et al., 2006). Knowledge engineering (KE) is a discipline that is concerned with the integration of knowledge into computer systems. It aims to assist solving

However, such approaches are difficult in fields like design where there are conflicting paradigms 'each containing it's more or less implicit view of the informativeness of different kinds of information sources' (Capurro and Hjørland, 2004, p. 395).

This problem of interoperation among different types and forms of knowledge has been and continues to be pervasive in knowledge management and knowledge engineering (Tamma and Payne, 2008). In the later part of the twentieth century this problem was the focus of much research into the establishment of federated databases and taxonomies or metadata schema, which were proposed as a way of resolving the problem of canonical synthesis.13 Research in this field has also been limited by the issue of semantic heterogeneity, whereby different concepts are represented through similar terms, akin to homonyms. This heterogeneity has also been recognised by some theorists as a problem in design discourse (Love, 2002). Computational ontologies, defined by Gruber (2009) as 'a set of representational primitives with which to model a domain of knowledge or discourse', were proposed as a method of improving knowledge representation that might enable greater understanding of the intuitive notions behind identity through better description logics.14 It has been recognised that such approaches are inevitably limited by the underlying assumptions inherent in the methods of classification and reasoning used in their development. Veltman (2004) suggests that such generalisations are more easily recognised in areas like economics and science where mathematically based principals such as calculation or prediction are required. Within the field of cognitive science three uses of computers are recognised. These include simulation, enhancement and the understanding of human cognition (Sowa, 2006). Many early AI projects were concerned with simulation, where it was proposed that computers would mimic and perhaps surpass human intelligence.

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complex problems that would normally require a high level of human expertise through computation (Studer, Benjamins and Fensel, 1998).

[13] The PC Mag Encyclopaedia defines canonical synthesis as 'The process of designing a model of a database without redundant data items. A canonical model, or schema, is independent of the hardware and software that will process the data.' http://www.pcmag.com/encyclopedia_term/0,2542,t=canonical+synthesis&i=39256,00.asp

[14] Gruber adds: 'The representational primitives are typically classes (or sets), attributes (or properties), and relationships (or relations among class members). The definitions of the representational primitives include information about their meaning and constraints on their logically consistent application. In the context of database systems, ontology can be viewed as a level of abstraction of data models, analogous to hierarchical and relational models, but intended for modelling knowledge about individuals, their attributes, and their relationships to other individuals' (2009, unpaged).

However, over time the AI approach has been replaced by a notion of computers assisting or enhancing human processes and capabilities. This approach to 'computational intelligence' has led to the development of a range of tools that seek to supplement, rather than mimic or replace, human cognition. This functional approach ignores many deeper philosophical issues about the relationship between technology and human beings. For example, the notion of the enhancement of human capabilities through technology can be considered in relation to the philosopher Bernard Stiegler's notion of technics, which is concerned with the relation between technology, time and the human (1998). Stiegler suggests that technics is a prosthetic supplementation of the human. In this respect prosthesis is not regarded as compensation for a loss or even just an additive dimension. He recognises that the term pro-thesis is both spatial and temporal. It implies being set in front or advance (Stiegler, 1998, p. 152), and forms part of his controversial proposition that 'techno-genesis precedes socio-genesis'. Stiegler has developed arguments about technology and its relation to the human that suggest a view of human life as 'epiphylogenetic', evolving according to a logic of prosthetic supplementation This term links notions of exteriorisation ('epi') and evolutionary development ('phylogenesis'). He suggests that, for human beings, the memory of the group is external and as such it is no longer species specific, but rather technological. For Stiegler, the experience of being and its transmission into knowledge is a function of mnemotechnics: the technical prostheses through which memory is recorded and transmitted across generations. This process is inevitably social and technological, rather than being limited to individual minds. Knowledge's contents, according to Stiegler, are thus constructed by their reproducibility, and knowledge's reproducibility is its producibility.

This technologisation and reproducibility of knowledge has occurred throughout the history of human development, for example in paintings, inscriptions, books and photographs. However, computerisation has led to a re-conceptualisation of knowledge production and transmission processes as rational 'information' technologies. This terminology reflects a shift from a notion of knowledge as mutable human understanding to information as objective fact or commodity. These technologies have changed the way we organise, store and access information and the ways we conceptualise and use it. Information can be considered in different ways. It can be thought of operationally as an objective document or 'thing' (Love, PhD Design Listserv: Information as an Entity rather than an Activity. Tue. 7 Oct. 2008). It might be thought of subjectively, that is it might be contained in something that can only be read from particular perspectives or with certain expertise (Capurro and Hjørland, 2004). Or it can be

thought of constructively, that is it will be understood in different ways by different people from different cultural backgrounds, who will interact with information in different ways (Krippendorff, 2006).

Different disciplinary perspectives and tensions between subjective and objective approaches to the theoretical and technical methods of the reception and communication of knowledge have contributed to these different concepts of information. The many definitions of the term 'information' reflect this underlying division. WordNet lists five different meanings, including information as:

- Data, a collection of facts from which conclusions may be drawn
- A message received and understood
- Knowledge acquired through study or experience or instruction
- The formal accusation of a crime
- Selective information, used in communication theory as a numerical measure of the uncertainty of an outcome, as in 'the signal contained thousands of bits of information'.
  (http://wordnetweb.princeton.edu/perl/webwn?s=information)

The last two definitions relate to specific contexts – one legal, the other communication theory – and are therefore less likely to be misinterpreted or contested. The first two of these definitions imply a notion of information as an object that can be transmitted and received, as an entity 'that could be passed from one place to another much like physical artefacts can' (Boyarski et al., 1997, p. 45). Information science and the computer technologies and methods developed to organise and utilise information are based on such objective notions of information that can be syntactically represented in systems based on rules of formal logic. Boyarski et al. recognise that the concept of information in terms of its relationship to technology is 'at best ambiguous and at worst deviously misleading our understanding of why we are developing this technology' (ibid.).

The third definition cited above suggests that information is interpreted and mediated by human beings through experiential, social or disciplinary perspectives. This culturally inscribed notion of information cannot be fully represented using current information technologies. Veltman (2004) recognises that the restricted sense of meaning evident in current information technologies is adequate for many areas of business and technical purpose, where machine-

to-machine communication is concerned with current information or 'today's world view' (p. 39). Such systems are structured to support simple transactions. He recognises that, within cultural domains, purpose and definition are much broader: history, context and the cumulative body of knowledge are significant; terms are not always static, nor do they always have a single meaning. These issues are seen to be critical to the problem of representing and communicating design knowledge that underpins this thesis inquiry.

Semantic Variations and Meta-theoretical Structures

There is a growing body of literature that discusses specific design research frameworks and particular methodological approaches as well as some texts that address design research in terms of broader theoretical perspectives. There are fewer texts that engage with meta-theoretical models or attempt to analyse or explore relationships and distinctions among different design research approaches across the field. In this context a meta-theory is defined as theory about theories. Jonas (2000) has proposed three levels of theory formation in design: the first is concerned with making, the second with the observation of design and the third, metatheory, with observing the observation of design (unpaged). Theories, for example by Buchanan, 2007, Margolin, 2003, Love, 2000, 2000b and Jonas, 2007, amongst others, seek to understand design research from meta-theoretical perspectives, although the theories developed by these authors are diverse and are based on very different philosophical and historical perspectives. The focus of this thesis project is not to develop a cohesive meta-theoretical overview, but to explore the productive and inherent unruliness of design research theories and to seek to identify patterns, commonalities and differences across this domain of discourse; to consider shifts of meaning and understanding; to trace linkages and to explore the porosity between seemingly incommensurate worlds. These indeterminate zones are regarded as spaces that expose different approaches and present opportunities to engage with design research theory, rather than obstacles that need to be smoothed over or unified. The process allows for information scaffolding (as a portable, reconfigurable structure) to be built up from and between theories, rather than developing, a priori, a formal structure into which theories must be fitted. It uses a bottom-up approach as a 'discovery procedure' (Sowa, 2006, p. 4).

The model developed by Jonas (2007/2008) engages with different historical approaches and theories of design research, rather than being based on an abstract ontological framework or categorisations from other disciplines. Jonas's

model, while published as a work in progress, is one of the most extensive identified in reviewing material for this thesis. It is built from the strategic model of design research proposed by Fraying (1993/1994) and/or Archer (1995) to identify categories of thematic concerns, claims, associated disciplinary approaches and references.[15] Jonas (1999), drawing from second-order cybernetics, describes design as a feedback system and recognises that design history is an 'immanent' part of design. He suggests that this feature distinguishes design from other scientific disciplines, and leads to a particular temporalisation of design theory. Design's dualisms and its systemic dynamics are acknowledged by Jonas in his description of design's historical trajectories as bifurcation cascades. He writes:

> The present situation ('today') of the discipline, of culture in general, is a product of its history. Who defines which elements are part of this history? We are positioned somewhere in the cascade ('today') according to the throughput of energy/information lambda (we can call this parameter 'cultural velocity'). One must take into account internal structures 'accumulated' in a system by its previous passage through bifurcations and along certain branches. The system is partly a memory of its past. (1999, unpaged)

Jonas's central concern is with the lack of design foundations. He notes the limitations of models from the formal sciences, the natural sciences and the humanities as models for design as well as a confusion of existing design theories. Jonas has also proposed a 'hyper-cyclic model' (2007/2008, unpaged) that he describes as a cybernetic substantiation that will serve as a framework for design and design research. This model is drawn from a systemic and evolutionary perspective, underpinned by a notion of design as a temporal intervention into evolutionary processes (Jonas, 2005; Jonas, 2007/2008). This approach recognises the complexity and dynamic nature of designing as a learning process within an overall evolutionary pattern. This model has been operationalised by Jonas and colleagues (Hugentobler, Jonas and Detlef, 2004; Jonas and Chow, 2008) into 'a methodological tool and medium for research through design' (2008, p. 1), called MAPS (Matching Analysis Projection Synthesis). MAPS is described as being 'designed to construct a fuzzy/flexible/adaptable connection between situations/contexts and processes and methods/tools in order to support project development' (www.design-research.org). The website also claims that MAPS will make potential problems

[15] This seminal model, which identifies approaches to research about, for or through design, is discussed in detail in Chapter Four.

explicit and that it will suggest processes and methods that will suit the project so as to better communicate and plan the project. This is proposed as a system to encourage engagement and consideration of methodological approaches rather than a problem-solving system or a diagnostic tool. The work being done by Jonas has been important to this thesis research not only because he engages with a number of critical issues that are central concerns to this project, such as design's dualisms, the issue of design science, the disciplinary status of design, evolutionary systems, the historicity of design theory and the archive of design, but because he is also engaged with exploring both theoretical and operational approaches to these issues. That is, his approach is built on practical philosophy rather than a separation between theory and practice, a position that also resonates with the approach taken to this thesis research.

Jonas and Chow's MAPS project differs from this thesis inquiry in two critical respects. Firstly, it is based on a meta-theory while this thesis seeks to investigate, represent and relate different theoretical models, mapping commonalities and differences to develop a dynamic hermeneutical structure. Secondly, while Jonas has also developed an online system to provide methodological support for the 'design (research) process', this has been developed as an online project diagnosis process using a decision-making system. In contrast, while this thesis project involves the experimental development of an online system that might be used to support methodological understanding for design researchers, this approach is not restricted to an investigation of methods of designing (or research through design) as is the MAPS system. Nor is it concerned with the development of a diagnostic system that could be used to prescribe the selection of methods in a particular project. Rather, it takes an exploratory approach based on hermeneutics and semantic frameworks to contextualise and locate methodological approaches. It aims to support interpretation, contextualisation and understanding across the field rather than diagnosis for specific projects.

However, the MAPS project is relevant to this thesis inquiry in several respects. It uses a dynamic systems approach to enable the representation of a diversity of approaches (as methods) that could be used in addressing specific design and research projects. As well, it introduces the notion of a field and a range of possible approaches. Jonas's writing acknowledges the historic underpinnings, the development, shifts, failings, reinterpretations and re-emergences of design theories. He recognises that design cannot produce a formalised body of generic disciplinary knowledge, but that design knowledge is contextualised and at best may be developed as an archive of projects. From such an archive some

tendencies might be observed, but these are likely to be temporally or contextually specific rather than generalisable. Jonas does not propose historic knowledge as a prerequisite for design expertise, nor that history should be an academic basis for design as a discipline, but suggests that the 'growing sediment of past discourse' may create a productive intellectual foundation for necessary and 'essentially unstable and risky and explorative action' (Jonas, 2000, unpaged). This approach is paralleled in the writings of Kim Veltman (2004) about the semantic web and culture.16 Veltman suggests that information systems within cultural domains must 'enable us to trace how meaning and knowledge organisation have evolved historically in different cultures' (p. 2). Knowledge structures and systems built for the representation of cultural knowledge must represent past as well as contemporary aspects and understandings of the domain.

Jonas's notion of design as a discipline is dynamic. He cautions against attempts to integrate design 'into a supposedly fixed constellation of established fields' (2000, unpaged). He recognises design as a groundless field: 'There is no stable disciplinary core but a fluid network of "chunks of ideas", re-established in communicative feedback at the interface between the contextual and the artefactual. Design is permanently re-creating its own ground' (2000, unpaged). This notion of the mapping, contextualisation and interpretation of 'initiatives' and approaches to design research as dynamic and multiple histories is important to this thesis project. The development of systems that might represent and usefully help to relate and support better understanding of some of the complexity, diversity and commonality of design research theories and practices cannot be approached as a traditional information science project. Just as a singular historical narrative of design cannot be produced, neither can a formal, top-down hierarchical taxonomy for design research be constructed. There are too many different starting points, too many diverse design research communities with different aims, theories and practices. They may sometimes use the same terms but mean very different things. However, dynamic, bottom-up processes of mapping, contextualising, interpreting, analysing and relating different perspectives offer different methodological approaches and potential outcomes.

[16] The vision for the semantic web, proposed by Tim Burners-Lee, is to develop technology that will support the retrieval of information from the internet based on meaning rather than spelling, as current word search technologies do.

Hermeneutical Frameworks

The process of relating different theoretical models involves analysis and interpretation. Hermeneutics, as an interpretative activity, has been proposed as a way of addressing design's dualistic frameworks and multiple identities (Coyne and Snodgrass, 1991, 1992; Friedman, 2002; Dorst, 2004).17 Within the methodological framework of this thesis project two different levels of hermeneutical processes can be recognised: one is concerned with hermeneutical interpretation of texts, the other with information hermeneutics. The first engages hermeneutics as a process of analysing and interpreting selected design research theories, considering specific texts to identify key ideas and tracing these ideas to form models, and then considering groups of models to identify patterns, commonalities, differences, linkages and references. Such patterns have been, where possible, correlated with other writing about conceptualisations of research, to cross-check or test the feasibility of this analysis. Within the area of research education some significant inquiry has taken place over the past decade into the attitudes and beliefs of researchers towards research. Such research has been driven by the economic agendas imposed by governments on universities through research performance and evaluation processes. In this context the development of research training programmes for university staff – particularly in what were previously professional areas such a design, nursing or teaching – has prompted closer examination of research policies and the ways academics understand research and learn or develop particular approaches to researching.

Angela Brew (2001) and Gerlese Akerlind (2008) have shown that researchers in general have very different conceptions of the value and approaches they take to research. Akerlind (p. 22) identifies four aspects that delineate academics' views of the nature of research. These include intentions, outcomes, questions and process. Akerlind's typology suggests there may be pre-understandings about approaches to research that can be correlated to the ways some design research theorists have framed or modelled particular theories about design research, and correlated to different ways design researchers may understand or approach research. These approaches may provide different conceptual pathways and linkages through which information can be accessed and associated concepts interrogated and explored. This is a significantly different approach from logic-based information technologies, which use hierarchically structured frameworks. It offers an approach based on information

[17] This approach to hermeneutical interpretation of design research theories must be distinguished from theories that propose a hermeneutical basis for design. See Jonas, 2007b, p. 1362.

hermeneutics, which recognises that 'understanding is determined by the pre-understanding of the observer' (Capurro and Hjørland, 2004, p. 395). The notion of information hermeneutics is also relevant to this thesis project. There is, firstly, a recognition of the different ways that the pre-understandings of an author, and then of an analyst, will affect the writing and understanding of a text. There is also recognition that people using an information resource will inevitably try and approach it through their existing knowledge frameworks. Given the fragmented and contested nature of 'information', even in the technical and commercial frameworks of 'information technologies', and of theories about design research, it is proposed that the incorporation of pathways that include more diverse frameworks of understanding, for example of researchers about research, would be useful in the organisation of a mnemotechne for design research. Capurro and Hjørland recognise that information hermeneutics is related to semantic approaches and social constructivism.

The social dynamic of terminology is a critical issue in the field of design research. Semantic issues also underpin most of the problems in the field of information organisation (Hjørland, 2007, p. 367). Liddament (1999) identified a fundamental problem to be the conceptualisation of language within computing. As a way of countering such reductionism, he proposed a language-oriented approach based on Witttgenstein's conception of a language-game, where a word can only have a fixed meaning within any particular language game. Liddament suggested that a 'reconceptualisation of computational techniques in terms of this alternative epistemological framework may help towards the generation of a powerful and constructive new paradigm to serve as an aid in design research' (p. 56). Language-games have also been recognised by other information theorists (for example, Sowa, 2006b) as a way of moving beyond the formal syntactical rules and static definitions that are defining features of information science approaches.[18]

Semantics and constructivist approaches also underpin and link other aspects of this project. The work of Joseph D. Novak and D. Bob Gowin (1984) into human learning and knowledge construction was framed by a social constructivist

[18] In a rejection of his earlier work on logic, Wittgenstein, in his later work, used the term 'language-game' to describe the multiplicity of forms of language, their fluidity of meaning and their various contextualisations. Instead of seeking generality, he suggested a notion of 'family resemblance' as the best analogy for connecting particular uses of the same word. The analogy between a language and a game emphasises that words themselves only have meaning in relation to human life and activities. (*Stanford Encyclopaedia of Philosophy*, http://plato.stanford.edu/entries/wittgenstein/)

approach to human cognition. Based on David Ausbel's cognitive theory of learning (1963), Novak developed a system of concept mapping to better represent children's conceptual understanding and to observe and evaluate 'explicit changes in the concept and propositional structures that construct those understandings' (Novak, 2006, p. 176).[19] Subsequently it was realised that concept mapping could be used in a number of different ways, for example as a method of recoding and comparing the analysis of information. In the late 1980s Novak and associates at the Florida Institute for Human and Machine Cognition (IHMC) developed software (C Map tools) to enhance the power and applicability of concept maps (Novak and Cañas, 2006). This approach was used as a tool for knowledge elicitation, but was also found to be a valuable method for organising information, due to its potential to synergistically represent structures of knowledge through information visualisation. The structuring of concept maps is based on identifying concepts (as primary elements of knowledge) and propositions (as relationships between concepts) to form a semantic unit. In this thesis project concept maps were initially used as a way of recording the analysis of key concepts and structures of different design research theories. This analytical process, recorded as C Maps, was used to build models of theories.

This approach can be described as a posteriori and based on literary warrant. That is, information categories were developed from a study and analysis of literature from the field. Taking an information science perspective, Bernard Frohman (1983) identified two different approaches to semantics: firstly, that categories can be given a priori as part of the meaning of a term for a particular concept. Such categories can be determined before examining the literature of a field. The second approach locates categories of the specific discourse within which the associated term is located. Thus semantic relations are formed a posteriori and can only be determined after an examination of the literature. Such categorisation is regarded as more adequate, because it is contextually related, but is less likely to be universal. The issue of 'the degree to which the categories devised by human ontologists should be thought of as universally applicable or objective, as opposed to artefacts of particular contexts' has been recognised by Catherine Legg (2007) as having 'bedevilled philosophical ontology from the beginning' (p. 425). It is also a fundamental issue that continues to underpin debates about formal and applied ontologies, and underpins tensions about canonicalisation and decentralisation in relation to the

[19] Ausbel proposed that learning takes place through the assimilation of new concepts and propositions into existing conceptual frameworks held by the learner.

development of newer, more relational information technologies like the semantic web.

Structure and Knowledge

Canonicalisation is the creation of a canon as an authoritative body of disciplinary or specialist knowledge. It can take the form of a sanctioned selection of literature or principles, standards or norms. The canon is a hegemonic formation in that it reflects not only the location and index of a discipline, but also a sanctioned approach to a particular form of cultural representation. Inevitably the knowledge within a canon will be contested and renewed if it is to remain relevant. It has also been recognised that technologies of knowledge transmission affect the form and mutability of knowledge:

> There is no immutable knowledge and rational knowledge is irreducibly open: the *transmission* of knowledge is their *transformation*, across which ranges the persistence of intransmissible knowledge, tested by a reality that appropriates it even while instrumentalizing it *as well as* the conditions for its elaboration and production. Knowledge's contents are constructed by their reproducibility, and knowledge's reproducibility *is* its producibility. (Stiegler, 2009, p. 136)

Structure, be it the form of the book as linear chapters and indexes, alphabetically organised encyclopedias or metadata schema of databases, is a fundamental aspect of mnemonic or knowledge technologies. Jonassen, Beissner and Yacci (1993) identify structure as being concerned with the recognition, observation, nature and stability of patterns and relationships of entities. They suggest it is fundamental to nearly every mode of inquiry. Structure is defined by the configuration and interrelationships in a system. It can take many forms, including hierarchies as sets of one-to-many relationships or networks featuring many-to-many relationships.

Sowa (1992) defines semantic networks as 'graphic notations for representing knowledge in patterns of interconnected nodes and arcs' (unpaged). While computer implementations of semantic networks were first developed for AI and machine translation, earlier versions were developed in disciplines such as philosophy, psychology and linguistics. There are several different types of semantic networks, but they are all forms of declarative graphic representation that can be used either to represent knowledge or to support automated systems

for reasoning about knowledge. They range from being highly informal to more formally defined systems of logic. Concept mapping is considered to be a method of representing structural knowledge. In concept mapping, the meaning of a concept depends on the relationships and associations each concept has with other concepts. Semantic networks are formed through the network of associations among related concepts. Semantic networks are also described as concept maps and are used as tools for spatially representing concepts and their interrelationships. These knowledge structures, which are also known as cognitive structures, conceptual structures or structural knowledge, are related to the ways that human being store and recall information in their minds (Novak and Cañas, 2006). Concept maps graphically represent concepts as nodes and labelled lines represent relationships among them. Mapping, or semantic networking, is the process of identifying important concepts, arranging those concepts spatially, identifying relationships among those concepts and labelling the nature of the semantic relationship among those concepts. Novak and Cañas (2006) describe this process as forming propositions: 'Propositions contain two or more concepts, connected using linking words or phrases to form a meaningful statement. Sometimes these are called semantic units or units of meaning' (unpaged).

Concept mapping, semantic networks and structural knowledge can also be described as cognitive structures. They have been linked to the patterns of relationships among concepts in memory (Preece, 1976); thus concept maps can be regarded as mnemotechne. Richard J. Shavelson describes such cognitive structures as hypothetical constructs 'referring to the organisation of the relationships of concepts in long-term memory, particularly semantic memory' (Shavelson, 1972, pp. 226–27). The notion of structural knowledge is central to both human and machine information processing and communication. In theory, semantic networks based on natural language structures or syntax can be refined, formalised and translated into forms of symbolic representation such as mathematical expressions, which can be processed by computers. The degree of syntactic formalism that supports computational processing is inevitably made at the expense of semantic richness and syntactic variation evident in forms of expression like poetry. However, structure is only one part of this computer ontology. There is a fundamental relationship between levels of formalism and processing, between structure and agency. The machine 'agents' of computing are algorithms that have a fundamental, ontological relationship to data structures:

> Algorithms and data structures have a symbiotic relationship. The more complex the data structure of a computer program, the simpler the algorithm needs to be and vice versa. Together, data structures and algorithms are two halves of the ontology of the world according to a computer. (Manovich, 2001, p. 223)

Semantic Frameworks

While computer-based information systems were initially organised on stand alone or proprietary databases, the rise of the World Wide Web (WWW) and, in particular, Web 2.0 (socially networked) and Web 3.0 (semantic web) technologies have introduced new approaches to the way information is collected, organised, shared and accessed. While early internet use was based on text for communication, retrospectively called Web 1.0 (W1), there have been significant developments in the use and capability of the WWW that have come not only through technological developments, but through new social practices enabled by the internet.

The defining theme of Web 2.0 (W2) has been described as the power of the web to harness 'collective intelligence' and challenge traditional systems of authorship and publication in relation to information gathering, discourse development and resource creation. This has in turn challenged older commercial models across a wide range of areas including software development and retailing (O'Reilly, 2005). It has also changed approaches to notions of copyright and resource development. The term Web 2.0 does not refer to any specific technological advancement, but to changes in the ways the WWW has been used by people.

Web 3.0 refers to the Semantic Web, proposed by World Wide Web Consortium (W3C) director Tim Berners-Lee in 2001. Berners-Lee has described his ambition for the semantic web as a 'web of meaning' rather than a 'web of links' (Legg, 2007, p. 410). The still unresolved project of the semantic web seeks to improve information retrieval on the internet through meaning rather than spelling. That is, it would move beyond Boolean word searches based on character recognition, through the implementation of a vast and more formalised data structure, to support more sophisticated computational agency across the enormous, unstructured WWW. Legg (2007, p. 407) has recognised some convergences between the semantic web project and that of older AI and knowledge representation projects which sought to develop formal ontologies

as 'machine readable theories of the most fundamental concepts or categories required in order to understand information belonging to any knowledge domain' (p. 407). While formal ontologies (such as the *Cyc* project, www.cyc.com) have been criticised for their complexity of categories and closed-world assumptions, that is that the system knows all there is to know within a given domain, criticism has also been made of the decentralised notion of the semantic web. These criticisms centre on its lack of logical consistency and the rapid changeability and unpredictability of web-based information. However, both approaches have been criticised (Legg, 2007) for assuming that the enormous shifts between general, intuitive human knowledge to highly formalised and logical schemas with particular kinds of controlled search can be made without a middle stage, developing intermediate conceptual results. While there is clear merit in addressing the lack of structure across the WWW to enable greater computational agency, the ever-expanding scale of the WWW (see Figure 1), the enormous range of material, the different types of people who use the Web and the different purposes they use it for, are just some of the problems to be faced in addressing this vast heterogeneity.[20] A contribution to the development of intermediate conceptual results using semantic web approaches as a critical and practical engagement with the structuring of knowledge in the significantly smaller but heterogeneous domain of design also underpins the rationale and approach of this thesis inquiry.

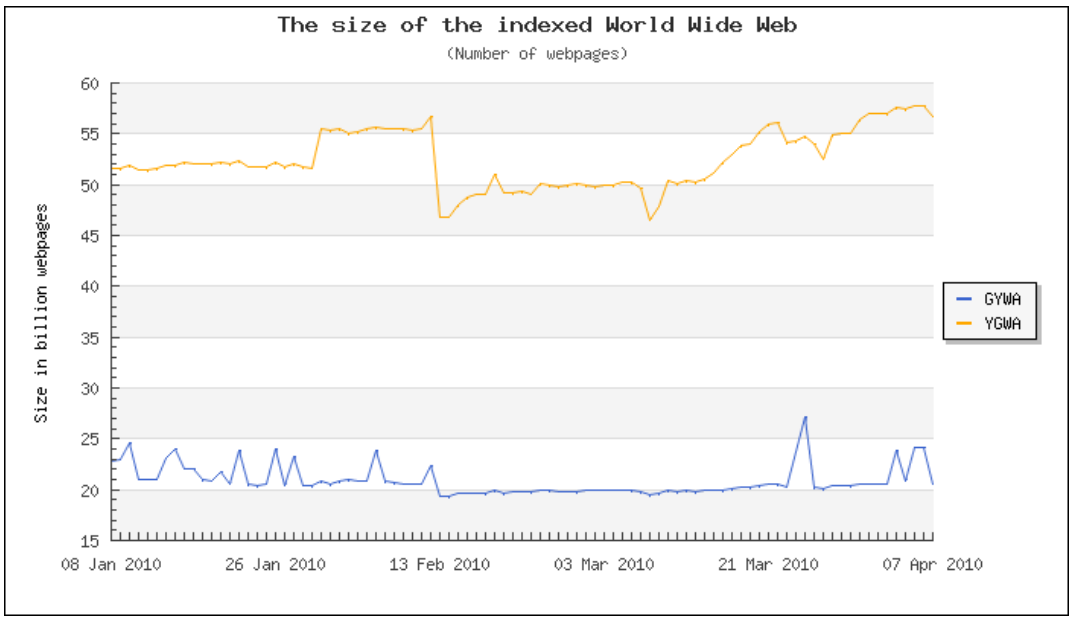

Figure 1: Graph showing the size of the World Wide Web on 7 April 2010, based on estimations of the numbers of pages indexed by Google, Bing, Yahoo Search and Ask.

[20] The website WorldWideWebSize.com identified that on Wednesday 7 April 2010, the Indexed Web contained over 20.51 billion pages.

> From the sum of these estimations, an overlap between these search engines is subtracted. The two different results relate to the sequence of correlations between the different search engines. (www.worldwidewebsize.com)

Online Design Resources

As part of this literature review an investigation of existing online design research resources was made to gauge developments in this area. While a number of offline design research tools were identified in the literature, for example by Shakeri and Brown, 2004, and by Reyman, 2001, most are focussed on design processes or methodologies of designing, rather than on design research. Offline resources are far more difficult to access and so to evaluate. Current online design research resources are limited. Few offer functionality beyond normal website features, such as menus, headings, keywords, hyperlinks or, in the case of blogs, tags and tag clouds. Fewer still use more sophisticated forms of computational agency. The online resources reviewed tended to fall into five categories:

1) Websites by design research organisations or academics that are primarily informational, notifying users about events or publications or identifying reference texts and links. They tend to have standard website features such as menus and hyperlinks, but offer little in the way of extended search capability. Content on these sites is generally developed by an editor or editorial group. Examples include:
Design Research Canada: http://www.designresearch.ca/en/
The Design Research Society website:
http://www.designresearchsociety.org/joomla/index.php
*All about design research (*edited by Dr Terence Love, Curtin University, W.A.):
http://www.allaboutdesignresearch.com/

2) Discussion groups, which may or may not be linked to a larger website. These range from listservs to forums.[21] These are social networks. Postings are by members of the community and range from news items to extensive debates on a wide range of design research topics, theories and approaches. The discursive nature of such sites has contributed much to the liveliness of design discourse.

[21] Listservs are subject-specific automated e-mail systems. Users who subscribe to a listserv are able to comment on related topics and receive comments and responses from other list subscribers via e-mail (http://www.domainhandbook.com/gloss.html).

These sites also include links to publications, papers, lists and references, but they tend to have limited degrees of searchability. Examples include:
PhD Design Listserv: www.jiscmail.ac.uk/lists/phd-design.html
Design Research Network: http://www.designresearchnetwork.org/drn/node

3) Blogs that present individual perspectives and opinions. Postings in blogs are written and presented sequentially using time/date of posting and headings. Information can be tagged using terms nominated by the blogger, and searches can be performed using these tags. Blogs often contain references to texts and events as hotlinks. Readers can respond to postings, introducing a level of interactivity. Blogs are self edited and tend towards opinion and news. Examples include:
Design Research: Sam Lander's blog on technology design and research methods
http://designresearch.wordpress.com
Design/research/writing: Ellen Lupton's blog
http://www.designwritingresearch.org

4) Open content resources work to build resources through collaboration. One of the most well-known open content projects is Wikipedia. There are few design resources in this category. However, there is one that, while still in the process of being developed, is interesting in terms of its aim, standards and structure. This is the *Theories Used in IS Research* wiki, run by York University, edited by Scott Schneberger and Mike Wade.
http://www.fsc.yorku.ca/york/istheory/wiki/index.php/Main_Page
The simple but usable wiki structure provides a template for building descriptions of information about research theories. While many of these theories are technical and specific to information system's research, the site also includes a number of broader approaches that are relevant to other design research approaches, for example Feminist Theory, Hermeneutics and Phenomenology. Like all open content developments, the growth and relevance of this site will depend on engagement and contribution by a broader community.

5) Design research tools. There are few true online resources in this category. One example is the MAPS project http://www.design-research.org. This is the only online design research tool identified that uses a highly developed computational intelligence to assist query- and decision-making that has been identified to date. In its current state it is presented as a test site and prototype. It provides limited amounts of information about specific methods, so is currently limited as a resource. But as a tool it enables the identification of

possible methods related to particular project concerns and parameters through a series of questions that require the researcher to think more deeply and make certain decisions about their project.

The site Research Design Connections http://www.researchdesignconnections.com/ describes itself as 'a knowledge tool to create great places'. This system is composed of a content-rich newsletter that is posted four times a year and an online searchable archive of past articles that summarise key findings on people and environments. The process followed by the group organising this site involves considerable background preparation searching for, locating and processing information so it can be usefully presented and linked to primary sources. This process is described on the website as involving:

- Scouring professional databases and current academic publications
- Selecting the articles that are deemed most useful and inviting proven experts to comment as guest columnists
- Extracting and integrating the essence of these articles
- Emphasising their relationships to practical, design solutions
- Presenting this information in straightforward text, figures, tables, and images
- Providing complete references for the sources used, so more information can be sought.

However, this site is an information resource rather than a knowledge discovery tool. The process of information collection and pre-processing is performed by human agents, not machine agents, and no additional search capability is provided. In this context it could be described as a knowledge tool (as is a library catalogue or index), but is somewhat limited in its capacity as a digital tool.

The MAPS project is described as helping to identify methods for both design projects (designing) and design research projects (research through design). It is focused on a specific task of identifying relevant methods. Jonas and Chow (2008) note that in practice this is a reflexive process, which uses a series of questions to help students to reflect on their projects as well as identifying possible methods to help them realise their projects. The Research Design Connections project is focussed on providing information to support designers to produce better designs. This concept of research relates more to a notion of

research for design (Frayling, 1993; Archer, 1995) by providing exemplars and references to support research for design development in a commercial environment, rather than by supporting more academically oriented research as knowledge creation or discovery, through or about design.

While this review does not extend to a consideration of methodology related websites in other disciplines, it is informative to make a comparison with one methodological website from a disciplinary area where there is greater consensus in terms of research approaches. The Web Centre of Social Research Methods: http://www.socialresearchmethods.net was developed at Stanford University, and is 'for people involved in applied social research and evaluation'. This extensive resource includes: a knowledge base on social research methods (Knowledge Base); a online tool for working with statistics (Selecting Statistics); a section on using computer simulation (Simulation Book); a series of links to other online publications about particular social research methods (Research Methods Tutorials); a section on research synthesis (Synthesis Galley); a section with methodology related publications and tools by the site author, William M. Trochim (Trochim Research); a link to a commercial concept mapping site (Concept Systems Inc.); and links to related research centres at Cornell University. This site provides a range of custom built resources, links and online tools to present a comprehensive portal for social science research that includes both informational and interactive resources. The domain of design research currently lacks resources with this level of information and interaction.

While the online design resources identified in this review provide information about design research, the organisation and access to this material, with the exception of the MAPS project, is limited to standard web-based formats. There are few examples of material that is formally organised to enable better search or query of information. There are limited opportunities for material to be discussed or cross-linked to other related texts. In the main, most resources are collections of texts or links, with few maps or overviews of how particular texts or ideas may relate to other material. Knowledge discovery in these examples is performed by users as human agents through the ability of an individual to navigate, identify and relate relevant material. Such approaches require contextualisation, evaluation and interpretation, which can lead to insight, but such a process is difficult and less successful if the searcher lacks background knowledge, specialist language or an overview of the domain.

Conclusion

This chapter presents a discussion of key texts and ideas that underpin, contextualise and expand on ideas relevant to the rationale and aims of this thesis inquiry. Reading for this review has been wide, encompassing references from a number of different disciplines, in order to articulate key ideas that have needed to be considered and understood from more than a single position. It was intended that this interdisciplinary approach would allow for new insights and understandings needed to properly site and develop this thesis project, which sits in a somewhat curious space at the intersections of design, technology, research and theory. Identifying relevant literature across these different areas has required considerable background reading and necessitated the understanding of new specialist terms and underlying principles in areas that extended far beyond this candidate's original area of expertise and frameworks of understanding in art and design. The timeframe for this research did not permit a complete survey of literature and deep level of reading across every area pertinent to this thesis. Rather the literature was assayed strategically in relation to the core concerns of this thesis. By considering relevant issues from a number of different disciplinary perspectives, established orthodoxies have been examined and the potential for new approaches and opportunities has been identified. This chapter, in the systematic treatment of literature via sub-headings, introduces key thematic issues which are more fully articulated in subsequent chapters.

Chapter Three

Design Research Theories and Methods

Ways of Researching

Introduction

'Design Research Theories and Methods: Ways of Researching' addresses the research design and methodological focus of this project. As the subject of this research is an inquiry into design research theory, including design research methodology, it is important to distinguish the subject of this project from a consideration of the methodological approach taken to conduct the research, which has shaped its development and realisation. Friedman suggests that methodology enables a consideration of the many aspects of how we engage in research. It provides a meta-narrative that places what has been done in a full research context. Methodology, he suggests, enables an explanation of choices, reasons and results (Friedman, PhD Design Listserv: Re: Design Methods (Questions for Jan Cocker). Mon. 25 March 2002). This chapter presents a consideration of the choices made in selecting particular ways of conducting this research project. The results of the research are presented and discussed in Chapters Four, Five, Six and Seven.

Within this project there was no single overarching methodological approach, but rather three distinct yet interconnected sections or phases, which required and drew from three contingent macro frameworks. The project is not located within one area of a specialised field using a conventional set of methods to probe one issue in great depth. Rather, it is located more broadly across these three areas, and includes certain zones of greater concentration or thickness. The focus and originality of this project lies in its engagement with relationality and the uncertain area between intuitive human approaches to knowledge

organisation and understanding and the highly formalised and logical schemas that are the basis of traditional computational approaches to knowledge representation and discovery.[22]

The main focus of this project is on the analysis, interpretation and relating of different design research theories, using a hermeneutical framework. This process has led to a series of mappings of specific theories, and of common or related approaches across different theories or groups of theories. The project has also been progressed through further consideration and investigation into the feasibility of using certain common perspectives, identified through this analysis, as a way of organising information for a resource about design research theory. This phase of the project has been developed within the framework of information hermeneutics, to support the representation of both the intended meanings of the various authors and the potential pathways or knowledge frameworks that might be followed by users of such a resource.[23] This system investigation, developed to proof-of-concept stage, is referred to as a design research resource in this thesis. The final phase of the project has involved an analysis of the approaches developed in this experimental phase in relation to formal and informal systems of knowledge representation and agency. This evaluation is focussed on the semantic capability, limitations and methods used in the experimentation and prototyping to inform the development of a design research resource. It also includes a consideration of the potential of this type of hermeneutically based system to assist resource users to gain greater access to information and help promote greater relational understanding of the heterogeneous field of design research. Just as the literature review for this project drew from a number of areas, the methodological approach taken in this thesis required the examination and adaptation of methods drawn from across a number of different fields, including design, philosophy, information and library science and research education.

[22] Relationality is characterised or constituted by relations as mutual connections or communications among things or groups. In the context of this thesis relationality is seen not only as a way of identifying and organising information through associations of meaning, but as a way of assisting access and understanding through systems that enable linkages between concepts, theories and bodies of information.

[23] It is recognised that while authorial intention will inevitably be interpreted by the reader, different positions are taken in engaging with what an author is trying to say in a text through a more critical approach, where the reader is evaluating the cogency or validity of an argument or relating one text to another. The hermeneutical process recognises that a text will be read and re-read, and that understanding will change over time and with deeper levels of immersion in a text.

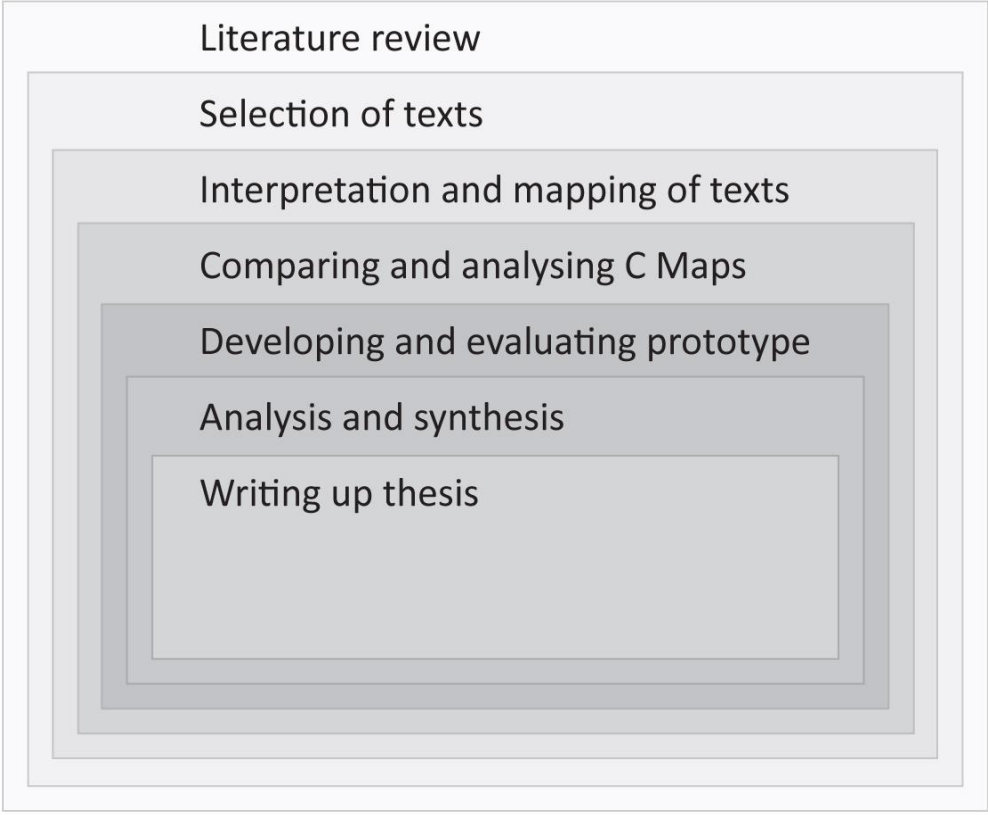

Figure 2: Diagram of stages of project methodology

The hermeneutical approach that has underpinned key aspects of this inquiry requires that the researcher's own position and presuppositions as a researcher are identified. The researcher's position is elucidated in this chapter through a discussion of the project background and the researcher's own motivations and context. Processes of selection, analysing, mapping and relating of design research theories are then considered. Approaches taken in relation to the organisation of information and the experimental development of an information system to proof-of-concept stage are discussed, and then the ways the system was evaluated are identified and, finally, key issues in this chapter are summarised in the conclusion

Background: Design Archives

The process of establishing the focus of inquiry and methodological approach within this project was not straightforward. The evolving concerns of the project went hand-in-hand with a trial-and-error process of identifying, experimenting with and evaluating different theoretical and technological approaches. This

initial engagement with design information and resource development grew from previous work building online design history archives. The issues of representation associated with the description of artefacts through metadata schemas and the semantic connotations inherent in the selection and standardisation of information fields and vocabularies (that is, the information design of a resource) became issues of greater interest than the primary research processes of locating, researching and documenting design artefacts or profiles of designers or design companies (as design history). The ontological inquiry that lay behind the metadata standard used in indexing artefacts in the database, based on the Getty Trust's Categories for a Description of a Work of Art (CDWA) and translated into Dublin Core standards, was of particular interest, due to its conceptual depth and complex representation of different types of information about art objects.[24] See Appendix One for the full list of metadata fields in the CDWA. The correlation between an artefact and the information about the artefact – be it descriptive, material, stylistic, historic, biographical, economic or concerned with provenance, function or a host of other conceptual framings – highlighted a problematic of representation and the ways such representation through text, image and information systematisation could enable or restrict access to knowledge. One significant limitation in relation to the design history archiving project was recognised in using a conceptual framework, developed by and for art and architectural historians and art museum curators, to try and describe and organise information about ephemeral, mass-produced, designed artefacts for use by designers, design students and researchers. The information associated with the designed artefact and forms of categorisation required in the metadata system were often very different, but no information standards for design artefacts were available.[25]

Notions of the archive, systems of mnemotechnics, and histories of design were also explored as part of the online archive-building process. This led to a deeper engagement with issues of design research, the epistemology of design and the

[24] The Dublin Core Metadata Initiative (DCMI) is an open organisation engaged in the development of interoperable metadata standards through which most resources can be described and catalogued. (http://dublincore.org/)

[25] Examples of such limitations were evident in areas of typographic analysis for graphic design artefacts and ergonomic analysis for products. In relation to typography the CDWA's 'inscription' category is for supplementary text that has been added to a work of art – such as the artist's signature or title. The interrelationship between text and image in graphic forms like advertising cannot adequately be represented in such a schema, let alone any detailed typographical analysis. Both would need to be added as supplementary categories. In relation to products, the CDWA does not require the 'function' of a work of art to be stated, as 'function' is not part of the ontology of Western art. This is in strong contrast to product design, where the use and usability of a product is critical. The indexing of non-material forms like service design is inconceivable in such a schema, unless artefacts recording or documenting the design of the service and its enactment were to be archived.

historicity of design theory. Through this investigation into the nature of design and the ways of organising information about the history of design, the dispersed, disputed and heterogeneous nature of design knowledge was recognised. In spite of the many claims made for a science of design, as 'an organised and systematised body of knowledge [resting] on a foundation in the natural world and the human socio-technical world' (Friedman, PhD Design Listserv: Design Methodology, Research Methodology, Methodological Awareness. Mon. 25 Mar 2002), there remains a fundamental lack of agreement about formalised systems of organisation for design knowledge (Poggenpohl, 1998, p. 117). Recognition of this problem led to a fuller investigation, through a review of design research literature, and a subsequent decision, prompted by supervisory cautions about the project becoming too broad, to focus this project on the area of design research theory. The nature of design, design's ontology and the framings and organisation of design knowledge in terms of its epistemology are fundamental and important issues for design research. Theoretical discourse about the nature of a discipline, the canon or body of knowledge that is its foundation and the way such knowledge is framed and organised are fundamental to the development of disciplinary identity. Much design research to date has focussed on inquiry into the practices and outcomes of design, such as design methodology, user-focused studies, product semantics or design history. Theoretical discourse that moves beyond studies of design practice or generalised principals that might be developed from such studies, to engage with design's critical and philosophical foundations, are less well developed. It was recognised that a study of theories of design research that attempted to articulate different understandings and approaches to the way design might be investigated could be a way of beginning to engage with some of the ontological and epistemological 'problems' that underpin the difficulties of developing relevant systems for organising and accessing design knowledge.

The subject of this thesis reflected a shift from earlier concerns with design history and online archiving to an inquiry into different conceptualisations of design as explicated in design research theory, and the ways these different understandings might be used to inform the organisation of information about design research methodology and help support recognition and relationship across these diverse perspectives. This focus and approach can be contrasted with the preoccupations of design science, which has sought to develop unified theories about the nature of design, or tended towards the development of ontological frameworks for tangible objects (artefacts) or processes of design that are related to design practice.

The decision to focus on design research theories was also influenced by the recognition that the area of design research methodology was seen as being somewhat problematic and contentious, both within the institution in which this researcher worked and studied and also by experts in the field (Margolin, 2002; Friedman, 2003). Many designers and design academics educated in the twentieth century received little formal training in design research or methodology and subsequently developed fragmentary understandings, often limited to a particular research framework, the associated set of methods and field professional design experience. In this context, the potential value of an archive of material about design research and methodology was recognised.[26] The archive could be accessed and explored by researchers and educators to help identify appropriate methodological approaches for projects as well as to help develop greater understanding of the rich methodological possibilities available to support cross-disciplinary approaches and understandings. However, it was acknowledged that the realisation of such a resource would require much preliminary research, in terms of the analysis and understanding of different theoretical approaches and the development of more useful forms of organisation to support access and understandings of material in such an archive. This 'preliminary research' became the central focus of this thesis.

In addition it was recognised that the technological systems used for knowledge organisation and recall, which the philosopher of technology Bernard Stiegler (1998) has described as mnemotechne, also informed approaches to categorisation. This led to further investigation into the philosophies and technologies that have informed the development of organisational systems such as catalogues, taxonomies, databases, semantic frameworks and ontologies used for structuring knowledge for technologically supported transmission in human societies.

Background: Engineering Knowledge

The ways that both human and machine agents might approach, search and associate data and the ways this might lead to or support understanding, became another point of interest. At this stage of the research, an association with KEDRI, the Knowledge Engineering and Discovery Research Institute at AUT University, was developed. Within this context, relationships between

[26] Jonas (2000) recognises the archival dimensions of design knowledge as a collection of exemplars with no axioms or refined conventions: 'Theories throughout the ages, methods, case studies: these are all testimonies to temporary fits of artefacts and contexts' (unpaged).

computation and information and the different forms and capabilities of systems activated by 'intelligent' agents became another area of focus. An initial review of publications about artificial intelligence or expert systems in design was undertaken. This included publications by Brown and Grecu, 1997; Shakeri and Brown, 2004; Gero, 1991, 2000, 2002; and Gero and Kannengiesser, 2004. As the researcher came from an art and design background, this process was demanding, as it required an engagement with new forms of specialist language, a strong technical focus and a coming to terms with a very different techno-functionalist frame of reference. The limitations of such approaches became evident. The development of formal information structures and the use of intelligent agents for solving design problems through AI in Design had some success in terms of highly specified task-based applications, but attempts to generalise such systems to work across a broader range of problems or to work in areas where problems were 'wicked' and unable to be formalised were inevitably limited. The concept of wicked problems was introduced by systems theorist Horst Rittell (Rittell and Weber, 1973). He recognised that while so-called 'tame problems', which are easily defined with a single goal, a set of rules and a correct solution, may be solved by machine intelligence, wicked problems, which are loosely formulated, persistent, and subject to redefinition and resolution in different ways over time, were more problematic. Buchanan (1996) and a number of other design theorists have recognised that most design problems are intrinsically wicked and that design as a discipline is 'fundamentally concerned with matters that admit of alternative resolutions' (Buchanan, 1995, p. 25). The wickedness of problems was recognised as a 'problem' not just for AI in design, but as part of a set of problematic assumptions that underpinned the notion of artificial intelligence.

AI pioneer John McCarthy's definition of artificial intelligence as 'the science and engineering of making intelligent machines' (2007, unpaged) is based on a fundamental premise that human intelligence depends on the manipulation of symbols. The philosopher of technology Hubert Dreyfus (1972) recognised and criticised both the epistemological limitations and the ontological assumptions of this position, claiming that not all human knowledge is symbolic and thus able to be formalised, nor can everything be described using logic, language and mathematics. He also stated that even when human beings do use explicit symbols, they do so against an unconscious background of knowledge and related experience. Without this context or situatedness, symbols lack meaning. These assumptions about human intelligence and symbol manipulation framed both the approach and the types of applications developed in AI and design research, which initially focussed on:

- Processes of designing artefacts and their associated ontological frameworks or
- The taxonomies of physical objects (as the outcome of designing and solution of the design problem) or
- Design processes (as tasks or problem-solving processes)

Such applications had limited relevance to what had become the subject of this thesis project – relating and modelling design research theory in its diverse and pluralistic forms. However, this further investigation of the literature led to an understanding of the problematic of the AI in Design 'View of Design' (Brown and Grecu, 1997) and a recognition of the need for forms of representation and agency that were semantically richer, contextualised and interpretively more flexible. A more relational approach that could enable heterogeneous information to be represented and used to support different understandings of design theory and design research approaches, rather than fixed and formalised frameworks developed to enable design problem solving, was recognised as an important focus of the project.

Some Key Distinctions

Distinctions need to be made here between methodology, methods and methodics in relation to this project. Methodology, as the study of method, enables an explanation of the choices involved in, the reasons for and the results of research. In the field of design there is also a differentiation to be made between design methodology, as the study of methods of designing, and design research methodology, as the study of methods of researching for, through or about design. Methods are regularised procedures used to perform specific tasks. Research methods are regularised or quasi-regularised procedures used to conduct and help validate or inform research. While design research can involve processes of designing, for example prototyping, and professional practices of designing can involve research, such as market evaluation, user feedback or human factors, the intended purpose and outcomes of designing and design research are different. Friedman writes 'research methods are not always part of design methods […] some of these are directly related to design. Others inform design and still others may inform design via the process of design research' (Friedman, PhD Design Listserv: Re: Design Methods (Questions for Jan Cocker). Mon. 25 March 2002).

Research has been defined as 'original investigation undertaken in order to gain knowledge and understanding' (1996 RAE document cited in Rust, Mottram and Till, 2007, p. 23). There are many different definitions of design.[27] Buchanan has defined design as 'the human power to conceive, plan, and realize products that serve human beings in the accomplishment of any individual or collective purpose' (Buchanan, 2001b, p. 9). In this and many other definitions of design the focus is on the development of a plan, proposal or artefact to achieve some end. While the practice of design may certainly contribute to the development of knowledge and understanding, this 'contribution to knowledge' is usually a secondary outcome rather than primary purpose. Friedman (2003) suggests: 'The practice of design is one foundation of design knowledge. Even though design knowledge arises in part from practice, it is not practice, but systematic and methodical inquiry into practice – and other issues – that constitute research as distinct from practice itself. The elements of design knowledge begin in many sources and practice is only one of them' (p. 512). This issue is less complicated when processes of designing are being investigated, as research about design, or if research is being conducted to support or assist design, as research for design. In these contexts there is a clear distinction made between the object of inquiry or thing being researched, the knowledge being created or research findings and a design process or resulting designed outcome.

This issue is more complicated when the processes and outcomes of design are proposed as a way to reveal, demonstrate or communicate research through design (practice-based or practice-led research). Archer (1995) recognised: 'There are circumstances where the best or only way to shed light on a proposition, a principle, a material, a process or a function is to attempt to construct something or to enact something, calculated to explore, embody or test it' (p. 11). In these circumstances processes or methods of designing are part of a research 'methodics' or collection of related methods (Bunge, 1999, p. 179) of a design research project. In themselves, however, the process of designing or its outcomes do not transparently and reflexively reveal new understandings or knowledge that has been developed. While such new insights can sometimes be 'read' from the designed artefact and understood by experts, this will depend on the familiarity of the expert with the field of inquiry and the reflexivity or transparency of the contribution. Within an academic context, where there is a commitment to the communicability of research for purposes of verifiability or examination, as well as knowledge transfer, such research projects require a

[27] Terrence Love (1998) produced a 30,000 word annotated bibliography on definitions of design made between 1962 and 1995, through an extensive literature review, which appears as an appendix to his PhD thesis: 'Social, Environmental and Ethical Factors in Engineering Design Theory: A Post Positivist Approach.'

corresponding narrative that can articulate and transmit the discoveries made during the research to other people. Rust et al. (2007) suggest that while the material produced during and from the process of designing might embody knowledge, it does not, in itself, transmit the arguments and evidence that reveal who created this knowledge and why it is original or significant. This tension between explicit and tacit outputs in art and design research has become the focus of much debate within the context of the institutionalisation of 'Art and Design' as a category within the university and the measurement and evaluation of research activities. This problem is exacerbated by the dominance of art practices that constitute a reading of design categories.

This research project is 'about design' and 'for design' in that it sets out to explore and relate design research theories and to investigate ways of developing an information structure and system that might begin to represent relationships between different understandings and approaches to design research. Most of the methods used in conducting this research have been drawn and adapted from other fields. The project has involved analysis and interpretation of theories as well as an investigation into, experimentation with and an evaluation of approaches that could be used in organising a knowledge resource. The methods used in developing and evaluating potential systems approaches, developed as part of this research project, are also included in a discussion of this project's methodics. However, while a system, as proof-of-concept, is designed – in that it is planned – it is not proposed here as a creative work, or form of artistic production, but as an experimental model through which certain approaches to relational organisation have been explored and some possibilities and limitations identified and analysed. This is in some part then, a project realised 'through design', but is primarily a project about design research and one that may prove to be useful for design research.

Selection, Analysis and Modelling of Design Theory Texts

The first phase of this project involved the identification, selection, analysis and modelling of design research theories. The process of identifying and selecting texts for analysis is discussed on pages 81-85 of this chapter. This is followed by a discussion of the approach taken in the analysis of these theories in relation to other analytical approaches that were considered and as a description of the process followed in this thesis. The modelling of the analysis into a framework or structure, using C Map tools software, the project research 'methodics' or collection of related methods (Bunge, 1999, p. 179) and further analytical stages

of comparing and relating these different models are addressed in the later stages of this chapter.

Thomas Mautner defines theory as 'a set of propositions which provide principles of analysis or explanation of subject matter' (Mautner, 1996, cited in Friedman, 2003, p. 514). Friedman proposes that in its most basic form a theory is a model. He describes a model as a simplified representation of reality. The purpose of such models and theories, he suggests, is to show or explain how things work (p. 519). The theories selected for this analysis provide explanations of how design research 'works' in terms of specific approaches or, in some instances, across the field. Friedman also distinguishes between theories that show a dynamic process or action, and more static models such as taxonomies. He identifies taxonomies as kinds of theory because they provide models of existing data and demonstrate relationships between and among facts (p. 518). He recognises that the identification of relationships distinguishes a model from a simple catalogue, and makes a distinction between structural models that are static, resembling maps, and dynamic models that can describe processes, activities or systems. In this mnemotechne project the analysis of selected theories was initially approached as a process of understanding and interpreting theories and representing them as models. However, comparing different theoretical models, identifying positions of commonality or distinctions and forming more complex and variable relational mapping across different theories is a dynamic process.

Identification of Material for Analysis

While some consideration was given to the nature and characteristics of general theories, for example the characteristics of general theories proposed by McNeil (1996, cited in Friedman, 2003), the selection of design research texts for analysis was not based on any correlation with such formal criteria, in part because many design research theories are emergent and are not always articulated parsimoniously or systematically.[28] Some one hundred and twelve texts,

[28] McNeil (1996) identifies the following eleven characteristics of general theories:

- Has a constitutive core of concepts mutually interrelated to one another
- Has a mutually productive, generative connection between central concepts and peripheral concepts where theory verges into practice
- Core concepts of a theory are stated in algorithmic compression and are parsimonious statements from which the phenomena can be reproduced
- Has an irreducible core of concepts which can't be changed without altering the scope and productivity of the theory

identified in writing about design research produced between 1969 and 2009, were read and considered. These texts are listed in Appendix Two. They were drawn from across the spectrum of writing about design, from books, journals, conference papers, websites and theses. They covered a range of design sub-disciplines or genres and different philosophical frameworks. From this body of design research literature a core group of twenty texts was selected and subject to deeper analysis and modelling. These texts are identified in Table 1 (p. 111). This selection of writings represented a range of authorial perspectives and included a variety of different theoretical understandings and approaches to design research from across a historical spectrum. The following criteria and factors were taken into account in refining the selection of texts for detailed analysis and modelling.

Texts had to address the field or parts of the field of design research. They would not be based on specific design research projects, case studies, problems or applications. Such approaches tend towards description and as singular instances provide a limited basis for theory building. Nor could texts focus primarily on other areas of design as a discipline, such as design practice, design history, design management, design education or design policy.[29] To have attempted to include such a broad focus across the whole field of design would have been extremely complex, presenting too much information with too great a variety and pitched at too many different levels. It would have been impossible to begin an initial study across such a complex and diverse arena. While recognising that much can be drawn from these domains and productively related to the discourse of design research, such dimensions, other than where the literature specifically addresses research related to these activities, for example research through practice, were deemed beyond the immediate scope of this inquiry.

- Two or more concepts in a theory must be complementary to each other
- The central concepts of a theory must be complementary to one another
- The central concepts of a theory must be expressed at a uniform level of discourse - different levels of discourse must be distinguished and used consistently
- More general or higher level theories must relate to less general or lower level theories and to special cases through a principle of correspondence, that is they are consistent
- Explicitly or implicitly a theory describes a dynamic flow with contours that trace relatively closed loops as well as open links
- A theory states invariant entities in its assumptions of formulas that provide standards for measurement
- Theories describe phenomena in the context of a conceptual space which establishes a relationship between the observer and the phenomenon observed.

(McNeil 1996, cited in Friedman, 2003, pp. 514–15)

[29] These different areas of design as a discipline are among those identified and discussed by Bonsiepe (1991).

In relation to the selection of specific texts for further analysis and modelling the following criteria were taken into account:

- Texts that began to articulate frameworks of understanding about the nature and different types of design research, that is writings that were ontological or epistemological in focus, were of particular interest
- Texts where authors presented an overview that acknowledged different frameworks and traditions across the field of design research were sought, as they moved beyond personal observations and subjective positions (lower-level theories) and engaged with more complex ideas and levels of discourse
- The clarity and level of discourse consistency across a theory was taken into account. Such consistency, through the consideration of different conceptual levels and relationships, is recognised as a feature of good theory building (Mautner, 1996), but also assisted the analysis and identification of key concepts and relationships in a theory
- The impact and significance of a theory, identified through citation, the standing of the publication and the profile of the author, were also taken into account. Such recognition is acknowledged through formal peer review processes, for example with conferences or journal articles as well as citation indexes, and is seen to validate the standing of the contributor and the level of contribution made to the field
- Research theories from other disciplines were excluded, unless such approaches had been adapted, reframed and used in the field of design research

An example of this sort of adaptation is the use of hermeneutical frameworks, developed, according to Gadamer, from allegorical interpretation and rhetoric in classical times, through approaches to Christian theological hermeneutics and subsequently reframed in the early nineteenth century by Friedrich Schleiermacher (1768–1834) to recognise the metaphysics of individuality and hermeneutics as a foundation 'for all historically based humanistic disciplines' (Gadamer, 2006, p. 35). In the twentieth century the emergence of philosophical hermeneutics, informed by the development of phenomenology, led to a shift from what was basically a methodological orientation of hermeneutics to a new sense of the hermeneutical as an ontological process, through the work of

Heidegger (1889–1976) and Gadamer (1900–2002). In the late twentieth century hermeneutics has been considered in relation to design (Snodgrass and Coyne, 1992, 1997; Friedman, 2003) and information systems research (Cole and Avison, 2007; Capurro, 2000; Chalmers, 2004).

With the analysis and identification of an initial ten texts, some further criteria for selection were developed in relation to the overall range and focus of the group of selected texts. These included the following:

- The diversity of approaches covered across different texts based on different positions and understandings of the field of design research. This diversity was actively sought and used as one criterion for selection so as to better reflect the pluralism of the domain
- Where gaps or thinness were recognised in terms of the representation of particular approaches, texts that addressed singular research frameworks with particular methodological approaches were sought and included as exemplars. This enabled and supported the articulation of different conceptual approaches across different texts at similar levels
- Once a larger body of texts was identified, further consideration was given to the relative depth and richness of some theories in comparison to the breadth and relative thinness of others. Some texts and theories that were initially disregarded as being too general or too specific, and so perhaps less interesting in terms of how they might be related to other theories, were reconsidered, included and fruitfully related to emergent concepts and frameworks identified from the analysis and comparison of theories from across the field.

Certain historic texts that are widely recognised as being seminal to the development of design as a discipline and to design research theory (such as Herbert Simon's *Sciences of the Artificial*, 1969, and Donald Schön's *Reflective Practitioner*, 1983) have not been included in this analysis. This exclusion was, in part, because both writers, while addressing the discipline of design, were commenting from other disciplinary perspectives and also because these texts,

in their original contexts of production, were focussed on the profession and practices of design rather than on design research.[30]

While there was a systematic approach to text selection, there was no attempt to represent every possible theoretical approach to design research, nor to create a definitive mapping of all the literature across the field, as this research was not concerned with trying to create an all encompassing meta-theory. A representative selection was made of texts that, as a group, presented a range of theories through which different approaches, understandings and relationships between these different conceptualisations could be traced and interrogated. The number of texts selected for deeper analysis was made pragmatically, so as to engage with a richness and complexity of relationships between several different perspectives within the timeframe of the research period. The scale of this selection was determined by the need to support the exploration of relational strategies, which required a diversity of theories rather than a comprehensive representation of all possible theories. This approach was not concerned with building a scientific framework, in the sense of attempting to totalise or create a universal schema into which information about design research methodology could be regimented. The selection and analysis of a considered and diverse, but by no means fully comprehensive selection, of theories was made to support an exploration of relationships between theories across sub-disciplinary boundaries. It was anticipated that this analysis might indicate possible approaches to structuring an information framework based on shared conceptualisations evident in the literature, rather than generalised principles. It was recognised that any such framework would need to be able to support the representation of different viewpoints and be dynamic, in the sense of being able to be extended in the future to include additional theories and further interpretative perspectives of additional authors, or developed subsequently by the selected authors.

Analysis of Theories

The process of analysis was conducted using a hermeneutical approach, which recognises a view of knowledge as historically founded interpretation. Chiari and Nuzzo (1996) recognise that such knowledge is contextually verifiable

[30] Later in the research process it was recognised that these texts act as critical pivot points across a number of design research theories. Because such seminal texts are often interpreted in very different ways by different theorists, they can be regarded as common locations from which different theoretical positions can be drawn out.

rather than universally valid and is linguistically generated and socially negotiated rather than cognitively and individually produced. Hermeneutics has been described as a practical art or techne, which is 'particularly required anytime the meaning of something is not clear or unambiguous' (Gadamer, 2006, p. 29). One of the primary aims of hermeneutics is 'to enact methodology based on the recognition that every research act is an act of interpretation' (Cole and Avison, 2007, p. 821). This approach recognises that the author of a text does not normally comment on its construction or significance, so a researcher needs to find ways of discovering meaning through the text itself (Seamon, 2000). Hermeneutical analysis requires an immersive engagement with a text:

> One embeds oneself in the process of getting involved in the text, one begins to discern configurations of meaning, of parts and wholes and their interrelationship, one receives certain messages and glimpses an unfolding development that beckons to be articulated and related to the total fabric of meaning. The hermeneutical approach seems to palpate its object and to make room for that object to reveal itself to our gaze and ears, to speak its own story to our understanding. (Von Eckartsberg, 1998, p. 50)

The hermeneutical approach seeks revelation from a text, an approach that recognises authorial intention, historicality, the pre-understanding a reader brings to a text and the transmission of meaning through the medium of language. Approach to the texts was made with an awareness of the historical horizon from which each text emerged. Interpretation is not a neutral act. The interpreter (or hermeneutician) also brings his or her own hermeneutical prejudices to bear, that is they have a tendency to negotiate the writings and ideas of others through their own cultural or philosophical frameworks. An act of interpretation inevitably requires a position and involves some form of judgement. Recognition of such critical positionings – of the author and of the interpreter – tends to emerge over time, through the reading and re-reading of a text. Interpretation is not a static process, but is a 'being-in-motion' (Heidegger, 1927). Snodgrass and Coyne note that the process of interpretation does not necessarily stop with the first access to meaning, 'since it can prompt a revision of the projection allowing other meanings to appear. Metaphors and models do not have a static, on-off meaning but are potentially capable of revealing multiple meanings that can be progressively disclosed by the back and forth meaning of the hermeneutical circle' (1992, p. 68). Context also influences and changes understanding. Interpretive clues can be detected from a context and the conceptual environment in which we encounter things. This plays an

important role in the way we interpret and assess them, and in the dynamic nature of interpretation: as the context changes so does our understanding of the meanings of the things we encounter.

At times, arguments developed and positions taken by some authors were difficult to interpret, in that they were quite foreign to the researcher's own academic and professional background, such as the AI in Design literature, which has emerged from computer science and engineering disciplines. Initially, it was important to try to approach such texts non-judgementally, to let them speak openly, before subjecting them to further analysis and evaluation. This process involved a number of readings of a text, identifying particular ideas and relating them to develop an understanding of the argument or overview, and then relating this perspective back to specific concepts and linkages of ideas within the text. This process corresponds with the description of hermeneutical method given by Coyne and Snodgrass:

> We pick up cues from the parts of a situation, which in turn trigger an expectation of the meaning of the situation as a whole. Therefore our understanding of the meanings of the whole and its parts develops in an interpretative circle. Our projected understandings and pre understandings play back and forth to refine and modify each other and, thus allow the emergence of richer and more comprehensive understandings. (1992, p. 68)

A fundamental concern in this thesis is the critique of the legacy in design discourse of a tradition of dualisms that establish divisions, such as between science and art or between theory and practice. The attempt to identify relational linkages across such sub-disciplinary divisions can be seen as a challenge to longstanding divisions within the cultures of design and recognition of the need for stronger cross-disciplinary research engagements. While this hermeneutic process led the researcher to an understanding of particular positions, it also led to the identification of commonalities and distinctions when different theories and groups of theories were compared. This comparative approach began to inform a greater awareness of the attributes and limitations of particular perspectives, leading to a greater critical awareness. Relationality implies a challenge to traditional linear systems of ordering and is, therefore, at heart, a political challenge that questions hierarchical forms of disciplinary governance.[31] Initial analyses of the design research texts were

[31] The mnemotechne project is not framed here as a politics of design discourse, but is grounded in the recognition that an emphasis on relationality implies a fundamental shift from

intended as a way of understanding their structure and construction by tracing and considering the ideas, arguments and approaches to design research unfolded by their exposition. This is a Kantian notion of critique, which engages with analyses in order to identify conditions of possibility or grounds for emergence (Kant, 1781). These notions of possibility and emergence challenge normative positions and in this sense are relevant to the central problematic and philosophical approach that underpins this thesis. Thus the approach taken to this analysis of design research theory texts can be described as a critical hermeneutics.

The focus for analysis was on understanding the text, identifying key ideas or concepts within the text and meaningful relationships between ideas within a theory and/or across different theories. This approach corresponds to Kees Dorst's suggestion that the 'anatomy of design research' (2007, p. 1) will require the identification of core assumptions that underpin existing ways of working. The process aimed to identify and map relationships as a precursor to the identification of patterns across the group of theories and the potential development of information structures.

While notes identifying key ideas and arguments were made from the texts during initial readings, a method was sought to help not only record but also to relate key concepts within a text. Given that re-readings of a text will often produced new insights or shifts in understanding, a dynamic method was sought to enable such changes of understanding to be incorporated. This method needed to be flexible and able to incorporate changes in understanding; to be able to represent complex ideas and arguments; and to be able to support comparisons between different theories. While notation can aid the hermeneutical process, it does not easily allow the incorporation of changes in understanding or re-interpretation of texts over a number of readings, or allow relational comparisons between texts to be made.

However, the forms of the texts were also diverse. Some of the ideas in the theories reviewed were written and developed over an extended series of papers (Archer, 1979, 1981, 1995; Buchanan, 2001, 2005, 2007; Jonas, 2004, 2007, 2007/08); across a number of chapters of a book (Nelson and Stolterman, 2003; Krippendorff, 2006) or briefly, across a few pages of a paper (Roth, 1999; Dorst, 2007). A wide range of different approaches were taken in the structuring and level of articulation across these theories. While certain approaches considered

established hierarchies of disciplinary knowledge towards more complex and diverse perspectives based on hermeneutical understanding and discursive engagement.

the whole field of design research, they were not always extended or developed in any depth. Such theories could be described as broad but thin. Other authors provided detailed models of very particular design research approaches. Some of these theories were developed over several years across a number of different papers and articles and then presented in books or major journal articles. Such theories could be described as narrow but deep. Some were only described in a single article. Other texts addressed the whole field of design research and were explored and traced across a number of levels of abstraction and comparative detail. These texts could be described as being both broad and rich. It became increasingly difficult to map this diversity, particularly as the hermeneutic process of interpretation, which moves from the identification and consideration of parts to a sense of the whole and back to parts in an iterative manner, also produces shifts in understanding. This process was further exacerbated when comparisons and contrasts between different theories were attempted. It was recognised that there was a need for better methods of recording analyses that would enable a mapping process that supported the representation of this diversity at different levels of granularity and abstraction across the range of theories, while yet enabling a comparative analysis.

Modelling and Comparing Theories

Some consideration was given to adapting a grounded theory approach, using text coding, concept grouping and category formation.[32] However, rather than mapping, these methods are premised on a process of data categorisation that involves the early identification of key concepts to support the coding of particular ideas prior to generalisation and theory development. It was felt that such an approach could over-ride and flatten any modelling that sought to express diversity of approach, terminology and conceptualisation that existed among different design research theory texts and the different relationships that existed among concepts. Taking a systematic approach to coding and categorising concepts in a text, to subsequently enable generalisation, did not seem to be the most appropriate way to understand a theory or the commonalities and distinctions that existed between different theories,

[32] Grounded theory is a qualitative social sciences research methodology initially proposed by Glaser and Strauss (1987) in which the researcher first collects data about a subject without preconceived ideas concerning its content or structure and then analyses the content to identify common themes or ideas which are then used to develop theory through generalisations about the meaning and relationships identified in the analysis. The theory is therefore 'grounded' in the data rather than the data having been collected to test a pre-existing theory, a process which may lead to bias.

particularly when authors have produced models that exist at different levels of granularity and are based on very different theoretical premises. Qualitative analysis software such as NUDIST was also considered.[33] However, NUDIST is based on a process of building a logical, hierarchical system of nodes to produce highly structured hierarchical database indexing into the documents to be analysed. While the hierarchical indexing of categories is recognised by the NUDIST community as encouraging the generation of new ideas, this software and approach did not seem to adequately support information hermeneutics as the representation of different world-views. Through a process of analysing and organising data it aims, rather, to develop a hierarchical taxonomy.

An investigation of mapping approaches was undertaken. Two types of mapping were considered: mind mapping and concept mapping. Mind-mapping processes allow the presentation of ideas in a radial, graphical, non-linear manner. While the branches of a mind map take the form of hierarchical tree structures, their radial arrangement disrupts the prioritising of concepts that are typically associated with linear structures such as information trees. The value of mind-mapping processes is that they allow the identification and association of concepts without first specifying a particular conceptual framework or structure. However, mind maps tend to develop from a central governing concept, and, while concepts can be linked, they do not allow such relationships to be specified. While the non-linear and visual approach of mind maps was recognised as useful, the focus on a central governing idea, and the inability to specify concept relationships, were seen as significant limitations.

A decision was made to use concept maps, which have some similarity to mind maps but are not dependant on a central concept and also allow the representation of connections between concepts in diverse patterns. Concept maps enable both structural and semantic representation. Jonassen (1993) has recognised structure as a way of identifying and representing the nature of patterns and the relationships of entities. Structural knowledge has been described as a way of describing the knowledge of how concepts within a domain are interrelated. Concept maps are also known as semantic frameworks or networks.

Concept mapping software, based on the work of Novak and Gowin (1984) into human learning and knowledge construction and discussed previously in

[33] NUDIST Vivo software is among the widely used qualitative software in the social sciences. See http://nudist-vivo.software.informer.com

Chapter Two, was used to support a hermeneutic approach for recording variant interpretations of a text. In being able to incorporate change over time, through the generation of new C Maps or the adaptation of earlier ones, C Maps have a performative and temporal flexibility as well as a structural dimension. The process of beginning the development of a C Map from a text using C Map tools version 4.11 is outlined below in Figures 3–5. These C Maps show, in a series of steps, how the analysis was conducted and the critical considerations made in interpreting and representing ideas from a text in a C Map. The section of the text analysed here is cited in Appendix Three and is taken from a chapter by Buchanan titled 'Strategies of Design Research: Productive Science and Rhetorical Inquiry' (in *Design Research Now,* edited by Ralph Michel, Birkhäuser, 2007). Within the text Buchanan identifies 'three major strategies of inquiry' (p. 56) that he suggests have emerged in the field of design in the twentieth century and have been important to the ongoing development of the discipline. In the first stage of developing the C Map (Figure 3) the author and date have been identified as a concept (identified in a rectangular box) that locates the source of this C Map model using a standard bibliographic convention (Buchanan, 2007). The concept of 'strategies of inquiry' that identifies a central idea and form of structuring in Buchanan's theory is also identified. Bibliographic citation is important in acknowledging the source text that is being interpreted and also helps distinguish this particular text from others analysed in this research, or from other texts produced by the same author. The identification of 'strategies of inquiry' as a central concept in this text was indicated by the title of Buchanan's chapter, 'Strategies of Design Research', and by the way the text itself is organised around strategies of research that are specifically identified by Buchanan. The phrase 'strategies of inquiry' and the relationships between this idea and other concepts in the text that are identified in the following C Maps (Figures 4–5) were not difficult to identify as Buchanan has included diagrams showing relationships between key ideas in this theory and provides definitions identifying these key concepts. Not all the theories and texts analysed and mapped in this thesis were as clear to map as this particular example:

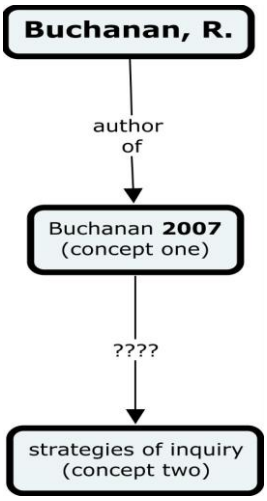

Figure 3: Initiation of C Map from text by Buchanan (2007) identifying author, text and central concept

The second step in developing the C Map (Figure 4) involved a consideration of the relationships between further groups of concepts in Buchanan's text. In considering the relationships between concepts a number of propositional terms were considered (Buchanan's own diagrams link one concept directly to another without using propositional terms, which are required in C Mapping). Buchanan's theory draws from his background in philosophy,[34] and this context is evident in his choice of terminology and forms of conceptualisation, for example in the use of concepts and terms such as dialectic, rhetorical inquiry and poetics. His approach is distinct from that of design research theorists who have backgrounds in professional design practice or education. Buchanan clearly articulates, names and defines the above approaches, so the term 'identifies' was used to describe the propositional relationship between the text by Buchanan and the central concept (strategies of inquiry). The selection of the term 'identifies', which acts as a proposition between the two concepts in this C Map is an interpretive act, although it is one through which the researcher seeks to replicate the approach taken by the author, evident in the composite structure of the text. The decision to place the author/text date concept at the top of the C Map identifies the source text from which the C Map has been drawn; the concept 'strategies of inquiry' comes from the body of the text, not the title.

The next layer of the C Map (Figure 4) identifies a third layer of concepts using the proposition 'includes approaches' which indicates a part/whole relationship between the upper level category of 'strategies of inquiry' and the three

[34] Buchanan received his PhD from the Committee on the Analysis of Ideas and the Study of Methods at the University of Chicago.

strategies specified by Buchanan as 'design inquiry', 'dialectic' and 'design science'. The subsets of 'rhetorical inquiry' and 'poetics or productive inquiry', sit under the category of design inquiry, and those of 'idealistic', 'materialistic' and 'sceptical' dialectic, under the category of dialectic. These concepts are clearly identified in the text by Buchanan and are represented in the C Map as sub-sets in a part/whole relationship through the propositional term 'includes approaches'. While this propositional term is not specified by Buchanan, it has been included in the C Map because it conveys the nested quality of these concepts, which are sub-components and can be combined to form the broader concept. The C Map attempts to trace and record the structure and relationships of key concepts in Buchanan's text that are identified by the author in diagrams (pp. 57–60) as well as in writing. These are represented in the C Map below as a set of nested concepts.

However, this initial mapping of key concepts is schematic rather than narrative. It sketches key ideas in Buchanan's theory but is still very limited, both in terms of representing his fuller theory, but also in terms of being able to make useful comparisons with other theoretical models.

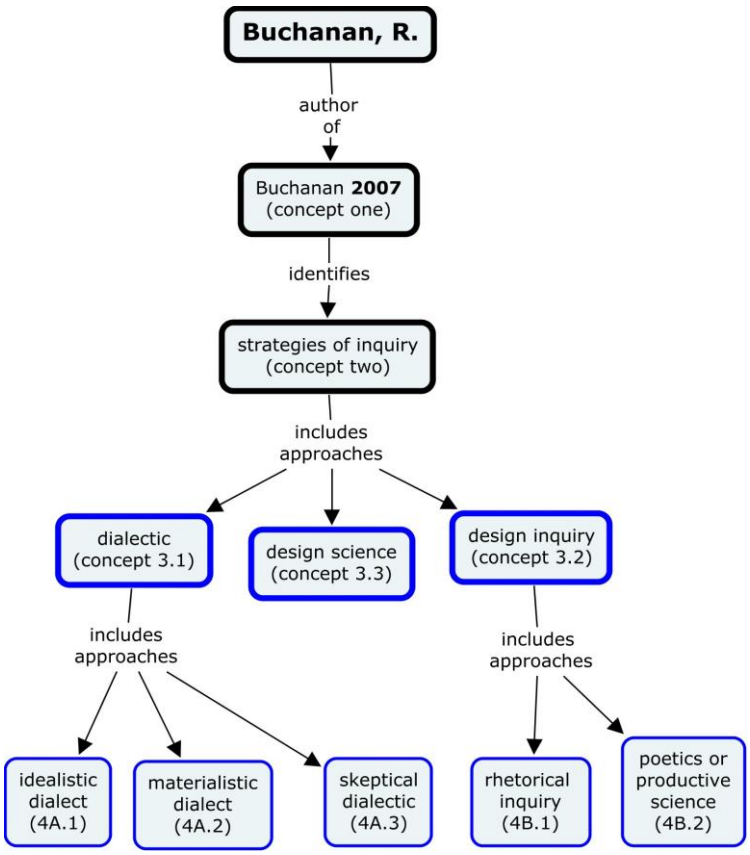

Figure 4: Development of C Map from Buchanan (2007) showing propositional terms and concept sub-sets

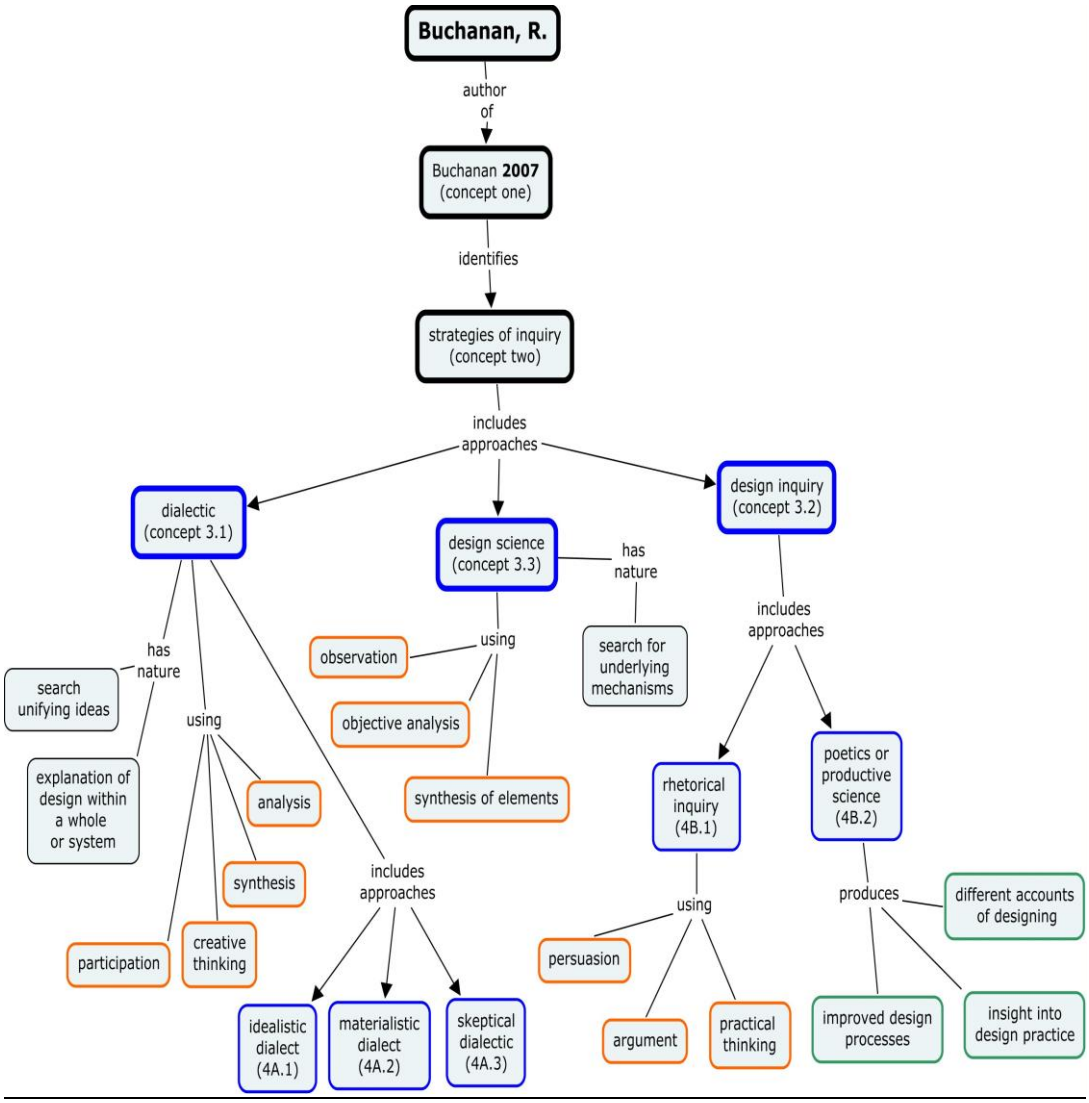

Figure 5: Adding further concepts and propositional terms to C Map from Buchanan, 2007

The next stage of developing the C Map (Figure 5) involved the addition of further qualifying or descriptive layers to the basic concept structure, using information and propositional terms from the text. For example: dialectic / is to / explain design within a whole system, or: design inquiry / seeks an / explanation of human experience, provide very brief definitions of the terms 'dialectic' and 'design inquiry' taken directly from Buchanan's text. Other sets of propositional terms include: 'with methods of', 'based on' and 'emphasises'. These various terms are used by Buchanan to identify particular methodological approaches or research processes. While such terminological variety of propositional terms is valued in written prose, it makes a C Map harder to read and limits the ability to compare similar types of concepts or to recognise patterns in a text or across different texts represented as C Maps. Some colour

coding was introduced to these C Maps at a later stage, identifying strategic approaches with a blue outline, research methods or approaches with orange and research outcomes with green.

In the next stage of developing the C Map from the Buchanan text, further information was added and some common propositional terms were developed and used to identify common classes of information (refer to Figure 6). Additional information from other sections of the 2007 paper and from an earlier, related conference paper by Buchanan (2005) was incorporated. The 2005 paper was an earlier version of the 2007 publication and in some areas provides more detailed definition or qualification of concepts. Some more general propositional terms were introduced to the C Map to more clearly identify particular types of information classes. For example, the definition or purpose of each strategy initially identified through terms such as 'is to' or 'seeks an' as in 'The first strategy is to explain design …' (p. 57), 'the second strategy is to explain …' (p. 57), 'the third strategy seeks an explanation in …' (p. 58), is expressed in the C Map through the proposition 'has nature', which identifies the ontological focus that underpins each strategy (Buchanan, 2007). Similarly, the methodological or research processes identified in relation to each strategy are recognised in the C Map through the propositional term 'uses' instead of phrases like 'with methods of' (2007, p. 57), 'based on' (2007, p. 58), 'often involves' (2006, p. 7) and 'through' (2005, p. 6) that Buchanan uses in the text. This process of analysing concepts and the ways arguments are articulated, identifying where certain commonalities of approach could be recognised and developing common propositional terms that represent the structure of the argument, was repeated through a number of iterations, re-examining the text and the C Map to ascertain the relevance of the interpretive mapping process and the ways the contexts and problem fields of a text might be explored and activated. Buchanan's theory is analysed and discussed in more detail in Chapter Five (pp. 185–88).

Using C Maps allowed for the charting of key ideas and arguments contained in a theory, and for the adjustment of these mappings as texts were reread and certain concepts, meanings, and relationships of ideas within the text reconsidered. C Maps are described as a knowledge representation tool (Novak and Cañas, 2006, p. 4) rather than a data analysis tool. However, a number of representational limitations are inherent to C mapping software. Lye (1996) has recognised that form opens up a text for dialogue: 'Form is a way of structuring the symbolic world so there is share-ability' (unpaged). However, the visual dimension of C Maps is based on encoding and decoding for readability, rather

than being a form of visualisation or visual communication. While the visual aspect of C Maps allows the structure of an argument or text to be manifest, the literary form of a text is not expressed in this form of visualisation. The visual expressivity of C Maps is limited, offering a set menu of text box shapes, line widths, colours and line shapes.[35] While there are various configurations evident across the different C Maps produced from texts analysed, metaphorical readings based on the shape of a C Map or the physical arrangement of a mapped argument or set of ideas represented could not be identified.

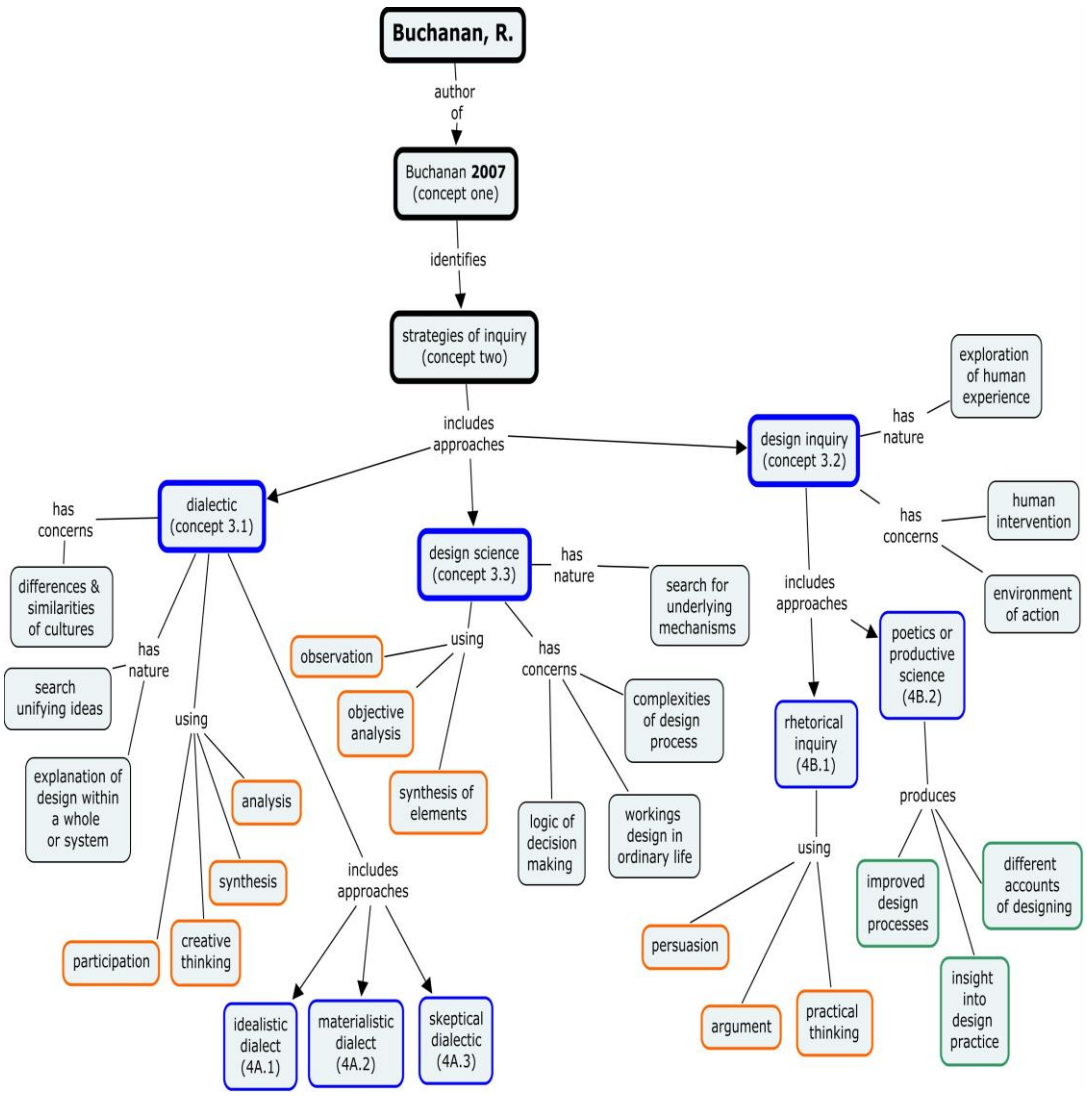

Figure 6: Adding further information and developing common propositional terms for C Map based on Buchanan, 2006, 2007

[35] The limitations of C Map visualisation and the need and opportunities for further research and development in this area are beyond the scope of this inquiry, but are noted in the conclusion of this thesis as one of a number of areas for further investigation arising from this research.

Beyond this limitation, there are also issues related to the readability of C Maps as two-dimensional images when complex multiple relationships are identified across numbers of concepts. Arguments, as relationships between groups of concepts identified using propositions, can be represented through C Maps, and can be exported into a computer language, OWL/RDF. While concepts in a C Map are usually arranged hierarchically, from general and inclusive at the top to specific and least general at the bottom, relationships between concepts in different areas of a concept map can be represented as cross links. However, if there are many such cross links C Maps can be difficult to read, as the representational form using multiple lines representing different relational linkages between different concepts will criss-cross each other over a two-dimensional pictorial surface, as in Figure 7 below.

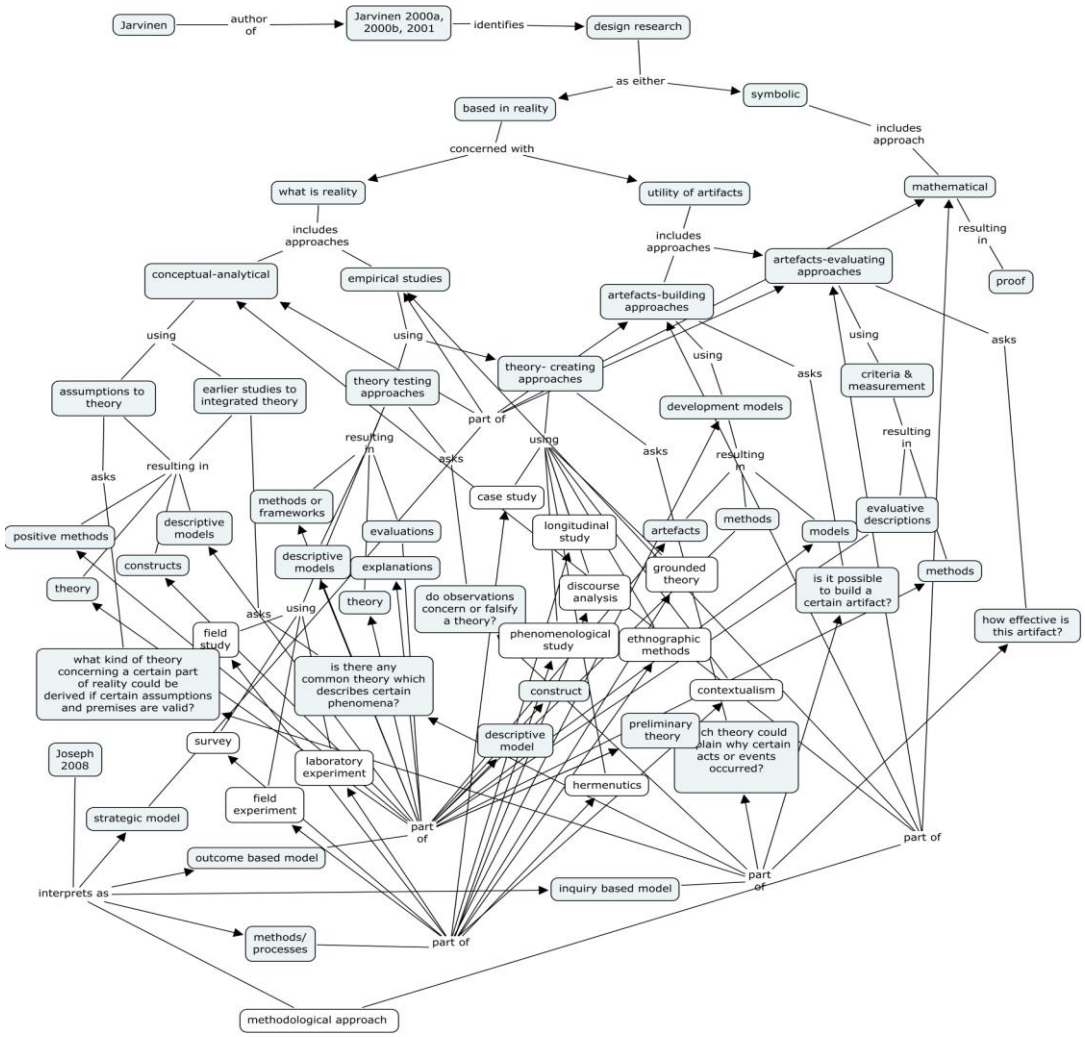

Figure 7: An early, 'in-process' C Map based on theories by Järvinen (2000a, 2000b) including initial categorisations of conceptual approaches identified by the researcher (Joseph, 2008)

Improvements in the visualisation capability of C Map software to include three-dimensional representation and navigation would help address this problem. Such capability would also introduce the potential for using geometries that could better enable more effective, spatialised representation of complex relationships. The concept mapping method was also used to support the comparing and relating of different theories. Two methods of comparison were tested: machine or automatic comparison and a visual/conceptual comparison. C Maps can be automatically compared and commonalities identified through the generation of lists of concepts within and across two C Maps.

However, while this process was useful in helping recognise the limitations of using different authorial terminology for propositions, it provided limited insight as it is basically a word search that identifies common terms rather than shared meaning. The following list was generated from an automatic comparison of two early C Maps developed from texts by Buchanan (2006, 2007) and Krippendorff (2006). This comparison was made before any general propositional terms were developed:

- Matched 0 of 33 (0%) propositions
- Matched 5 of 34 (14%) concepts
- 5 using partial text: analysis = protocol analysis/ objective analysis = analysis and grouping/ identifying functional elements of effective products = products/ observation = observational methods/ participation = stakeholder participation in design process.

The texts analysed were notable for their diversity of terminology and for differences in the way seemingly common terms were defined and used. In attempting to map each text, the terminology used for concepts was generally taken verbatim from each text. Because of the different definitions, meanings or levels of granularity associated with common terms used by different authors, the same term was sometimes used to mean very different things. Thus results for machine-supported comparisons based on word searches and the identification of common terms was limited. This is not just a problem with C Map software or the methodology of this project, but is a fundamental issue for any form of automated word-based searching, which recognises collections of letters or words rather than their meanings and particular contexts.

A visual consideration and comparison of C Maps, using printed maps pinned up on a wall, and further hermeneutical analysis proved to be a more effective approach. The C Maps acted as diagrammatic text summaries, keeping things visible to support reading across texts.[36] This led to the identification of a number of conceptual and historical linkages and shifts across different theories, and to the development of a series of composite C Maps that began to explore relationships between different theories. This was an iterative process, where an emergent pattern was recognised within a theory or between two or more theories. Any emergent patterns of theorisation were considered in relation to other theories. A range of criteria were used to identify commonalities. Each theory was considered in terms of the overall argument made by the author during the reading/analysis process, the mapping/re-reading/remapping processes and from the C Map as a 'knowledge representation' derived from the theory. Where some commonality was evident, informal groupings of theories, as pairs or sets, were made to support further comparison.

A number of factors were considered in analysing the theories. A timeline, based on publication dates, was drawn up to see whether there were shared ideas or reactions against particular approaches that existed between temporally related publications. A fundamental strategic approach that was identified and discussed by one author in relation to his or her theory was also considered in relation to approaches taken by other theorists. A particular term identified in one theory might also be used in another theory – requiring a deeper consideration of the way the term was used in each instance. Questions were asked: Was there a conceptual linkage or was the same term being used by different authors to mean very different things? If an idea or approach was expressed by one author did it correspond to a concept in another theory even though different terminology was used? Thus patterns were drawn out through a hermeneutical engagement with each text and with pairs or groups of texts being considered in relation to one another. Where similar interpretive strategies were recognised they were identified in the C Maps through the use of colour coding.

[36] This form of visual analysis and recording was not concerned with formal values of images such as line, value, shape, form, space, colour or texture, nor with the principals of visual composition such as balance, contrast, movement, emphasis, pattern, etc. (Glatstein, undated). It did not involve reading or decoding images based on methods of content analysis, historical analysis, structuralist analysis, iconography, psychoanalysis, social semiotic analysis, film analysis or ethno-methodology (Van Leeuwin and Jewitt, 2001). Rather it involved textual comparison across a number of maps.

This mnemotechne project involved an initial process of hermeneutical analysis in the reading and evaluation of one hundred and twelve primary texts. Following the selection of twenty of these texts for further analysis, an invariant summary device (C Map tools) was used for further evaluation. However, two kinds of relations can be recognised using this approach to building a representational structure: between concept (c)–proposition (p)–concept (c), or between p–c–p. These forms of mapping are not the same, and offer quite different diagnostics. In developing C Maps both sets of relationships need to be considered. The c–p–c approach focuses on the relationship between subject and object, while the p–c–p approach tends to focus on the flow and location of concepts within the overall argument. More critically, every proposition can be recognised as a relation between concepts, while each concept is seen as a relation between propositions. Thus a relational analysis does not start with a fixed set of concepts and a fixed set of propositions and ask how they should be structured and distributed. Rather, a relational model recognises the play of differences and transmutations of concepts into propositional relations and propositions into conceptual relations. This relational mapping process reflected the analysis of a particular theoretical argument made in a text, the identification of certain similarities and distinctions across pairs and groups of theories and the gradual recognition of patterns and development of composite models across groups of theories.

Development of C Map Models

Snodgrass and Coyne suggest that one criterion for the hermeneutical assessment of a model can be the accuracy with which it approximates what it models (1992, p. 69). However, ascertaining the accuracy of a model's proximity to a specific design research theory text, or group of texts, is problematic, because the meaning of a text is open to interpretation and cannot be definitively measured. However, the intention of the analysis and mapping was to describe what were understood to be key ideas and outline the argument of a text. This intention guided decisions made as to the selection of concepts that identified key ideas in a theory and the choice of propositions that identified the relationships between these ideas. However, in composite C Maps, which were developed to explore and represent common approaches and concepts identified across theories, there is no originary text. This process extended from a critical analysis of specific theories to an interpretation of ways these theories might be correlated. The assessment of the C Map models involved an iterative process of consideration and reconsideration – from readings of the primary

texts to the generation of C Map models based on the researcher's understanding and interpretation of the theory and critical re-considerations of both texts and C maps. A similar process was followed in relation to the critical analysis of groups of texts and the new composite C Maps generated which identified and grouped common approaches or ideas across different theories. Most models required several stages of adjustment and reconsideration before the structural framings of particular theoretical positions were identified and mapped to show emerging ontological conceptualisations in the field. This process was not concerned with accuracy, or with the development of a meta-theory. Instead, it was concerned with an underlying ontology of differentiation.

While attempting to 'map' particular theories as C Maps, the use of actual terms and conceptualisations of specific authors were maintained as far as possible so that these models could be correlated with the originary texts. However, some terms, particularly propositional ones, which define the relationship between two or more concepts, were adjusted to facilitate comparison and relationality between different texts. These terminological adjustments were made to help identify common classes of information across theories or groups of theories. It is recognised however that such adjustments are inevitably interpretive.[37]

The mnemotechne project is concerned with understanding design research theories and the ways relationships between theories might be modelled or represented as systems of theory, or theories about theory. The process of identifying relationships and common approaches between different theories and groups of theories was not aimed toward the development of a unified or meta-theory, but was guided by a recognised need to represent the pluralism of design research and with the intention of creating a resource that could be accessed through multiple perspectives relevant to the prior understandings and knowledge of the researcher about research and the discipline of design.

A meta-theoretical approach implies a cohesive, overarching model that may not be possible in a diverse and heterogeneous 'human science' like design (Buchanan, 2001b). The C Map models, as models of theories by particular authors and as composite models of groups of types of theories, were developed

[37] Consideration was given to asking authors to develop their own C Maps or to comment on the researcher's C Maps, but initial queries made to two authors received no response. It was recognised that many authors had no experience of working with C Maps and this may be a disincentive to their engagement. Given that some authors of theories were deceased and that initial queries suggested that authorial responses would be low, it was decided to work hermeneutically with the texts and not seek authorial feedback. This would give a commonality of approach across all the models, rather than mixing the researcher's models with models proposed by authors.

to represent the ideas and forms of particular design research theories and the commonalities and divergences between different theories interpreted by the researcher. This approach to knowledge representation, drawn from textual discourse, can be contrasted to logic-based models that have tended to dominate approaches to design's ontological and epistemological framing. Snodgrass and Coyne suggest that models are metaphors which cannot be assessed by logic, but rather by the criteria which apply to matters of interpretation: 'the semantic and disclosive functions of models are not founded on their logical structures but on their metaphorical structures. Models are metaphors and metaphors convey their meanings by way of a hermeneutic understanding' (1992, p. 56). These authors also suggest that such hermeneutical metaphors should 'replace the logic based models that have driven design research over the last fifty years' (1992, p. 69). Logic-based models are built on assumptions of realism and fixed definition, while metaphors are interpretive and do not claim to be the same as the actual thing they represent. As interpretations they are never closed or sealed. This metaphorical approach would seem to be more closely aligned with the nature of design, which, as the design philosopher Tony Fry has pointed out (1999), must always remain open to possibilities.

Through an iterative process of relating, comparing, mapping, analysing and remapping theories, different strategic approaches or conceptual understandings were identified. These frameworks and their related theoretical associations are discussed in more detail in Chapters Six and Seven of this thesis. While the emergence of these groupings across a number of different theories confirmed certain primordial structures, there were some hesitations about the relevance and robustness of the identified categories. There is little work done in this field to which one can compare these results (Chow, 2006). The value of such categorisation was considered in terms of the way it might be used to inform the basis of a practical application in the form of an information structure and system to organise, query and relate information about design research theory. According to Gadamer (1976), the validity of an interpretation can be gauged through the degree to which it gives rise to new insights and new disclosures of meaning and the way it stands up to the test of its practical application. Snodgrass and Coyne (1992) also recognise the importance of application: 'The assessment of the validity of a metaphor or […] model proceeds by an appeal to its potential deployability arrived at by projective anticipations and not by objective logic or subjective intuition' (p. 69). One strategy for testing the analysis was to explore the potential development of an application in the form of the design for an information system.

In a further process of comparing composite models of common approaches identified across different theories, consideration was also given to other texts about approaches and attitudes to research, written by tertiary educational theorists involved in research about the nature and perceptions of academics towards research. Some correlations were identified that gave new insights and understandings (discussed more fully in Chapter Seven). However, the deployability of these insights through practical application, where new horizons of disclosure could be revealed thereby disclosing new insights and meanings, was still uncertain.

Contexts of Deployment: Information Hermeneutics

Hermeneutics can also be considered in relation to information science. Capurro writes:

> We can consider the process of storage and retrieval of information hermeneutically as the articulation of the relationship between the existential world-openness of the inquirer, his/her different open and socially shared horizons of pre-understanding and the established horizon of the system. The information seeking process is basically an interpretation process having to do with the (life-) context and the background of the inquirer and with that of the people who store different kinds of linguistic expressions having a meaning within fixed contexts of understanding such as thesauri, key words and classification schemes. (Capurro, 2000, p. 4)

Information hermeneutics recognises both the pre-understanding of the information 'user' and the formalised framework that organises the information system. Traditional information systems approaches have emphasised 'fixed contexts of understanding' as metadata schemes, vocabularies and ontologies. Within the field of design research, little attention has been paid to the socially shared horizons of pre-understandings of design researchers, that is to the philosophical frameworks and methodological systems that particular groups of researchers share and adhere to, described here as an horizon because they define the researchers' breadth of viewpoint. Rather, the main emphasis has been placed on researching processes of design (Dorst, 2007) or on attempts to create fixed or generalised contexts of understanding for design, which were major foci of both the Design Methods and the AI in Design movements. However, the notion of a generalised context for design has been strongly

contested. Coyne and Snodgrass (1992) recognised that the physical and conceptual environment in which things function plays an important role in the way we interpret and assess them. Changes in context affect our understanding of the meanings of the models we encounter.

Brew (2001) and Akerlind (2008) suggest that researchers, both within and across different disciplinary fields, have specific conceptions of the values and approaches they take to research. In particular, Akerlind (p. 22) identified approaches that delineate academics' views of the nature of research that she summarises as intentions, outcomes, questions and process. These approaches were considered in relation to the shared conceptualisations that were identified through the analysis of design research theories in this project. This comparative approach, while again raising issues of terminological heterogeneity, seems to indicate there are some fundamental perspectives on the nature of research and values ascribed to the activity of research that are shared by groups of academics across different disciplines and institutions. The reasons for these perspectives are not addressed in this project, but they would seem to indicate that individual sensibilities or experiences might influence the way researchers understand research, and that this can be quite distinct from a disciplinary perspective. While the categories of research approach identified by Akerlind are informal categories, they suggest some general sorts of horizons of pre-understanding that can not only be correlated with the way some design research theorists have framed or modelled particular theories about design research, but can also be correlated with the different ways design researchers understand or approach research. In this context it was proposed that these types or categories of models of design research may, if included in the structure of a system, provide more singular pathways, related to a researcher's implicit approaches to research rather than her explicit understanding of theories about the domain of design research, through which information can be accessed and explored. Capurro and Hjørland (2004) have recognised the difference between the representation of information 'in domains that have a high degree of consensus and explicit relevance criteria', like science, and domains, like design, that 'have different conflicting paradigms, each containing its own more or less implicit view of the informedness of different kinds of information sources' (p. 395). They describe this domain analytic approach as hermeneutic because any understanding is determined by 'the pre-understanding of the observer' (ibid.). If the ways researchers tend to describe their approach to research correlates with an analysis of particular design research theories, such frameworks may provide a useful way for design researchers to access information about design research: 'With the statedness of a part of a community background in a system,

the inquirer can match his/her questions and backgrounds of pre-understanding against it' (Capurro, 2000, p. 4). However, such systems need to be able to incorporate parts of different communities. Information hermeneutics has provided insight into ways that the problem of the limited available forms of representation and accessibility to design research knowledge might be approached. The analysis of theories gave rise not only to maps of concepts and ideas from theories, but to models of research pre-understanding. The next critical issue in the research process was to identify a way that these different types of 'informedness' could be used to support greater access to information about and to the understanding of approaches to design research.

Developing Structures

An investigation of software used for building computational ontologies was instigated in parallel with the process of analysis of design research theories and the development of C Maps. An early version of the software Protégé was being used by researchers at KEDRI for building information structures to support the development of bioinformatics knowledge discovery systems (Kasabov, Jain et al., 2006). The development of a more structured system using Protégé could be supported by staff at KEDRI.[38] However, while Protégé was useful in a field with widespread conceptual consensus and explicit relevance criteria, such as bioinformatics, it was difficult to use to structure and represent information from a heterogeneous and contested domain like design. Protégé is a frame-based system. Frames were developed by Marvin Minsky (1975) and are made up of a collection of named data structures inside of which are located slots, where attributes of the entity represented in a frame can be represented. Early frame-based systems lacked semantic expressivity, so a new branch of logic known as description logics was developed.[39] This was intended to add more 'logical expressivity' to these representation languages, in order to deal with 'a full range of typical human assertions' (Legg, 2007, p. 42). However, human assertions are not always logical.

[38] Since the time of this initial investigation a newer version of Protégé has been released that supports semantic web capability.

[39] Description logics (DLs) are formal knowledge representation languages that are based on logical statements relating roles and/or concepts. Frames and semantic networks lack formal, logic-based semantics, so DLs were introduced to overcome this problem. DLs are more expressive than propositional logic, but have more efficient decision problems (problems that have answers that are more complex than a simple 'yes' or 'no') than first-order predicate logic.

While all knowledge organisation systems (KOS) represent selections of concepts that are, to a greater or lesser extent, enriched with information about their semantic relations, levels of semantic expressivity vary immensely across different systems and technologies. In the field of knowledge systems, ontologies include a wide range of scales of expressivity, from catalogues and thesauri, to frames and higher order logics (MacGuiness, 2003). Frames allow class and subclass relationships to be represented. If the subclass relationship is made transitive, the ontology can represent inheritance or a subsumption hierarchy as a collection of nested sets. However, frame-based systems require the consistency of a systematised knowledge domain.

In a frame-based system, information must be broken down into segments and placed into specific frames or slots. This approach works well when dealing with information about characteristics of artefacts as whole/parts relationships, or processes as tasks and subtasks, but does not allow the representation of more abstract concepts or contexts that do not always fit so neatly into subsumption hierarchies. Following a lecture by Danni Vrandečić, a member of the Semantic Media Wiki (SMW) development group at KEDRI in 2007, the potential of using semantic wiki technologies was considered. This approach was supported by the contemporaneous development and release of new software that worked alongside C Map tools, called COE or Collaborative Ontology Environment. This enables C Maps to be exported into OWL/RDF, which is a web ontology language and description framework that includes formal semantics and an extensive vocabulary.

Semantic Media Wiki (SMW) is an extension of Media Wiki, the wiki system that underpins the open-source online encyclopaedia Wikipedia. SMW is described as helping to 'search, organise, tag, browse, evaluate and share a wiki's content by adding "semantic annotations" (Krötzch, M., Vrandečić D. and Völkel, M., 2005). The scale and ambition of the semantic web project is to create better associations between meaning and content on the World Wide Web (WWW), and to establish a layer of machine understandable data that would enable a higher degree of automation and more intelligent applications. This has led to the identification of a number of significant challenges related both to the particular limitations of logic-based systems and to the organisation of material on the vast scale and levels of heterogeneity of the WWW. However, the adaptation of semantic web approaches to a more contained and structured wiki environment that, while web based, contains a number of common structures such as categories and lists, presents an opportunity to develop a rich semantic structure that can be built up from and closely related to specific content, rather

than imposed as a set of fixed categories or frames into which information is formatted.

The potential for creating a resource using media wiki that included information about source texts as well as information structures developed from an analysis and modelling of them was investigated. The structure of the resource could be 'annotated' directly from the wiki content, using the mappings made as C Maps of individual texts/theories, as well as relationships between groups of theories, and exported into OWL/RDF to form semantic scaffolds. Cole and Avison (2007) recognise the intertwined nature of description and interpretation in information systems. The SMW approach appeared to enable the representation of both description and interpretation. The different networks of relationships, conceptualisations and interpretative perspectives could be made explicit and used to question, search and associate information and support new 'knowledge discovery' approaches.

It was also recognised that there was potential for future collaboration using this system, both in terms of content development and in the development of information frameworks and categories. While there have been many calls for the collaborative development of online design resources (Poggenpohl, 1998; Salustri and Rodgers, 2008), there has been little activity in this area to date. One of the biggest stumbling blocks to such potentially significant and useful developments has been the lack of consensus and infrastructure to support such initiatives. However, the scale of such an undertaking, and the fundamental tension in any such approach due to the heterogeneity of design research theories and the logical basis of computational ontologies, led to a decision to focus the mnemotechne project on this tension rather than introduce a third focus such as collaborative resource development.

Initial explorations towards a test version of a design research resource, using basic wiki building software (Media Wiki), was begun in parallel with the C Mapping process. This allowed for the development and editing of content and a consideration of ways it might be organised using a web-based wiki structuring process with headings and hyperlinks. This process required a consideration of relevant content and an initial structuring by establishing information headings and lists. The wiki building process allows for changes to be made to this heading structure without too much difficulty – at least while the wiki is of a relatively modest scale. Technical support was used in setting up this wiki and in subsequent Semantic Media Wiki developments.

A second test version wiki was developed in order to experiment with Semantic Media Wiki software. To assist this process, more specific types of C Maps were developed for each text. One type, called 'semantic versions', included a mapping of relevant concepts in a text to a series of different categories identified through the analysis of the design research texts, to facilitate the development of a semantic structure. A further version of the C Maps, called 'thesis versions', were compiled as simplified C Maps to be used as images to accompany the description of each text on the wiki. These were akin to road maps of each text. In spite of some further simplification, these maps were hard to decipher – a problem related not only to the complexity of some of the texts and analyses, but also to the limited visualisation capability of the C Map tools software.

A third version of the design research resource was then built to proof-of-concept stage using the SMW platform. It incorporated refinements to both the content and the semantic structure developed through the two earlier test versions. A proof of concept is a sort of early prototype that demonstrates the feasibility of an idea, but it is recognised as being an incomplete realisation. A proof of concept is seen as a milestone on the way to a fully functioning prototype, developed to prove core ideas and test the viability and workability of an approach. Its purpose is to prove that a concept, theory or approach is probably capable of implementation in a useful manner. The proof-of-concept model was seen to support the direction of the relational models developed through the analysis of theories, in that one way of evaluating the relevance of a model can be through its usability. That is, a theoretical model can be tested through application. This stage of application also ties in with Gadamer's notion of hermeneutics as a practical philosophy, and Snodgrass and Coyne's pragmatic framework that recognises people as interpretive beings who exist and operate in social and a practical contexts (2006).

While this project was not developed beyond proof-of-concept stage, it was necessary to evaluate the level of achievement, limitations and future potential of the system. The processes used to make this evaluation included an identification of the inherent capability of the system through review and basic searchability tests conducted by the researcher and the technical developer. Testing involved the development and reiteration of a set of test questions to evaluate potential query response capability. It also included evaluations made in relation to a set of criteria identified by Veltman (2004), based on the needs of a semantic web for culture, and another set of criteria of capabilities of semantic wiki systems, identified by Krötzch, Vrandečić and Völkel (2005). This led to the

identification of a number of limitations and potentials of the system, and the recognition of possible areas of future development. Finally, some consideration was given to the potential of the future use or application of computational intelligence to support knowledge discovery processes. Given the early prototype of this system development, this process involved a correlation of the demonstrated system's potential with capabilities identified in the literature.

Conclusion

This chapter discusses project methodology in terms of the context, approaches and methods used to conduct this research. The distinctive focus of this project is an engagement with relationality in order to challenge the limitations of older dualistic frameworks or more recent fragmentary models of design as a discipline. These ontological understandings have influenced the theories and practices of design research. The project also negotiates another dualism that is part of the ontological basis of information science, between intuitive, human approaches to knowledge organisation and understanding, and highly formalised schemas that underpin computational approaches to knowledge representation and organisation.

A process of critical hermeneutics was used to analyse and model a selection of design research theories. This interpretive approach stands in contrast to scientific or artistic approaches that underpin much design research. Hermeneutics recognises historical and contextual influences. Such interpretation is generated through language, which is socially negotiated rather than based in cognition or individual production. In considering the ways such interpretations of meaning, structure and strategy in design research theories can be used to develop information frameworks to support better relational understanding, the project also draws from information hermeneutics. This is based on the recognition that any information-seeking process is interpretive, and can be related to the particular history and context of an inquirer. It also recognises that purportedly authoritative vocabularies and classification schemes, developed by information technologists and professionals, are also influenced by the particular perspectives and understandings of those technologists and professionals, rather than purely objective criteria (Capurro, 2000).

The use of concept-mapping software for recording the analyses of design research theories, supporting and documenting relational analysis across pairs

and groups of theories and for developing semantic structures for use in information resource building, is discussed in terms of its conceptual rationale, limitations and practical application. The exploration, development and evaluation of a design research resource using Semantic Media Wiki software are considered in relation to the use of concept maps to inform the development of information structures. The potential of semantic web technologies to enable the development of more flexible structures to support hermeneutically inflected search and discovery approaches within an information system is also considered in relation to the development of a system, to proof-of-concept stage, within this project.

The methodological approach taken in this project is not located within one area of a specialised field, nor does it use a conventional set of methods to probe one issue in depth. Given the broad scope of the field of design articulated in this thesis through design research theory, and the vital potential of design's integrative position across different disciplines, this research draws methodologically from a range of disciplines and frameworks to identify, articulate and activate new relational understandings.

Chapter Four

Design Research: The Early Frameworks

Derivatives and Borrowings

Introduction

'Design Research – the Early Frameworks: Derivatives and Borrowings' includes an analysis of eleven of the twenty design research texts that were selected for this thesis project. A further nine texts are discussed in Chapter Five (see Table 1 below). Chapters Four and Five include a discussion and some analysis of each theory, accompanied by concept maps that outline some of the key concepts and relationships of ideas in each theory. A comparative analysis of these theories is undertaken in Chapter Six.

Texts Analysed in Chapter Four	**Texts Analysed in Chapter Five**
Bruce Archer (1981, 1995)	Klaus Krippendorff (2006)
Ken Friedman (2003)	Elizabeth Saunders and Peter Kwok Chan (2007)
Nigel Cross (2006)	Ezio Manzini (2007)
Wojciech Gasparski et al. (1995)	Sharon Poggenpohl (2000)
Pertti Järvinen (2000a, 2000b, 2001)	Terrence Love (2000a, 2000b)
Richard Coyne and Adrian Snodgrass (1991)	Kees Dorst (2008)
Stephen Scrivener (2000)	Harold Nelson and Eric Stolterman (2003)
Victor Margolin (2002)	Richard Buchanan (2005, 2007)
Susan Roth (1999)	Wolfgang Jonas (2007/2008)
David Seamon (2000)	
David Wang and Sarah Wagner (2007)	

Table 1: Design research theory texts analysed in Chapters Four and Five

The eleven texts discussed in this chapter are considered in terms of originary models of design research that have, in the main, been informed or influenced by other disciplinary frameworks. They have been described as originary as they engage with theoretical approaches that informed the early development of design research and were framed by – or in reaction to – frameworks drawn from other disciplines. Some of these texts mark threshold moments in the development of design research theory, in the sense of marking significant changes in approach or moments of new understanding. While all these theories engage with the nature and forms of design research, many of the approaches they outline can be mapped along a linear continuum that extends from scientific and objective approaches to constructivist and interpretive approaches to artistic and subjective approaches (see Figure 8).

This locates the historically derived, disciplinary positions of science, the humanities and fine arts. It is the trajectory between the oppositional positions of rational science and mysterious art that Coyne and Snodgrass have described as design's 'dual knowledge thesis' (1991), as discussed previously. The orientation towards this science/humanities/creative arts continuum has defined the selection of the texts and theories discussed within this chapter, while those discussed in Chapter Five tend to have a more multidimensional orientation in that they have developed from more complex understandings of research that have developed over time within the discipline of design, or with a sense of design as an inter-discipline that necessarily engages with many other disciplinary approaches. These include areas such as business and technology that do not sit neatly along the traditional linear science/humanities/art axis.

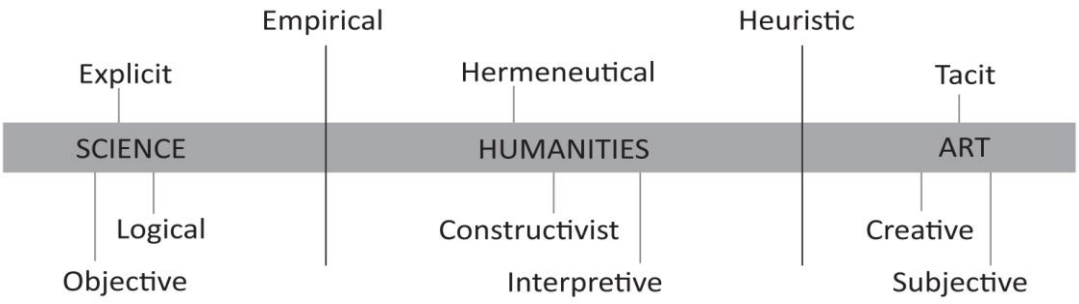

Figure 8: Linear conceptualisation of design research methodology (after Yap, 2009)

The eleven texts considered in this chapter range in publication date from 1981 to 2007, although the contexts addressed in these publications relate to specific methodological positions that emerged in the recent past and extend into the present. Chow (2006) has referred to this phenomenon as 'epigenesis', or a recycling occurring over a longer period that references earlier ideas about design research. For example, Gasparski et al. (1995) identify theories in their discussion of design science, ranging from the mid-1950s into the late 1990s. The selection of eleven texts also includes some more recent publications, indicating the ongoing influence of historic points of reference to understandings of design research theory. Philosophical references from the nineteenth and early twentieth centuries are also made in a number of these texts, for example in Coyne and Snodgrass (1991), Seamon (20000) and Wang and Wagner (2007). These eleven theories present different understandings of design research that emerged during the second half of the twentieth century, as the parameters of design as a discipline were being established. They have drawn from, or reacted against research frameworks established in other areas, translating and extending methodological approaches from other disciplines in relation to design research. Such approaches have been vital to the emergence and development of design as a discipline. These originary frameworks were important in informing and establishing a theoretical basis for the development of so-called 'designerly approaches' to research (Cross, 2006). Designerly approaches are those that have developed from within the discipline of design and draw from processes, understandings and particularities of design, rather than from other disciplines. This shift marked an important threshold moment of disciplinary formation, from external to reflexive definition and methodological understanding.

While a number of the models discussed in this chapter recognise the emergence of designerly approaches to research, they tend to engage with or react against conceptualisations along a science/humanities/art continuum. This linear continuum, based on Western epistemological traditions and built on oppositional positioning, underpins design's dual knowledge thesis. Jonas and Chow (2008) have described the development of these dualisms as stemming from the rejection of first-generation design methods in the early 1970s, which resulted both in a dismissal of methods, as universal approaches to designing, and a parallel swing to scientific methods for design research.[40] This anti-methods shift may also be linked to a coincidental movement in counter-

[40] The term 'first generation design methods' was coined by Horst Rittel (1972) to distinguish the scientific and systematising approach to method that was the focus of the Design Methods Movement from so-called 'second generation methods', which are based on argumentation, issues and user participation.

culturalism. The tendency towards scientific methods was not specific to design. Rather, design tended to follow the positioning of other disciplines, for example the writings of Herbert Simon, which stemmed from computer science and were influential on the development of the Artificial Intelligence in Design group. Angela Brew (2001) has noted the 'important tension between rigidity and creativity' that underlies traditional approaches to academic research (p. 28). She has also drawn attention to the limited extent to which traditional research boundaries have been broken down. Traditional, in this context, refers to established methodological approaches within well-established academic disciplines. She ascribes such a limitation as being dependant 'not on the level of familiarity of researchers with new ideas, but on their views of the ways in which the overall intellectual climate influences their research' (ibid).

Analyses of these eleven texts engage the historical frameworks underpinning the development of design research and the intellectual climates in which these approaches were developed. In the next section of this chapter, the establishment of the Design Methods Movement is discussed in relation to the writings of Bruce Archer (1981, 1995), Ken Friedman (2003) and Nigel Cross (2006). This is extended into a consideration of design science through the writings of Cross (1981, 2000, 2006), Gasparski et al. (1995) and Järvinen (2000, 2001). This is followed by a section on dualistic frameworks, which considers the oppositional positioning of design science and design as creative practice through the writing of Coyne and Snodgrass (1991), who recognise and challenge this polarisation through hermeneutics. This is followed by a consideration of an early text by Stephen Scrivener (2000), who was among the first wave of academics to articulate approaches to so-called 'creative practice-led' or 'practice-based' design research in relation to the development of institutional research evaluation in the UK under the RAE system in the 1990s. Following this, analyses of some humanities-based interpretive frameworks associated with the writings of Victor Margolin (2002) and Susan Roth (1999) are undertaken. Finally, a particular methodological approach – phenomenology – drawn from early twentieth-century philosophical traditions and extended into design research, particularly in architecture, is considered through the writings of David Seamon (2000) and David Wang and Sarah Wagner (2007). The decision to include an analysis of these texts addressing this particular methodological framework was made towards the end of the text selection process, in part to explore how a seemingly singular framework could be related to more complex or differentiated theories of design research, and also because 'phenomenology' is identified in a number of different design research theories, but is defined and categorised in a number of different ways. The chapter

concludes with a discussion of some issues associated with the development of maps of key ideas in these theories and a summary of key points made in the chapter. A number of other texts are also cited and discussed in this chapter in relation to the development of design research theory.[41] The significance of the ideas in these texts along with the reasons why they were not selected for a more detailed mapping and analysis within this project are also discussed in this chapter.

The Design Methods Movement

The Design Methods Movement that developed in the UK in the 1960s is regarded by most design historians and theorists as the formal beginning of design research (Cross, 1984; Bayazit, 2004; Margolin and Buchanan, 1995). This movement was profoundly influenced by technological developments and ideas stimulated by them. Nigan Bayazit (2004) has noted the influence of systems analysis and systems theory on the establishment of first-generation or systematic design methods (p. 18). Dorst (2006) recognises the influence of the literature generated by early artificial intelligence pioneers and the rational, problem-solving paradigm that inspired the development of design methodology (p. 9). The emergence of dualistic frameworks in design research has been associated with the rejection of the first-generation design methods associated with this period (Dorst and Dijkhuis, 1995; Jonas and Chow, 2008). A consideration of this movement and the subsequent reactions against it are therefore important in any overview of design research or study of design research methodology and theory. According to Archer (1979), the development of the Design Methods Movement followed a 1962 conference, 'The Conference on Systematic and Intuitive Methods in Engineering, Industrial Design, Architecture and Communications', held at the Department of Aeronautics, Imperial College, London, and organised by John Chris Jones and Peter Slann.[42] The conference participants were concerned about approaches that would support the shift away from craft-based approaches to design in light of the evolving complexity of late-industrial societies. This development was influenced by the experiences of design teams during World War Two and subsequent labour shortages that required new approaches and ways of collaborating (Buchanan, 2001b; Bayazit, 2004). Working in cross-disciplinary

[41] For example, writings by S. A. Gregory (1966), Herbert Simon (1969), John Chris Jones (1970), Horst Rittel (1972) and Donald Schön (1983).

[42] See John Chris Jones's notes on this conference, posted in 2002 at http://www.softopia.demon.co.uk/2.2/dmconference1962.html

teams, designers needed to understand and be able to integrate specialist approaches. It was believed that particular methods could be identified, articulated, systematised and generalised to be applicable in a range of design situations. These approaches were linked to other proto-developments in engineering design and information technology, developments in such areas as operational research, systems science or first-order cybernetic processes, and artificial intelligence (AI). The formation of the Design Methods Movement led to the development of a number of design research initiatives and organisations. The Design Research Society was founded in the UK in April 1966 with its purpose being to promote the study of and research into the process of designing across its many different fields. Rachael Luck (2006) has noted that the locus of design research activity at this time was in the fields of architecture and engineering (p. 20). Texts by Bruce Archer and by Nigel Cross, which drew from personal engagement during this seminal period in the development of design research, were identified as key theoretical perspectives on this period and were subject to further analysis, mapping and interpretation in this thesis.

Bruce Archer (1922–2005) was closely associated with the formation of the Design Methods Movement in the UK. He is recognised as a pioneer of design research, who helped to establish design as an academic discipline. Two of his articles on design research were considered as part of this analysis. In the first, from 1981, Archer proposed a taxonomy of design research, identifying three 'sub-disciplines' of design research and ten 'areas' as design research sub-categories (see map of Archer's theories, Figure 9). Sub-disciplines were defined by Archer as 'capable of expression as coherent bodies of knowledge with credible boundaries and specific fields of application' (1981, p. 35). Archer's ten 'areas' were based on objects of study or subject areas of design research, some of which were theoretically oriented and others of which were more practically based. This paper by Archer is the earliest text attempting to systematically map the field of design research that was analysed in this inquiry.[43] Like a number of texts that give an overview and analysis of the Design Methods Movement written by those involved in its development, this text was published more than decade after the culmination of the movement.[44] This appears to be due, at least in part, to the schism that erupted and split the Design Methods Movement in the 1970s, which led pioneers like Christopher Alexander to reject design

[43] Herbert Simon's seminal text *The Sciences of the Artificial* was published in 1969; its focus was on artificial intelligence and the design process. According to Simon, the design process has seven stages. These are: define, research, ideate, prototype, choose, implement and learn. The main focus of Simon's writing about design is in relation to problem solving and the design process, rather than the broader field of design research.

[44] Nigel Cross has published a number of key papers and books about the Design Methods Movement.

methodology: 'I feel that a terrific part of it has become an intellectual game, and its largely for that reason I've disassociated from the field' (1971, p. 3). It took some time for such reactions and rejections to be reflected on and better understood by the participants, and for more considered perspectives of the ideas and achievements of the Design Methods Movement to be published.

There are a number of different approaches that can be identified in the ways that design 'sub-disciplines' are defined in design discourse. The term sub-discipline is sometimes used as a way of describing genres or areas of established professional practice, such as 'graphic design' or 'interior design' (Friedman, 2000). The limitation of such designation of forms of professional practice as disciplinary subfields has been recognised by Victor Margolin (1996). He has written of the collapse of traditional areas of professional practice, such as graphic design, industrial design, architecture or urban planning that:

> Corresponded to aggregates of problems that appeared relatively coherent and distinct. In recent years […] the boundaries around these problem areas have begun to collapse due to the influence of new technology, new management strategies, new social forces and new intellectual currents. As a result the old divisions of design practice now appear increasingly inadequate and ineffectual. (p. 23)

These shifts have affected all aspects of design and have called into question the validity of using 'established' areas of professional practice as a way of defining sub-disciplinary borders. However, the relative inertia of institutions – both professional and pedagogic – has seen the prolongation of these older, industrial, sub-disciplinary boundaries into the twenty-first century.

Archer's approach to sub-disciplinary classification, developed some fifteen years prior to Margolin's caution, takes an epistemological, rather than professionally oriented approach. Archer leaves aside professional design boundaries and identifies design knowledge frameworks in terms of:

- Design phenomenology or the interpretive study of design experience
- Design praxiology or design activity, its organisation and apparatus
- Design philosophy or logic of discourse on matters of concern in the design area

Archer's epistemological designations do not rely on dualistic distinctions, but on different approaches to the way design knowledge might be developed, explored and understood. The significance of Archer's analysis is evident in the way it has informed or underpinned subsequent theory development (Cross, 2005; Love, 2000, 2000b).

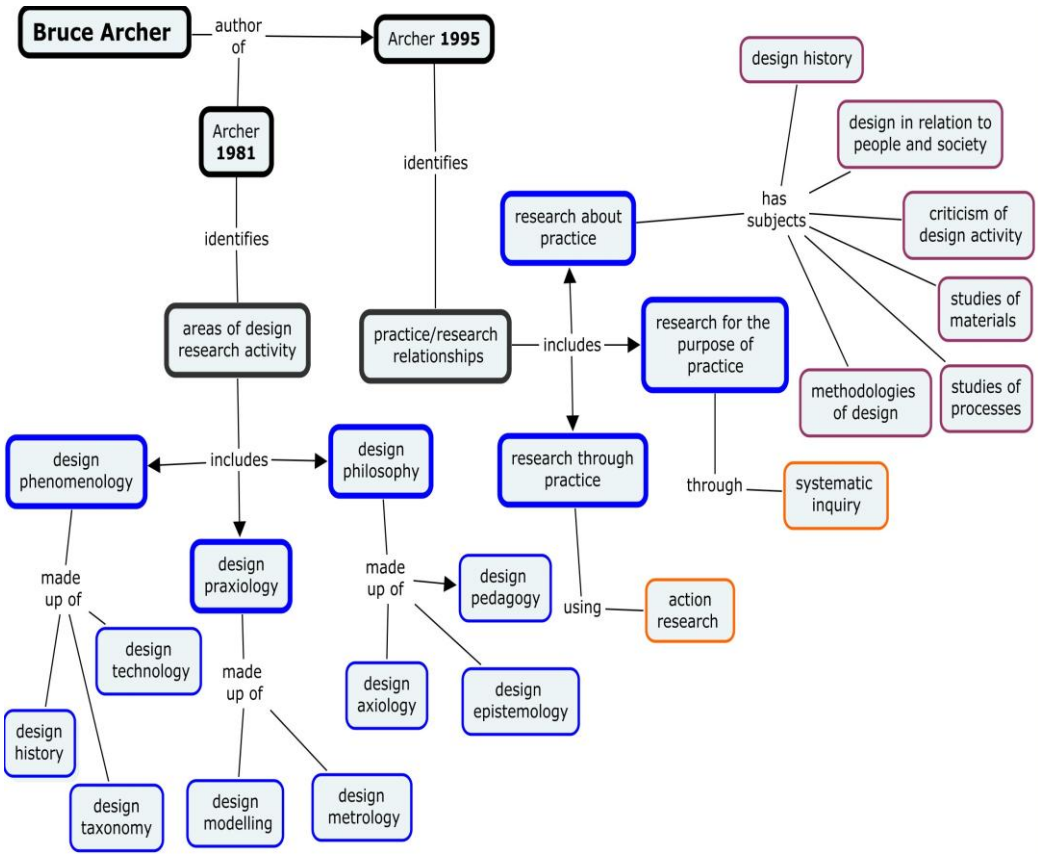

Figure 9: C Map outline based on theories by Archer (1981, 1995)

Archer's 1995 text articulates another model, based on a consideration of research in relation to design practice (p. 11).[45] Archer identified three different types of research:

[45] There is some debate about the origin of this particular model, which was published by Archer in 1995, and a similar model published earlier by Christopher Frayling in 1993. Chris Rust has noted: 'Archer's paper post-dates Frayling but there is evidence he was developing the three-part scheme much earlier, in the 1980s' (Rust, PhD-Design Listserv: Research Into, By and For Design, Mon. 22 Sept. 2008). Archer's text was used initially in this study because a copy of the text was sourced first. While a copy of the Frayling text was subsequently obtained, the decision was made to work with and model Archer's text as the concepts in it were more fully articulated and could also be related to ideas in Archer's 1981 text.

- Research about practice
- Research for the purposes of practice
- Research through practice

This approach correlates with the Design Methods Movement's primary concern with a notion of research focussed on the development of knowledge about and understanding of methods of design practice, a concern that has continued as a major focus of design science for some thirty years (Dorst, 2008). Archer developed his taxonomy of design inquiry so that design could be clearly distinguished from other established academic disciplines. In science, different types of research are distinguished according to differing levels of theoretical abstraction and application, in taxonomies such as basic, applied and clinical research. This schema of types of scientific research implies a hierarchy that moves from a lower order of clinical or practical application (that usually engages with single or small groups of applications) to groupings or classes of problems as applied research to general theory formulation in basic or 'pure' research (see Figure 10). This research schema has been cited by Friedman (2003) in his model of design research. Friedman's position is articulated in reaction to the rise of 'practice-based' design research within university design departments and a growth of PhD design theses which he sees as focussing on specific design projects with no imperative to theorise from or relate particular projects to general principles. Friedman (2003) suggests that systemic thought, developed into theory, distinguishes 'a science and a craft' (p. 513). He highlights the role of theory in helping to frame and organise observations so they can be used to formulate general principles or more broadly applicable methods or tools: 'Theory permits us to question what we see and do. It helps us develop generalisable answers that can be put to use by human beings in other times and places' (ibid.). This distinction highlights differences between traditional notions of academic research practice and design practice. If the purpose of research is to create new and transferrable knowledge, how might this be reconciled with or extended through notions of design practice? Archer's theory begins to explore the potential of research in relation to design practice, while Friedman's theory seems to ignore it.

One limitation of Archer's text, which is more extensively articulated than Frayling's, is that it didn't provide a fuller contextualisation of these approaches to design research – they are outlined only briefly as part of this five-page paper from 1995. Friedman (PhD Design Listserv, Subject: Research Into, By and For Design. Sun. 21 Sept. 2008), suggests that both Christopher Frayling's and Archer's models were informed by Herbert Read's writings about strategies of

art education (Read, 1974). Friedman sees this underlying lack of distinction, between pedagogy and research, as undermining an argument for research through practice, as 'a significant weak area in the argument for the concept of research by design' (ibid.). However, while Friedman has questioned the relevance of these categories, the 'tripartite model' by Frayling/Archer has informed ongoing theoretical debate and has been used productively as the basis for the development of a number of more recent conceptualisations and perspectives on design research (Findelli, 1998; Jonas, 2007, 2008; Chow and Jonas, 2008; Scrivener, 2000).

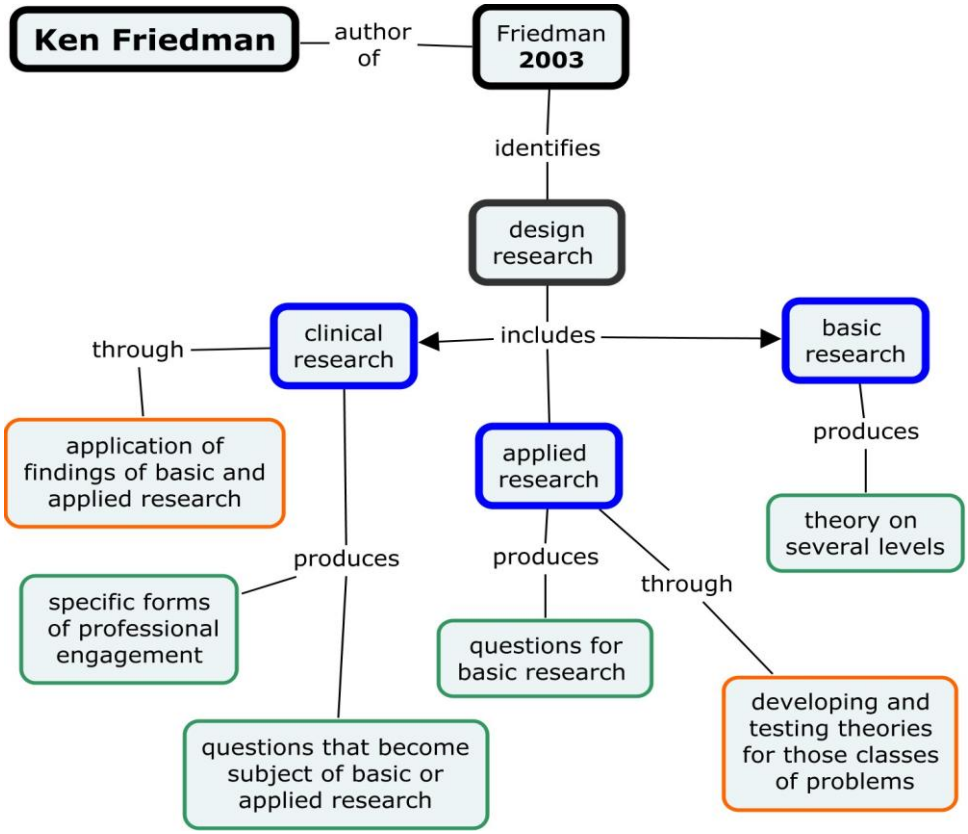

Figure 10: C Map outline based on a theory by Friedman (2003)

The 'scientific categories' of clinical/basic/applied research, cited by Friedman (2003) cannot be directly correlated with Archer's (1995) categories as Archer's model is based on ways of researching and understanding design practice while Friedman's is concerned with fundamental research levels set within a rationalist framework and based on an unstated hierarchy of theory development over practical application.

Correlating such models is difficult because the forms of categorisation are not consistent between the two approaches – that is, they are based on different

beliefs about the world and different sets of values. They sit at different levels of abstraction. A consideration of these two models highlights some key issues associated with trying to correlate different theories: the different contexts in which these theoretical models were developed, the difficulty of comparing models that are rooted in very different conceptual frameworks, and some of the tensions around the relationship between design practice and design research evident in certain areas of design discourse.

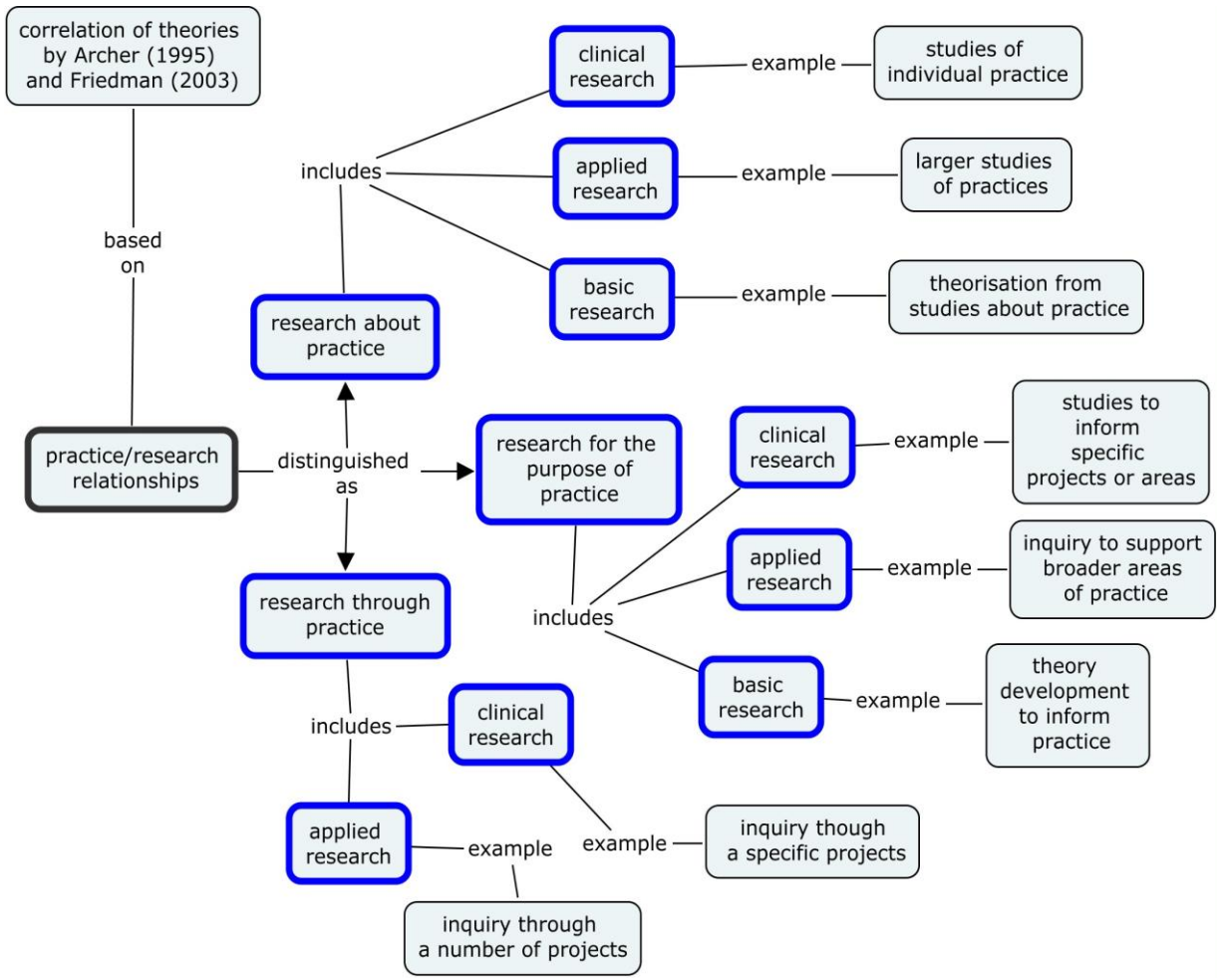

Figure 11: C Map model of possible relationship between Archer's (1995) model and Freidman's (2003) model of design research

Research about design practice can involve studies of or experiments through specific instances, groups of cases and/or the theorisation of such practices. This can occur across levels of 'clinical, applied and basic research, depending on the project focus. Similarly, research for and through practice can be approached through individual and larger group studies or cases, and research for practice

is generally oriented towards theorisation. While relationships between these two theories can be modelled (see Figure 11), with some of Friedman's scientifically based research categories sitting under Archer's practice-oriented schema, the value of such sub-categorisation in relation to better ways of understanding and theorising approaches to design research or in relation to improving or assisting design research practices, would need to be explored. Within the context of this project any correlation between these two theories would seem to have limited value.

Rankel and Racine (2010) have proposed a model that equates basic research with 'research about design', clinical research with 'research for design' and applied research with 'research through design'. While this model is highly integrated, it would appear to limit the scope of the different purposes of design research identified by Archer by superimposing a somewhat narrow interpretation of a scientific typology of research. It is not clear why the scale of research 'for design' should be limited to specific cases or applications. Or why research 'though design' – a category that is normally associated with 'practice-based research' – should be linked to more generalisable 'applied' research. In most instances, research through design is developed for individual or a small number of projects, an approach that has been criticised by Friedman (2003) because it ignores the development of generalisable knowledge or theory building.

A consideration of approaches to the conceptualisation and categorisation of design research in different theories is central to the focus of this mnemotechne project. The 1995 model by Archer, which categorises research in relation to practice, is based on a specific conceptualisation of research that identifies design as practice rather than subsuming it under a broader, disciplinary notion of design. Later theories based on this model (Findelli, 1998; Jonas, 2007; Chow and Jonas, 2009) have extended it to identify the three types of research as 'for, about and through design' (Chow and Jonas, 2009 p. 3). In terms of these types of research, this thesis project is 'for' and 'about' design as a discipline rather than as a practice. In relation to Friedman's categorisation, the location of this thesis project is more difficult – it certainly isn't applied or clinical research – but Friedman's definition of basic research as a 'search for general principals' is scientific and is at odds with the rationale for this investigation, which seeks to develop better relational understanding across different theories rather than looking for or creating general theories. Chow and Jonas (2009) have recognised the 'misunderstanding' that occurs when generic design models are considered as normative standards (p. 14) rather than as reflective tools or transferrable

innovations (p. 15). A reconsideration and re-articulation of the scope of basic research, to include investigations of theories and principles without the need for generalisation, would address this problem and allow the mnemotechne project to be considered as basic research, in that it engages with the issue of the nature of design as a discipline and the nature and forms of design research as a significant aspect of that disciplinary identity, which can also support and extend ways of exploring and articulating that identity.

A further correlation of Friedman's 2003 model with Archer's 1981 model (see Table 2) reveals some more robust correlations between these theories, with areas of design epistemology, pedagogy, technology and philosophy, as defined by Archer, corresponding to aspects of basic research. The areas of design praxiology, metrology, modelling, axiology, taxonomy, technology and history can be related to aspects of applied research, and some areas of design pedagogy, history, phenomenology, praxology and modelling can be related to clinical research. The categories of phenomenology, pedagogy, praxiology, metrology, etc. are categories based on particular areas of knowledge and associated ways of knowing. For example, pedagogy is associated with educational knowledge and ways of teaching, metrology with dimensions and ways of measuring, and praxiology with human conduct. Specifying them as design phenomenology or design pedagogy frames particular design concerns in terms of these broader knowledge categories.

A key focus of the Design Methods Movement was the development and recognition of design as a discipline. The articulation of design through existing epistemological frameworks was strategically important in helping gain recognition for the emergent discipline. The emergence of design research theory and its corresponding discourse initially relied on knowledge concepts and models external to the discipline of design.

While he is recognised for introducing the notion of 'designerly ways of thinking' and making a significant contribution to the emergence of the field of design as a discipline, Nigel Cross (2006, 2006b) has also framed design research in relation to older disciplinary frameworks and traditional epistemologies.[46]

[46] Nigel Cross is Emeritus Professor of Design Studies at the Open University in the UK. His academic and practical backgrounds are in architecture and industrial design. He has been engaged in design research since the 1960s. His research has been in areas of computer-aided design, design methodology and design epistemology, with a special interest in design cognition.

Scientific categories (Friedman, 2003)	**Definition**	**Archer's categories (1981)**	**Definition**
Basic research	Search for general principles	Design epistemology	Nature and validity of ways of knowing
		Design pedagogy	Principles of design education
		Design technology	Principles underlying operations of things
		Design philosophy	Logic of design discourse
Applied research	Adapting basic research findings to classes of problems	Design praxiology	Design activity, its organisation and apparatus
		Design metrology	Measurement in relation to design phenomena
		Design modelling	Modelling and communication of design ideas
		Design axiology	Value in design area relationships
		Design taxonomy	Classification of design phenomena
		Design technology	Systems comprising designs
		Design history	How things came to be what they are in the design area
Clinical research	Application of basic and applied findings to specific cases	Design pedagogy	Practices of design education
		Design history	Cases of what things are in the design area
		Design phenomenology	Interpretive study of design experience
		Design praxiology	Design activity
		Design modelling	Modelling and communication of design ideas

Table 2: Correlation of Friedman's model (2003) with Archer's model (1981)

While the text by Cross used in this analysis was published in 2006, his work in this area covers more than three decades, and stems from his engagement with the Design Methods Movement as a student. Thus there is a closer temporal correspondence between Archer's 1981 perspective and Cross's 2006 model than would initially appear from a consideration of publication dates. Cross also recognised three approaches to design research: epistemology, as the study of designerly ways of knowing, praxiology, as the study of practices and processes of design, and design methodology and phenomenology, as the study of form or configuration of artefacts.

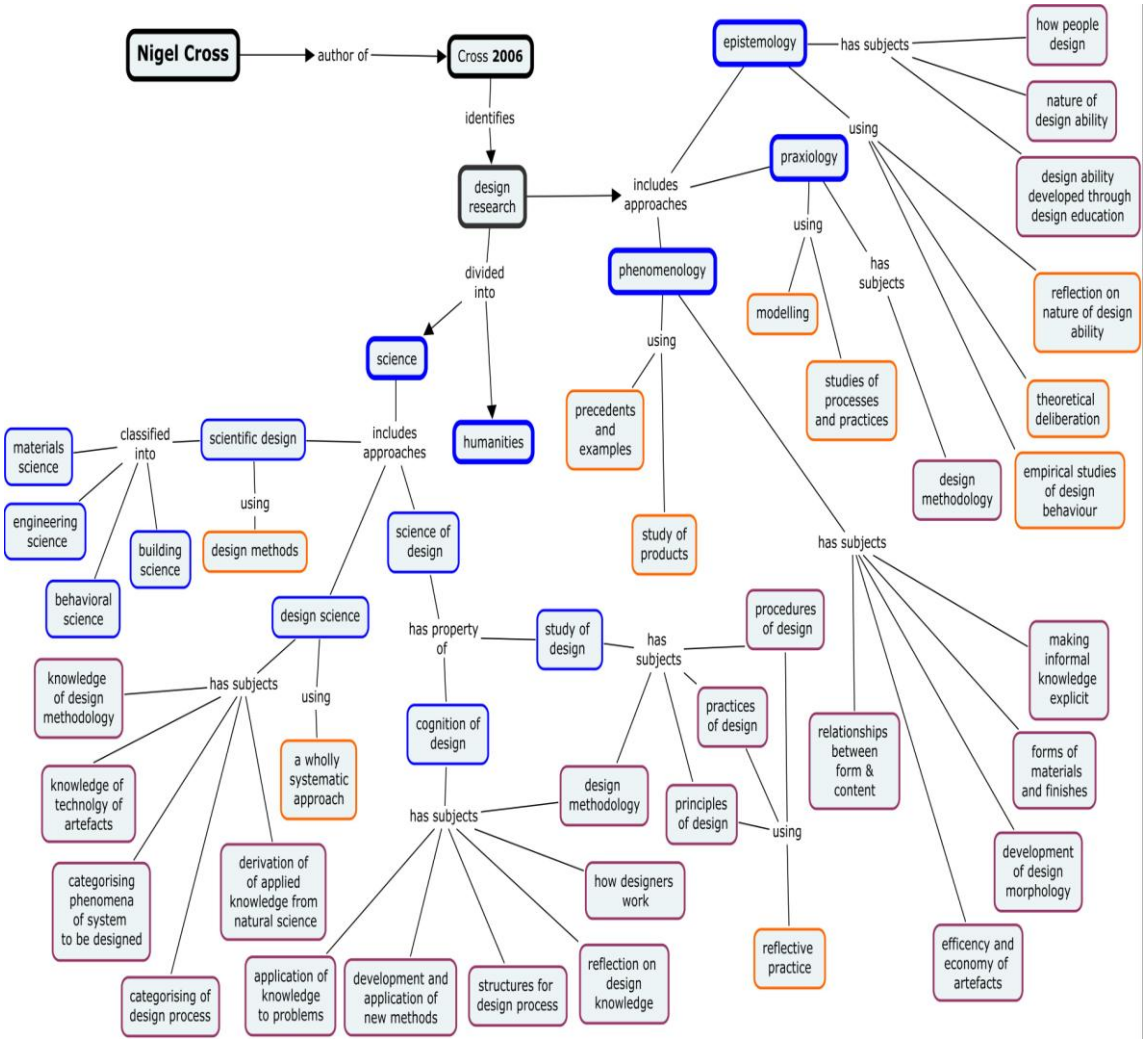

Figure 12: C Map outline based on theory by Cross, 2006

A comparison between Archer's and Cross's models in terms of concepts and definitions reveals some strong correspondences, for example both recognise the area of design praxiology. Other categories have both overlaps and distinctions,

for example different definitions and types of activities are identified in the category of design phenomenology, with Cross's definition being concerned with the study of artefacts, while Archer's recognises a broader range of activities and considerations. Further overlaps and distinctions lie between categories of design philosophy and design epistemology. Epistemology in Archer's model is but one of three 'areas' under the category of design philosophy, while it forms a major category of its own in Cross's model. Design pedagogy is identified as another sub-field by Archer, while design education, described as 'design ability developed through design education', is identified as one of the concerns of design epistemology by Cross (p. 100).

In spite of these differences of terminology and definition, there are some parallels between these two models and the approaches taken to the conceptualisation and categorisation of types of design research. Such comparison is possible because both models sit at similar levels of abstraction, in that they are concerned with categorising different ways of knowing as types of design knowledge.

Archer's 'sub-disciplines' (1981)	**Definition**	**Cross's 'approaches' (2006)**	**Definition**
Design phenomenology includes design history, taxonomy and technology	Interpretive study of design experience	Phenomenology	Study of form or configuration of artefacts
Design praxiology includes design modelling and metrology	Design activity, its organisation and apparatus	Praxiology	Study of practices and processes of design
Design philosophy includes design axiology, epistemology and pedagogy	Logic of design discourse	Epistemology	Study of designerly ways of knowing

Table 3: A comparison of categories and definitions from Archer's model (1981) and Cross's model (2006)

A distinction can be made here between knowledge about form and the processes of designing, and knowledge about designerly ways of knowing. These can be seen as distinct modes of knowing, one concerned with the processes and outcomes of designing, the other with a more reflexive mode of understanding ways of knowing about design. These types of knowledge sit at

different theoretical levels. Jonas (2000) has distinguished three theoretical levels in design: 1) at the level of making, 2) at the level of methodology, that is concerning the process of designing, and 3) at a meta-theoretical level, that is concerning observing the observation of design (unpaged). These types of knowledge about things and making, about how and why things are produced and used and about how designerly things are known, are paralleled in the organisation of theories by Archer and Cross. Within the context of this aspect of the Archer/Cross theoretical framework, this thesis inquiry is concerned with observing the observation of design research theorisation and knowledge about designerly ways of knowing about design research.

Design and Science

While Nigel Cross published a number of key texts recording his developing ideas about design research methodology over some three decades, he has summarised his position in his 2006 book *Designerly Ways of Knowing*. In this he recognises design, not as a science, but as an area that is searching for 'intellectual awareness' (p. 102) that can only be developed through a designerly approach to design research. Cross considered the original Design Methods' approaches as attempts to integrate objective and rational methods into the practice of design. Scientific method, he suggests, was borrowed as one of these frameworks, with the term 'design science', as a systematic approach to practising design, being coined in 1966 at the Second Conference on Design Methods.[47] The relationships between design, science and research have been both critical and contentious in the development of design as a discipline.

Cross (2006) has recognised a fundamental division between scientifically oriented and humanities-based design research. He has explored a number of different understandings of the relationship between design and science, noting: 'Despite several attempts at classification there remains some confusion about the design-science relationship' (p. 97). He identifies three different scientific approaches to design research as:

- 'Scientific Design,' with its origins in scientific methods and operational research

[47] The second conference on The Teaching of Engineering Design was held at the Royal Hotel, Scarborough, UK, from April 13–16, 1966. See *Design Journal,* January 1996. http://vads.ahds.ac.uk/diad/article.php?year=1966&title=205&article=d.205.30

- 'Design Science,' based in the search for the development of design method as a single rationalised approach to designing. Other aims held for design science, such as the systematic organisation of design knowledge sought by Hubka and Elder (1987), are also recognised
- 'Science of Design,' which, according to Cross, refers to the body of work which attempts to improve the understanding of design through systematic, reliable methods of investigation. A science of design was also defined by Gasparski and Strzalecki (1990) as 'a federation of sub disciplines having design as the subject of their cognitive interests' (in Cross, 2006, p. 99). Cross recognises this approach as design methodology or 'the study of the principles, practices and procedures of design' (p. 99)

Within this schema distinctions are made between operational research that uses scientific methods, research towards a systematic and unified theory of design, and approaches that support the understanding of design through systematic methods. This analysis by Cross has informed further design research discourse. For example, it is cited by Krippendorff (2005, pp. 100 and 101) in his own consideration of design science and has informed Krippendorff's nomination of yet another approach – a 'science for design'.[48] While Cross cites Gasparski and Strzalecki (1990) and identifies their approach as a science of design, not all aspects of Gasparski et al.'s extensive model of design science (1995), which recognised and mapped a broader history of design research beyond the confines of English-speaking cultures, sit neatly within Cross's categorisation.[49]

Cross's analysis, while addressing the broader field of design research, focuses on the influence of scientific approaches in Europe and the Unites States during

[48] See Chapter Five for further discussion of Krippendorff's theory of human-centred design research.

[49] Design historian Jonathan Woodham has recognised and written about the dominance of Western European/American versions of design history (2005). While this issue is slowly being addressed through a growing number of regional and national design history publications, the discourse around the history of design research is more limited. The few authors from English-speaking cultures who address the history of design research tend to focus any analysis of design science on the Design Methods Movement and the writings of Herbert Simon (1969). See for example, Margolin, 2010; Cross, 2000; Bayazit, 2004. Gasparski has recognised and tried to address this limitation on the part of Western theorists and historians and has contributed an important Eastern European perspective. However, Asian, Australasian, South American and African design research histories are absent from the historical discourse.

the twentieth century. Cross was a witness to these shifts, which he describes as taking place over three distinct phases: the search for scientific design products in the first half of the twentieth century (scientific design), a concern for scientific design process in the 1960s (design science) and the emergence of the study (or science) of design, as a study of the principles, procedures and practices of design, in the later part of the twentieth century (Cross, 2001). Ultimately he came to recognise design as a discipline rather than a science (Cross 2006) and recognised too that design methods do not need to be framed as a binary choice between science and art. Despite attempts by Cross and others to engage with and critique the design–-science relationship (de Vries, Cross and Grant, 1993), and the more differentiated frameworks they have proposed, design science as a monolithic and largely unquestioned methodological position is still strongly promoted in areas such as engineering design and information technology design (Vaishnavi and Kuechler, 2004; Eekels, 2000). Krippendorff has also articulated some of the distinctions between different scientific frameworks, recognising that scientifically oriented design researchers are concerned with what things are, technologically centred designers are more interested in how things work while human-centred designers are fundamentally concerned with the conceptions and meanings people bring to design (Krippendorff, PhD Design listserv. Subject: Re: Current Trends in Design Research, Where are We Going. Mon. September 14 2009). However, researchers working within more established frameworks often accept a given framework and do not question the assumptions behind their approach. In addition, 'scientific' approaches to design research are often categorised as a singular approach (Margolin, 2002; Buchanan, 2007), when there are several different perspectives within the broader category of design science.

Two additional theories of design research from design science and technology perspectives were analysed as part of this thesis. A paper by Gasparski et al. (1995), analysed in this thesis, is written from an engineering-design perspective, while papers by Järvinen (2000, 2002) are based on an information-systems design perspective.

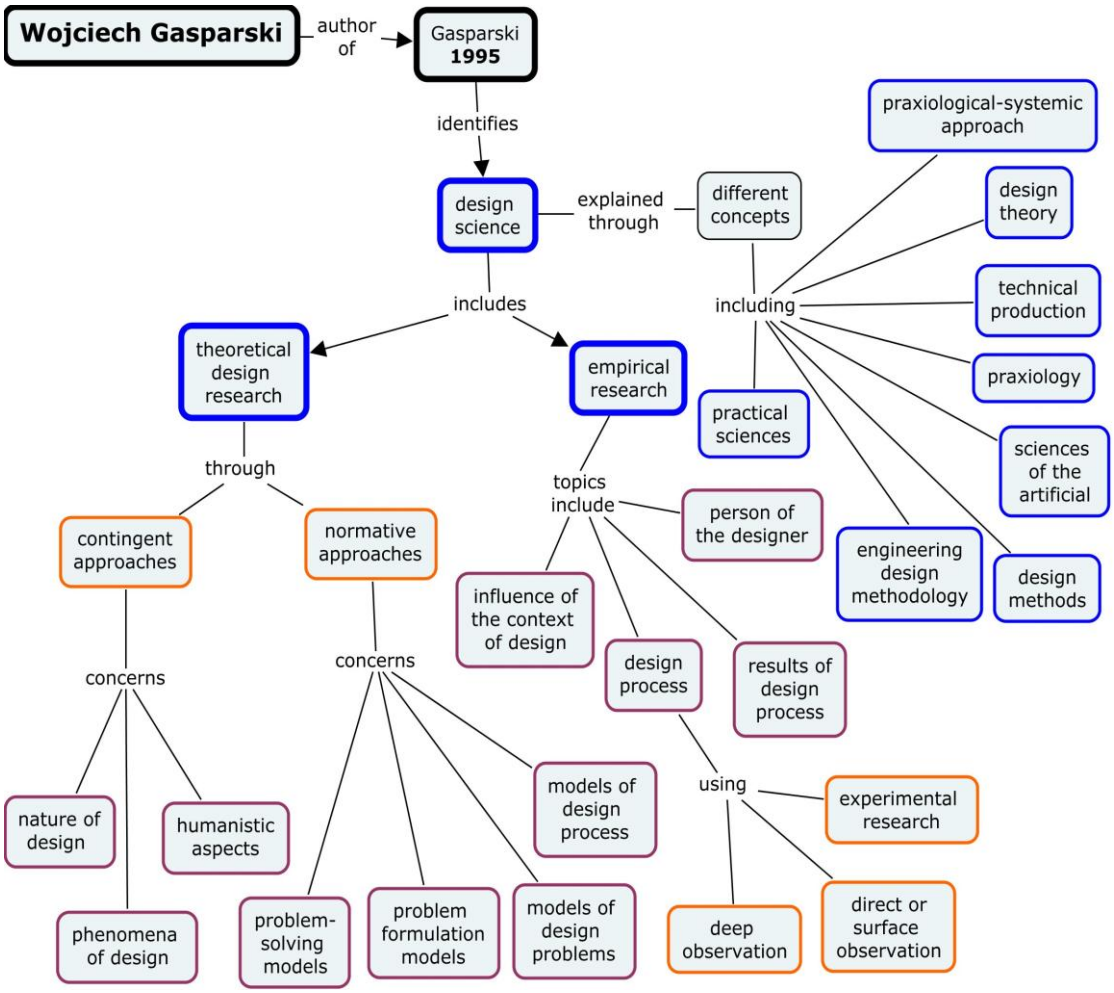

Figure 13: C Map outline based on theory by Gasparski, Gregory, Foque and Strazaleki (1995)

The model of design science proposed by Gasparski et al. (1995) addresses 'that sphere of activity which links knowledge derived from science, divided into various disciplines, with the needs for a unified […] practice' (p. 19). The authors suggest that in the early context of design research it was expected that systems engineering would be treated as the normative methodology for the design of complex objects and would become a paradigm for the rational theory of design (p. 17). However, those expectations were not fulfilled and subsequently several different concepts of design science emerged (pp.17 and 18).[50] Gasparski et al. identify eight different theoretical approaches to design science, citing key writers and texts for each approach. This framework is historically and culturally more extensive than most Anglo-American models,

[50] While systematic methods are fundamental to the research and practice of science, where results must be replicable so as to be verifiable, they are less relevant to the research and practice of design, where original or highly contextualised results rather than repeatable results are sought.

with reference texts cited ranging from 1936 to 1972. This detailed model recognises Herbert Simon's *Sciences of the Artificial* (1969) and S. A. Gregory's *The Design Method* (1966). It also acknowledges the areas of practical science, technical production, engineering design and mathematical and praxiological approaches as different perspectives on design science. The authors acknowledge that any linking between knowledge and types of practice is always related to a particular value system. In this case, Gasparski's own inclination is identified as a 'praxiological-systemic' approach, which he describes as an adaptation of the philosophy and logic of science to differentiate general and detailed methodology. His concern is with the object of design and design process. Praxiology, as the study of design methodology through the study of the processes of design and applications that aid designers, is an approach also recognised by both Archer and Cross as fundamental to design research. Yet Cross (2001) recognised the problematic of scientific approaches to method in design, noting: 'There may indeed be a critical distinction to be made: method may be vital to the practice of science (where it validates results), but not to the practice of design (where results do not have to be repeatable, and in most cases, must not be repeated, or copied)' (p. 51). The historic dominance and limitations of the focus of design research on methods of design has been critiqued by Kees Dorst (1997) and is discussed further in Chapter Five.

Gasparski et al.'s model also recognises another fundamental methodological distinction in design science research, between empirical and theoretical approaches.[51] Distinctions between theoretical and empirical approaches are also recognised in the model of design research in information systems developed by Pertti Järvinen (2000a, 2000b, 2001). Gasparski et al. recognise a further distinction within the area of theoretical research, between normative approaches, which focus on specification, and contingent approaches, which focus on understanding. Some of the conceptualisations evident in aspects of Gasparski et al.'s model can also be found in Järvinen's theory.

[51] Empiricism relies on information gained through observation, actual measurement or experiment, that is on evidence that is observed through the senses. Theoretical approaches are based on hypotheses rather than practical considerations and deploy concepts that cannot be empirically observed but are believed to be functional.

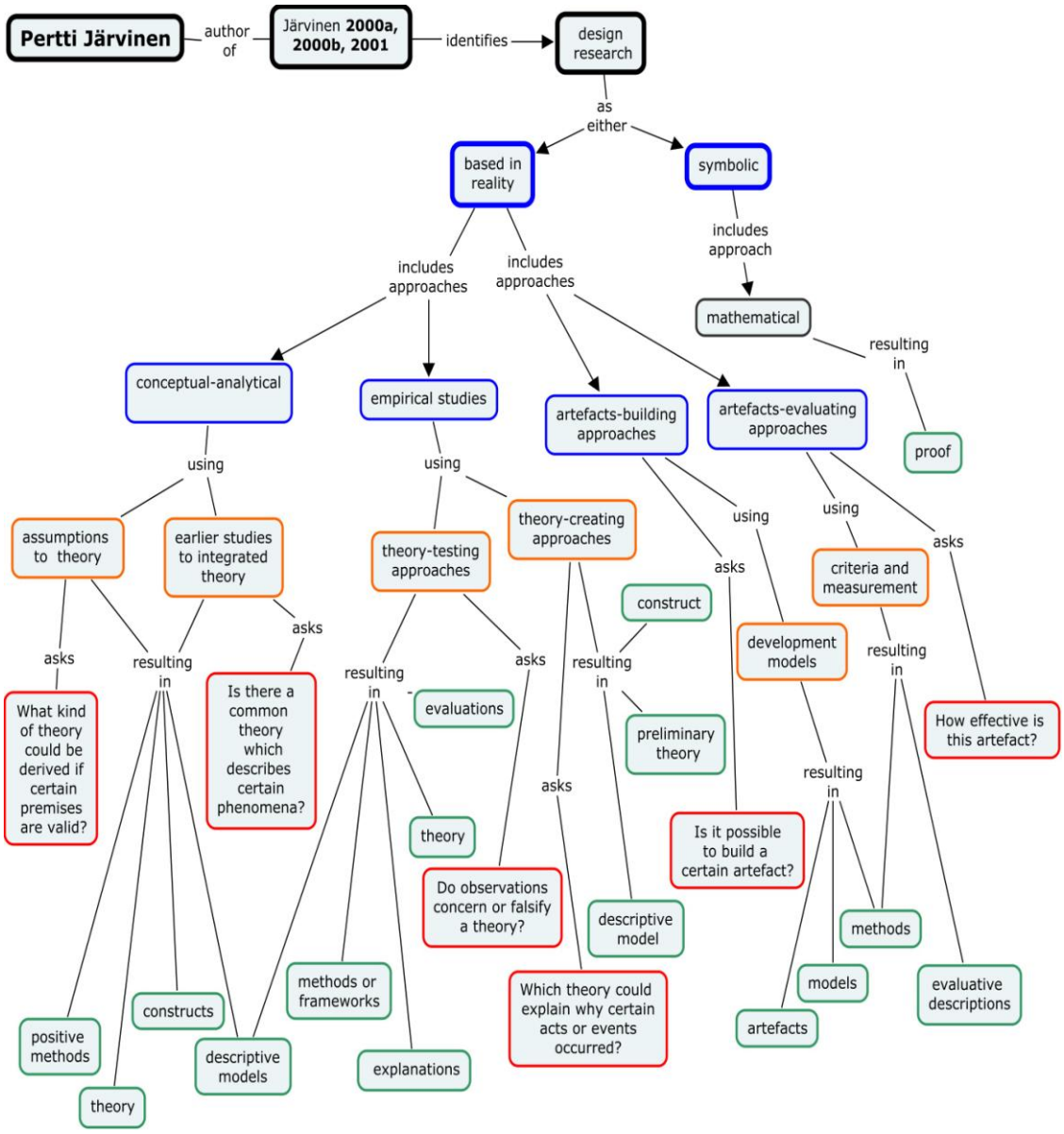

Figure 14: C Map outline based on theory by Järvinen (2000a, 2000b, 2001)

Järvinen locates information systems research at 'the interaction of design and natural sciences' (2000, p .1). His taxonomy of research methods in information-system design recognises two higher-level approaches: mathematical methods, concerned with formal or symbolic language systems that do not have a direct reference to objects in reality, and approaches which study reality. This constitutes a distinction between abstract (mathematical) approaches and empirical or concrete approaches that are concerned with the observation of material things. Within the class of 'studies of reality', Järvinen differentiates approaches that question the basis of reality from approaches stressing the utility of artefacts. The two classes are based on 'whether the research question refers to what is a (part of) reality or does it stress the utility of an artefact?'(p.

252). This emphasis on utility reflects both a focus on functionality, derived from engineering, and the 'user-centred' approach that is predominant in information-systems design. From 'methods concerning reality' Järvinen identifies conceptual-analytical approaches based on methods for theoretical development and empirical approaches. This might be interpreted as another abstract/concrete dualism, but Järvinen recognises that empirically oriented studies are not always removed from rationalist approaches. Theory testing or theory-creating methods can be used depending on whether there is a theory, model or framework guiding the study or whether a new theory, grounded on data, is being developed. Here a distinction is recognised between observing and knowing, where rationalism can know what's not observable because it employs theoretical models. While not made explicit, Järvinen's association between empirical studies and theorisation seems to acknowledge that while these two approaches are historically distinct, empirical approaches can be influenced by theoretical frameworks. At the same time, the interpretation of empirically derived data that might lead to theory formation can be influenced by a researcher's own internal representation of the world. This approach recognises that the border between scientific rationalism, where knowledge can be acquired by deductive reasoning without resort to experience, and empiricism, where truth is sensory rather than intellectual, is mediated by relativist notions, where values are not absolute, but are contingent on the persons or groups holding them.

Järvinen's categorisation of artefactual approaches, specifically the building and evaluating of artefacts, is distinct from earlier design science research models, such as Gasparski's, which tend to focus on methodological orientations rather than forms of research outcome. Järvinen defines artefacts from an information-systems perspective, as human-made constructions that may contain physical, human and data resources (2000b, p. 253). This specification relates to technological artefacts, such as websites and computer programs. His focus on ways of measuring utility recognises a fundamental concern of information-systems developers, which is grounded in a techno-functional perspective. This distinction between research into the purpose and activity of design and the resulting production of artefacts is not articulated in models developed by Archer or Gasparski et al. Cross acknowledges certain approaches to or through artefacts in relation to different aspects of his model of design research. For example, 'the systematic knowledge of […] the scientific/technological underpinnings of design artefacts' (2006, p. 98) is recognised by Cross as part of design science. He recognises that design knowledge 'resides in products themselves' (p. 101) and that 'the study of forms or configurations of artefacts,

their meanings and economies' is identified as part of design phenomenology (ibid.). But these considerations of artefacts are linked to particular philosophical and methodological approaches to design research, rather than artefact-ness, in itself, being grounds for types of categorisation. Järvinen makes a primary distinction between research through symbolic and research through reality-based approaches. He makes a further distinction within the category of research that is based in reality, between research concerned with the nature of reality (being) and research into the utility of artefacts (becoming). These fundamental forms of knowledge are paralleled, to some extent, by the model of design research developed by design theorists Harold Nelson and Eric Stolterman (2003), who recognise a distinction between being and becoming that goes back to Platonic metaphysics and a differentiation made between essences and appearances. Nelson and Stolterman characterise design research in terms of its relation to 'the true, the real and the ideal'.[52]

The role of the artefact in design research is another focus in Järvinen's technologically oriented model. He distinguishes two sub-categories of methodological approach concerned with the utility of artefacts: one that is process oriented, concerned with artefact-building approaches using development models, the other with artefact-evaluating approaches employing the establishment of criteria and measurement. Järvinen recognises the ideas of Nunamaker, Chen and Purdie (1991) and their consideration of the artefact in systems development. They suggest that the artefact functions as a bridge between technological research and social research (Järvinen, 2000a, p. 128), a conception of artefact that moves beyond the purely functional approach of earlier techno-scientific models. Artefacts are central to many theories of design research, for example as an object of research (Margolin, 2002) or as a research outcome (Järvinen, 2000b). This range of significance suggests that the nature and role of the artefact in design research warrants deeper consideration. The artefact is also a point of critical focus and distinction in the theory of 'research-in-design' proposed by Scrivener (2000, 2000b).

Dualistic Frameworks

Stephen Scrivener's model identifies and compares two approaches to design research, one which he describes as technological research, or problem-solving projects, and the other as creative production projects, which are developed by

[52] Their theory is analysed and discussed in more detail in Chapter Five.

artists and designers who are experienced practitioners and 'want to engage in research that will contribute to their ongoing practice' (p. 2). Scrivener's theory was produced as part of a discourse that developed in relation to the growth of PhDs in design within the tertiary art and design education system during the 1990s.[53]

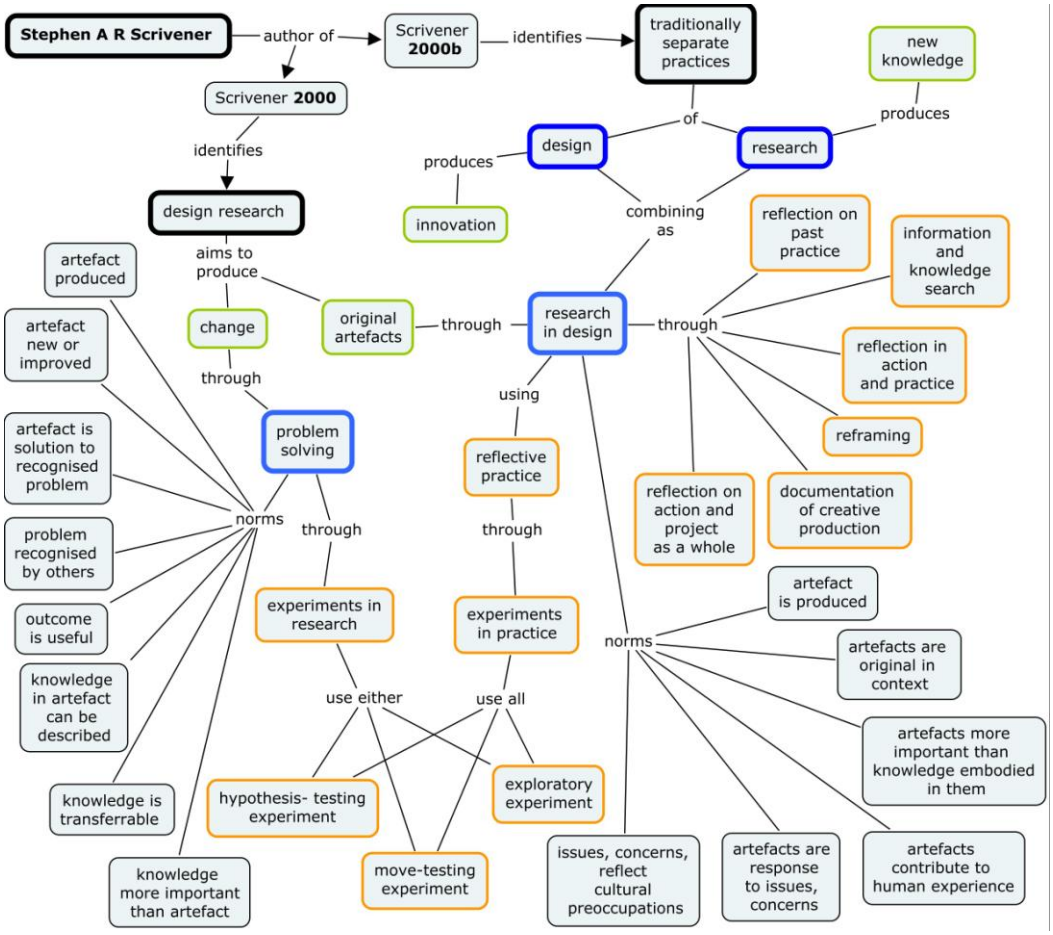

Figure 15: C Map outline based on theory by Scrivener (2000, 2000b)

The text by Scrivener was selected for analysis because it exemplifies a position that places systematic approaches to design research in contrast to creative, practice-based approaches. Scrivener's theory can also be considered in relation to the theory of design and knowledge produced by Coyne and Snodgrass (1991, 1997) in that both engage with a fundamental dualism between rational and intuitive approaches in design, and both draw on Donald Schön's influential text *The Reflective Practitioner: How Professionals Think in Action*

[53] This focus was evident in the PhD in Design conferences held at Ohio, USA, in 1998 and at La Clusaz, France, in 2000.

(1983).[54] However, these authors take very different positions and approaches towards their interpretations of this dualistic positioning and to Schön's ideas about design practice.

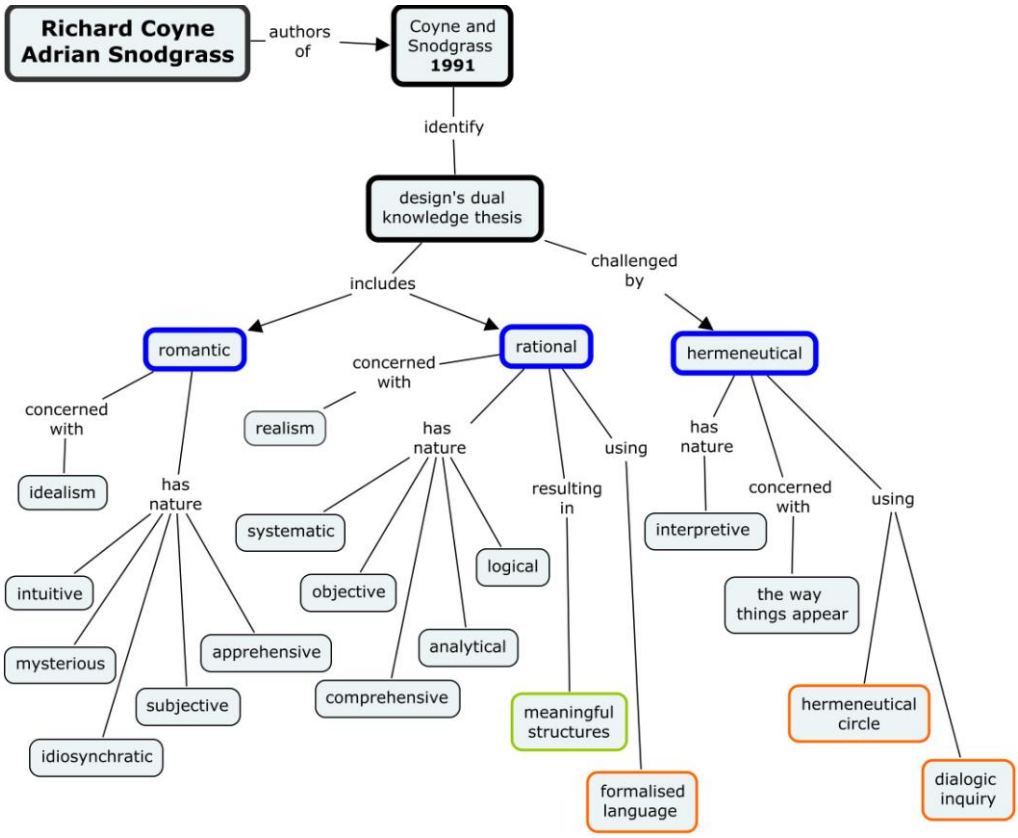

Figure 16: C Map outline based on theory by Coyne and Snodgrass, 1991

Coyne and Snodgrass (1991) identify traditional approaches to design as logical, analytical and rational, and based in science, or as subjective, idiosyncratic and romantic, and based in art. As mentioned earlier in this thesis, they have described these opposing ontological positions as design's 'dual knowledge thesis'. The origins of this dualism stem from a Cartesian tradition that separated subject and object. Coyne and Snodgrass claim this dual knowledge

[54] Schön challenged the stance of design science, proposing instead a constructivist perspective that focussed on an epistemology of practice, based on the intuitive or accumulated knowledge practitioners bring to problematic situations, rather than the formalised, problem-solving approaches posited by Simon. Schön studied and wrote about the way professionals in areas like nursing and architecture engage in reflective practice, a notion that has been taken up and extended by design theorists and design researchers, especially those engaged with 'practice-based' research like Scrivener. Schön's writing has been interpreted to support a number of different positions – as can be seen in the comparison of texts analysed in this thesis. The significance of Schön's writing to design discourse is recognised here, but his text was not analysed and modelled for this thesis, as it is focussed on professional practice rather than research.

thesis is untenable, and propose a third way, a hermeneutical approach to design, based on understanding accomplished through interpretation. In claiming design as an interpretative activity that relates to understanding design situations, rather than depending on either formulae or intuition, they consider Schön's notion of reflection–in-action in design practice as a hermeneutical or interpretive approach. Coyne and Snodgrass developed this theory in the context of the University of Sydney's Faculty of Architecture in the early 1990s, in relation to debates that emerged between design science approaches based in cognitive science and artificial intelligence (see Gero and Maher, 1988; Gero, 1990) and orthodox notions of architectural studio practice, which were based on professional expertise and 'attributed to the subjective nature of the design process' (Coyne and Snodgrass, 1991, p. 125). In this discourse the authors, drawing on the philosophical writings of Hans-Georg Gadamer and Jurgen Habermas, argued that the subject-object distinction that underpins design's dual knowledge thesis was a disabling way of structuring how we understand the world (1991, p. 129). They recognise that meanings exist prior to any separation of subject and object, and proposed a hermeneutical thesis for design that is concerned with understanding rather than based on codified knowledge or tacit processes of creativity and intuition:

> We do not stand back from the world in order to understand it. What we normally regard as an objective position is nothing more than a position prescribed within a particular horizon sanctioned by the conventions of modern science. According to the hermeneutical thesis, in bringing our expectations to bear in interpreting a situation there is a melding of subject and object. Knowledge about the world is self knowledge. To assert that there exists a world independent of our experience of it, or to maintain that the world exists only for us is to engage in philosophical games that have no practical purpose [...] The dissolution between subject and object represents the most profound challenge to the notion of design as mysterious and belonging to the realm of the subjective. It strikes at the heart of the Romantic tradition within which much design discourse is conducted. (p. 128)

In this context, Schön's analysis of the architectural design studio and processes of reflective practice are discussed in relation to the hermeneutical circle of understanding and dialogical processes. While Coyne and Snodgrass make but a few specific references to design research in these texts, their philosophical engagement with the theories and practices of design, in terms of the nature of design knowledge, provides an analysis and deeper articulation of underlying paradigmatic assumptions upon which design research models are based. The

focus of this text on design knowledge and ways of knowing (epistemology) underpins both the practice and the research of design.

Scrivener's model, in contrast, seeks to articulate what he describes as 'creative production' approaches in contrast to 'technology oriented' design research, perpetuating, rather than challenging, this fundamental dualism. His discourse is concerned with supporting:

> Practitioners who want to engage in research that will contribute to their ongoing practice […] (who) wish to conduct the research through art or design making [...] Typically, the candidates involved are artists or studio/craft designers, focussed on producing work that will stand up in the public domain (e.g. be worthy of exhibition). For them, doctoral study is seen as an opportunity to develop as creators and to produce more satisfactory work. (2000, p .2)

While the two articles of Scrivener's analysed in this thesis specifically address design research, his framework for creative production is artisanal and oriented towards the development of aesthetic objects through the subjectivity and tacit understanding of the maker. That is, it appears to be an argument based on traditions of visual art practice and Romantic philosophies that seek 'to reconcile the self-identity of man with that of the world around him' (Coyne and Snodgrass, 1991, p. 128). This approach is based in aesthetic philosophy underpinned by Kantian aesthetics. Critically, such practice-based research is submitted for pedagogic examination rather than for circulation in a world of aesthetic commodities (galleries) or designed artefact systems or environments. The ongoing and still contentious debate around design and the nature and validity of practice-based research has emerged from areas and practices of art and design schools that were initially located in the English polytechnic system and focussed on professional art and design education[55]. Institutional mergers of

[55] The historical association of art and design in terms of these disciplinary and institutional developments stemmed from distinctions made between the fine arts and the applied arts as a consequence of the industrial revolution, and from the educational regimes which developed to support these two approaches (Lewis and Lewis, 1995). For example, the *École nationale des arts décoratifs* in Paris (National School of Decorative Arts) developed from the Royal Free School of Art (*École royale gratuite de dessin*), founded in 1766 by Jean-Jacques Bachelier, and confirmed by royal patent in 1767. The French tern *dessin* can be translated as drawing or picture, as well as design. The purpose of the Royal Free School of Art was the development of artistic crafts to improve the quality of manufactured goods. In 1877 the school became the National School of Decorative Arts (*École nationale des arts décoratifs*) before taking its current name of ENSAD (*École nationale supérieure des arts décoratifs*) in 1927. (http://www.ensad.fr/spip.php?page=accueil&lang=en). Kant also made a sharp distinction

polytechnics into universities were part of an economically motivated shift that saw these practically focussed art and design schools amalgamated into institutions that were organised along historic lines of disciplinary division with established research cultures (Woodham, 2001). Similar institutional shifts, along with the development of doctoral level design programmes and government-imposed research evaluation regimes, were subsequently emulated in Australia and New Zealand.

The core of this debate about what Scrivener calls research through 'creative production', but is more often referred to as 'practice-based' or 'practice-led' research, centres around the issue of whether creative practices can be considered as research and how the artefacts produced through these practices might be regarded or justified as research outcomes.[56] This is an ontological issue, concerning the nature of research, the nature of design and the nature of creative practice. It is also an epistemological issue, concerned with forms of knowledge and the way knowledge is generated, communicated and evaluated, and the contexts within which it is produced and evaluated.

Scrivener recognises that both research and design are practices, but distinguishes these practices in terms of their respective purposes: the aim of design, he suggests, is innovation, while the purpose of research is to acquire new knowledge, and he claims that 'dominant epistemologies do not admit design as a legitimate knowledge acquisition method' (2000b, p. 388). In this context, Scrivener appears to be referring to the creative practice of design, as he acknowledges in another paper (Scrivener, 2000) that technological research models of design, based on problem solving, are widely recognised and used. The characteristics of this technological approach to design that involves the making of products include the following: that the outcome of research is usually a new or improved artefact, that the need for the product is justified, that the solution identified through the research addresses the problem and is of interest within the domain and that the knowledge embodied in the object is applicable to other contexts – that is, it is generalisable and transferrable. Above all Scrivener emphasises that in this approach the knowledge embodied in the artefact is more significant than the artefact itself. This view of the artefact in design research corresponds to Bruce Archer's notion of research through design, where 'the best or only way to shed light on a proposition, a principle, a material, a process or a function is to attempt to construct something, or to enact

between fine and applied arts, and this position is relevant to the notion of the dual knowledge thesis, as well as current discourse about art and craft.

[56] Niedderer and Roworth-Stokes (2007) have conducted an analysis of the diverse terminology related to research and creative practice.

something, calculated to explore, embody or test it' (Archer, 1995, p. 11). Scrivener's notion of creative-production projects, as the other half of a dualistic model, is framed in opposition to this set of characteristics. He notes that in creative production research, while an artefact is produced it is not always new or improved, nor is necessarily useful, nor is it a solution to a recognised problem. Knowledge is less important than the artefact itself, and any knowledge may not necessarily be reusable or transferrable. In this framework, the artefacts themselves are the project outcomes rather than exemplars of the project findings (2000, p. 3). Scrivener draws on Schön's writing to suggest a method for conducting creative production projects, using 'reflective practice'. He claims that Schön:

> Conceives the design task as a unique situation and design as a process of learning about the problem. Given complexity and uncertainty, ordering schemes, usually drawn from past experience, must be selected and imposed on the situation. But as the situation talks back the problem may need to be reframed. Closure of the task depends on the gradual shift from exploration to commitment. (2000b, p. 388)

While pointing out the significance of Schön's theory of reflection-in-practice to his own theory of research-in-design, Scrivener notes that Schön presents a theory of practice that is conceived in terms of problems and solutions (2000, p. 7), and uses scientific language of 'theory of action, logic, experimentation, hypothesis and experimental rigor' that is very different to his own sense of creative production. However, he claims that 'the things onto which these words are attached, the processes and its characteristics, seem to capture much of that which I have also observed in the actions of my creative-production project students' (2000, pp. 7 and 8). Schön's consideration of professional practice was developed through studies of teacher education, the health professions and architectural design. He was concerned with approaches based on technical or scientific knowledge in relation to 'artistry' or tacit knowledge gained through experience in developing professional excellence as part of professional education.

Scrivener proposes a process based on Schön's descriptions of reflection in and on design that should be recorded systematically by researchers (p. 9) to make a project more accessible both to the researcher and others. He outlines a series of stages through which a practitioner will guide a creative-production project, including reflection on past practice, an 'appreciation' process where issues and goals for further investigation are identified, a search for information and

knowledge relevant to the issues and goals, the process of documenting and reflecting in and on action, and on practice at the completion of 'work episodes', and a final stage of reflection at the end of the project. He also suggests a structure for a project report. Scrivener suggests that this formalisation of process is a way of distinguishing normal processes of 'art and design making' from creative project design research, and that it contributes to the development of art and design making and will consequently become accepted as research in design. However, the argument he makes, that because art- and design-making happens within a doctoral studies programme it becomes research, doesn't address the question of the relationship of the academy to design and design research, or the significance and purpose of design research beyond enabling design students to gain higher qualifications or staff being recognised as 'research active'. While Scrivener suggests that the term research is not absolute, 'that it is socially constructed depending on the community using the term' (p. 14), his theory is based on a comparison of research processes and outcomes rather than on deeper considerations of the nature or theories of design knowledge, beyond the notion of tacit forms of practice. Scrivener's model can be seen as reinforcing another dualism, that between theory and practice.

Interpretive Frameworks

The limitation of any binary framework, which places things in opposition, is that it ignores what might lie between or beyond the identified polarities. As noted previously, Coyne and Snodgrass (1991) have recognised the longstanding, dualistic way of conceptualising design as being logical, analytical and rational, and based in science, or as subjective, idiosyncratic and romantic, and based in art. While the terminology they use is different to Scrivener's, their description of this fundamental conceptualisation parallels much of his description of technology-oriented and creative production-based research. In claiming creative practice as research, Scrivener attempts to articulate this 'mysterious' domain. However, such articulation might be extended through further consideration of the nature and role of a work of art, which seems to be the focus of such creative production projects. In addition, further engagement with the nature of artefacts in design and an examination of the nature and theories of design knowledge, particularly as they relate to divisions between theoretical and practical knowledge, would also be relevant to this discourse. Coyne and Snodgrass do not focus on the 'artistic' side of the science/art dualism, beyond a discussion of Romanticism and design (2001, pp. 128 and 129) and references to authors whose writing exemplifies this approach

(Abercrombie, 1984). They discuss some of the limitations of the scientific approach in their 1997 article 'Is Designing Hermeneutical?' (Snodgrass and Coyne, 1997) where they consider the position of design in relation to the natural sciences and the limitation of approaches based on formal logic. Their main focus, however, is the articulation of a third way, a hermeneutical approach towards design, based on understanding accomplished through interpretation.

In considering design as an interpretive activity (1997, p. 28), Coyne and Snodgrass claim a distinction between hermeneutical and epistemological activities. They reconsider the relationship between theory and practice in terms of the intertwined processes of knowledge formation as understanding and application through the hermeneutical approach:

> Designing is a hermeneutical rather than an epistemological event. In the hermeneutical event application is interwoven with and wholly inseparable from interpretation and understanding; in the epistemological event, knowledge and its application are separate and sequential; knowledge is prior to its application. The answers to the questions arising in the situation are known in advance. They do not vary according to particular exigencies or contingencies. In the epistemological schema, theory precedes practice. In the hermeneutical event theory cannot be divorced from practice. The theory, such as it is, only comes into consciousness, is only clarified, and disclosed, in the process of its application. Theory and practice coalesce in the act of interpretation; general principles are revealed as what they are. Are revealed to be what they are, come to be understood in their being, in the unfolding of their application in the event. (1997, p. 28)

The notion of design as a hermeneutical activity overcomes the dualism between theoretically based scientific approaches and practically based creative approaches by focussing on interpretation and dialogue rather than problem solving or creativity. While Dorst (2008) and others have recognised that much design research is concerned with discovering or formalising knowledge about the practice(s) of designing, the field of design research is far broader than this, as is recognised in the diverse theories considered in this thesis and by the range of design research practices evident in events such as the bi-annual DRS conferences (http://www.designresearchsociety.org). While this thesis inquiry is, at heart, epistemological, in that it is concerned with the different ways design research is known and organised, the methodological approach taken in this

inquiry is hermeneutical, seeking to interpret and understand relationships between different epistemological approaches. Thus hermeneutics and Coyne and Snodgrass's theory of design have been influential in the design of this thesis research.

Coyne and Snodgrass also refer to Schön's notion of reflection-in-action, which they identify as 'a clear and straightforward account of the hermeneutical circle' (1997, p. 22):

> The designer proceeds by way of a continuing inter-referencing of a projected whole and the particulars that make up the design situation. In the design process we project the meaning of the whole and work out the implications of this projection by referring back to the parts. There is a prescient anticipation of the whole, which is then explicated in the individual parts. The design is continually re-determined by an anticipatory movement of pre-understanding. The designer has an anticipation of the whole which guides his or her understanding of the particularities. Understanding arises by a process of constant revisions. (ibid.)

Like Scrivener, they acknowledge that the design process uncovers tacit understanding, and they recognise that this process is never fixed or complete, because new understandings can develop: 'The design event is an inexhaustibly prolific and productive matrix, because it is a matrix that is ever reforming itself in conformity with its product' (p. 31). However, while Scrivener's theory draws from Schön's approach to present a series of steps and a process diagram (Scrivener, 2000b, p. 391) as a method of reflective practice to be used by design researchers, Coyne and Snodgrass insist that 'hermeneutics is not a method for practice, teaching or research' (1991, p. 126). Rather, they suggest it as a way of looking at things, a theory of knowledge, a way of understanding that is distinct from the 'comprehensive' logic-based approach of design science and the intuitive 'apprehensive' approach of creative practice. Their notion of meaning in artefacts is also more complex, recognising the design process as a disclosure – in two co-existent senses:

> It is a disclosing of the artefact being designed; and secondly and simultaneously, it is an unfolding of self understanding, since it reveals one's pre-understanding. It uncovers the preconceptions that are constitutive of the design outcome and at the same time, brings to light the prejudices that are constitutive of what we are (1991, p. 25).

Thus the meaning of an artefact is not based on what the designer or researcher wants the viewer, user or examiner to understand, but will depend on the frameworks of pre-understanding the designer brings to the project, the process they go through in developing the project and the frameworks the reader or viewer brings to interpret the project. Within a hermeneutical framework the artefact is a text and will be understood through acts of projection on the part of the reader or viewer. It will be read 'with particular expectations in regard to certain meaning' (Gadamer, cited in Coyne and Snodgrass, 1991, p. 125). Scrivener's notion of artefacts is defined by the subject/object frameworks of his dualistic model, and overlooks that it is not an artefact in itself, but the interpretations of meanings of the artefact-as-text, 'the working out of possibilities of projected understandings' (Snodgrass and Coyne, 1997, p. 14), that is significant both in design practice and in design research.

Coyne and Snodgrass claim that design is hermeneutical and that hermeneutic studies attempt to answer the question: How does understanding arise? (1997, p. 11). They propose a theory of design that can inform a different approach to design research, one concerned with understanding rather than knowledge production (as if knowledge is a product or artefact) or the development of professional practice. This approach suggests a way of eroding divisions, such as those between theory and practice or science and art that have been historically significant in the development and conceptualisation of design as a discipline, and have underpinned the theories and practices of design research. These dualisms reflected broader paradigmatic positions that historically have informed particular approaches to design, and design's location as an inter-discipline, creating a discursive space where these different positions could be considered in relation to each other. Hermeneutics was initiated in the late nineteenth century to overcome the fundamental division between value and fact that was opened by the development of the human sciences in relation to the natural sciences (Gadamer, 1976). This tension between positivist and constructivist positions has also been interpreted by some theorists as a difference between scientific- and humanities-based approaches to design and design research.

Design Studies

Victor Margolin has proposed a 'terrain of a broadly conceived design research community' (2002, p. 6). This model has been drawn from different essays in his

book *The Politics of the Artificial* (2002). Describing his approach as 'a social philosophy of design' (p. 4), Margolin's approach to design studies frames design as a social, rather than a scientific, artistic or interpretive practice. Margolin's terrain of design research recognises three distinct arenas: 'design methods', 'project-oriented research' and 'design as cultural practice'. The first of these, design methods, is named after the Design Methods Movement. Within this area he identifies behaviourism and phenomenology as two distinctive 'reality based approaches' within this field

Margolin's second category of design research is described as 'project oriented research'. This title might seem to suggest practice-based or practice-led research, but this is not the case. Project-oriented research, according to Margolin, is utilitarian and is concerned with commercial and technical production areas. It involves evaluation and 'concrete tasks where value can be measured in terms of market place success or failure' (p. 249). Methods in this field, according to Margolin, tend to emphasise the integration of different types of expertise required to produce specific products instead of drawing from general or abstract theories.

This particular category of design research does not immediately correspond to categories in any of the other models analysed in this thesis, but nonetheless indicates a particular framework for design research – one that is located within the logistical and economic frameworks related to business and manufacturing.[57] Margolin identifies this approach with consumption, marketing, management and technological processes that are underpinned by an expansionist approach associated with a business agenda. Margolin has demonstrated a long-standing commitment to a sustainable design agenda. He recognises that the sustainability agenda tends to be described in dialectical terms, as economic expansion versus sustainability. Within this framework, his category of project-based design would seem to equate with expansionist activities of manufacturing and increasing production.

[57] It may relate in part to what Nigel Cross (2006) identifies as the industrialised design approach of 'scientific design', which draws from material science, engineering design, building science and behavioural science, although Margolin's 'project-oriented' category would seem to have a stronger economic emphasis.

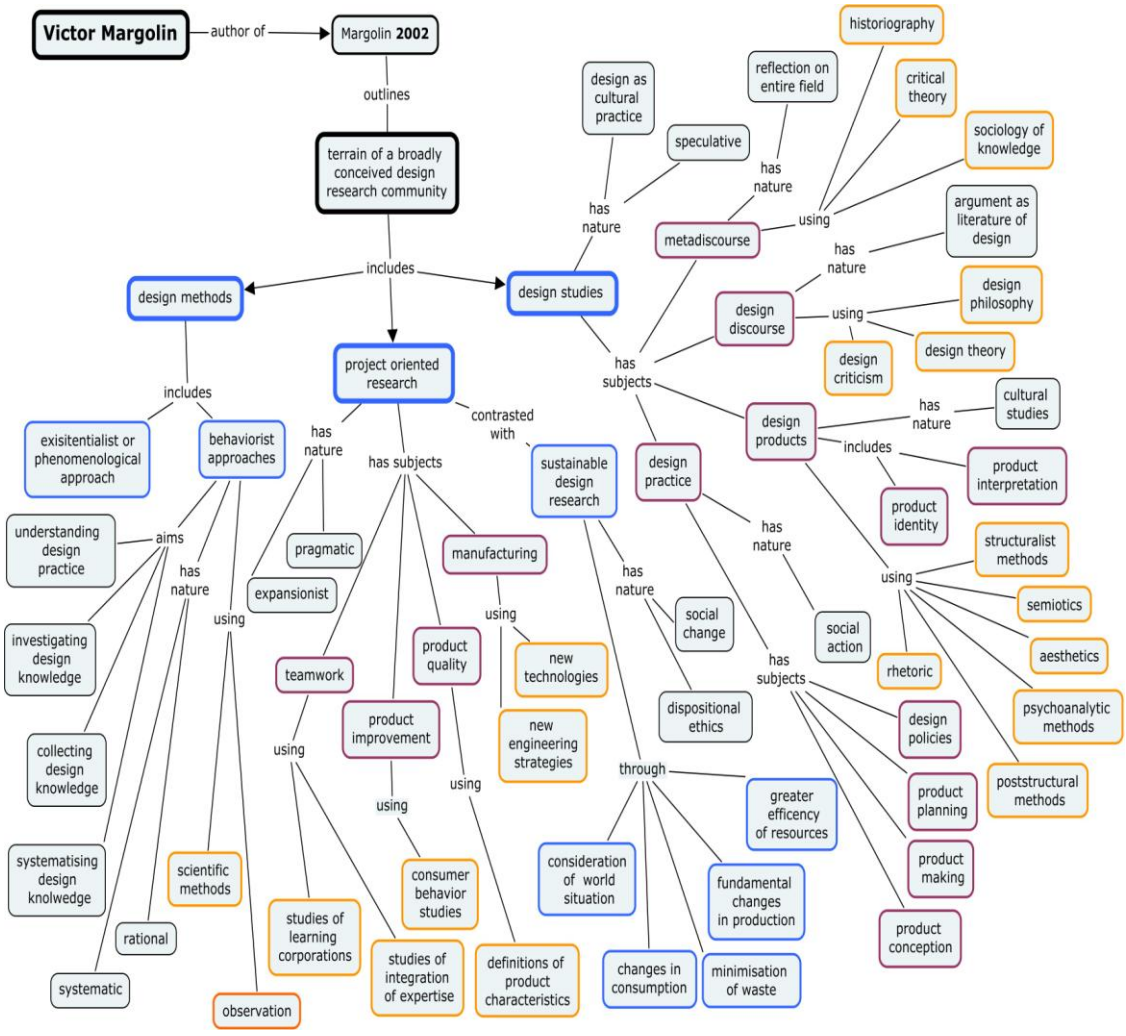

Figure 17: C Map outline based on theory by Margolin, 2002

The need to explore this 'project-based' agenda beyond notions of technology, value creation, production, reception and increasing consumption, to include what have long been regarded as separate 'eco-design' issues of waste, energy use, recyclability and social and environmental impact, is becoming more widely recognised. Margolin's framing of the project-based category of design research, as outlined in the chapter titled 'The Multiple Tasks of Design Studies' (pp. 245–59) in his book, has been extended and further considered in this analysis in relation to the sustainability agenda that he outlines in another section of the book ('Design at the Cross Roads', pp. 29–37).[58] The framing of

[58] *The Politics of the Artificial* is based on papers written by Margolin over a twenty-year period. While he revised particular essays for this publication, they have not been re-written so as to

research for commercial and technical production areas needs to be part of a critical economic, social, environmental and technical continuum, rather than a separate or alternative set of issues. In the introduction to his book Margolin recognises this 'rhetorical conflict' between sustainable models and expansionist economies. He suggests that design 'as a demonstrative form of problem solving, might provide new and valid compromise to the current ideological stalemate between proponents of the two models' (p. 3). The 'project' of project-oriented research, Margolin suggests, should be extended, not in terms of ever-increasing economic growth and mass consumption, but in terms of critically and practically accounting for the problems this industrial agenda has created. This articulation of polarities between models of design based on increasing production and consumption and those based on social and environmental sustainability locates a need and opportunity for design research to develop new ways of thinking about, researching and practicing design. Margolin has written elsewhere that if designers are to participate in resolving these problems through new and productive courses of action, they will have to move from second-domain design, where product design has been located since the nineteenth century, to fourth-domain design or the design of complex systems (Margolin, 1996, p. 23).[59]

The category of design research given most emphasis in Margolin's model is 'design studies', and this is concerned with design as cultural practice. He defines this approach as 'modes of thought that recognize design as a practice within a culture and bring to bear on its study the methods that have been used to understand other cultural practices and their resultant artefacts' (p. 251). Margolin identifies 'design as culture' methods as based on techniques of the humanities and social sciences. He sees the aims of this approach as being to develop a greater understanding of design as a whole, rather than as applied knowledge related to specific projects. This is distinct from the focus of design science, which is concerned with design methods and outcomes of design as a process through exploring the broader context of design both as a discipline and as an ethos or way of life. Margolin proposes that the study of design as cultural practice is best organised into four 'topics' rather than categories based on academic disciplines, and identifies these as Design Practice, Design Products,

present a particular or cohesive argument. Rather, as a collection of essays they reflect Margolin's concerns and the development of his ideas over the period.

[59] This notion of four design domains is taken from Buchanan, 1992, p. 9, and includes

- First domain: Symbolic and visual communication
- Second domain: Material objects
- Third domain: Activities and organised services
- Fourth domain: Complex systems and environments.

Design Discourse and Metadiscourse. While design practice is recognised here as a component of the 'design as culture' approach, Margolin's nomination of humanities and social science methodologies indicates a concern with the study of professional practice rather than practice-led approaches, and includes topically oriented areas such as design policies, product planning, product making and product conception, indicating business and political areas of consideration along with areas of design practice. This interpretation is supported by the texts Margolin cites as examples in this field, which include Schön's *Reflective Practitioner* (1983) as well as Donald Norman's *Psychology of Everyday Things* (1988) and Lucy Suchman's *Plans and Situated Actions* (1987).[60] This approach is focussed on the study of design practice or research about practice, rather than research through or in practice. Margolin proposes that such research is conducted through methods drawn from humanities and social sciences research, including historiography, critical theory and the sociology of knowledge. The product-focussed approaches identified by Margolin include structuralist methods, semiotics, rhetoric, aesthetics and psychoanalytical and post-structural methods, suggesting a focus on the meaning of products rather than processes of design or the evaluation of their use or function.

Margolin's theory presents an overview of design research that distinguishes the area of design studies, which is socio-cultural in orientation and draws from humanities-based approaches. The area of design studies was strongly championed by Margolin (1989, 1992, 2002) and reflected developments in the area of cultural studies and the emergence of the field of design history (a point strongly emphasised by Woodham, 1995). However, the polarity between scientific- and humanities-based approaches to design research has also been recognised as another fundamental dualism underpinning design research theory (Chow and Jonas, 2008). The third area of design research identified by Margolin, 'project oriented research', introduces a category of technologically and business-oriented research that is distinct from notions of technology-oriented research introduced in the models developed by Järvinen or by Scrivener, in that it also includes a sociological focus, for example Margolin includes 'studies of learning corporations' under the category of project-oriented research. Thus Margolin's model, interpreted from across various sections of his 2002 book, can also be seen to present a linear conceptualisation, with design science (design methods) at one end and design studies, drawing

[60] These references are not indicated on the simplified C Map of Margolin's theory that is reproduced in this chapter (Figure 17), but are indicated on the fuller 'working' C Map reproduced in Appendix Four. C Maps in Chapters Four and Five have been simplified for ease of reading and better communication of key concepts of particular theories.

from methods used in the humanities, at the other, and with project-oriented research, with a socio-technical focus, located between these two extremes.

The model proposed by Susan Roth (1999, pp. 18–26) also recognises the area of design studies, and was published in a special themed design-research issue of the journal *Design Issues* (Vol. 15, No. 2). Roth makes a distinction between design research in professional and academic environments. She recognises that the outcome of research in professional design practice is usually proprietary information that is not circulated outside the client/provider relationship. The context of professionally based research is left out of many theories of design research, for example Scrivener's theory is oriented towards research in the academy. Roth's position regarding professional practice research can be correlated, in part, to Margolin's project-oriented research, but is hard to locate in relation to other more academically or philosophically oriented models. Roth recognises that professional practice approaches tend to use multiple methods derived from social and behavioural sciences, business and marketing analysis.

Roth's theory has stronger links with other models in her categorisation of design research in the academic environment, and identifies three approaches to design research: 'creative practice based research', 'design studies' and 'research tied to practice'. The category of design studies can be correlated with Margolin's framework, recognising a focus on 'objects and processes from perspectives of critical theory and humanistic inquiry' (Roth, p. 19). The category of 'research tied to practice' identified by Roth is broad, and recognises a range of concerns, ranging from studies of the context of practice, the effects of new technologies, business and production methods on design, to research to improve design practice. This includes 'design methods', which is recognised as one of three possible approaches, along with participatory and interactive design approaches, associated with improving the processes of designing products. Roth's concept of 'creative practice-based research' is more complex. She identifies this category as resulting in the production of artefacts, as Scrivener does. However, she also voices some criticism of practice-based research, stating that such research programmes 'could be considered an extension of the undergraduate approach to education, which in the best institutions requires that students conduct preliminary research in order to arrive at an informed solution' (p. 19). This implies that although she recognises 'creative practice-based research' she sees a distinction between research done for a design project, where information and references are collected to inform or inspire a design project, and research that is conducted through the design process, where the focus is not only on the production of an artefact, but on the

meaning and knowledge conveyed through the artefact. Roth attempts to map the broader terrain of design research, rather than promote a particular methodological approach, or argue one approach in relation to another.

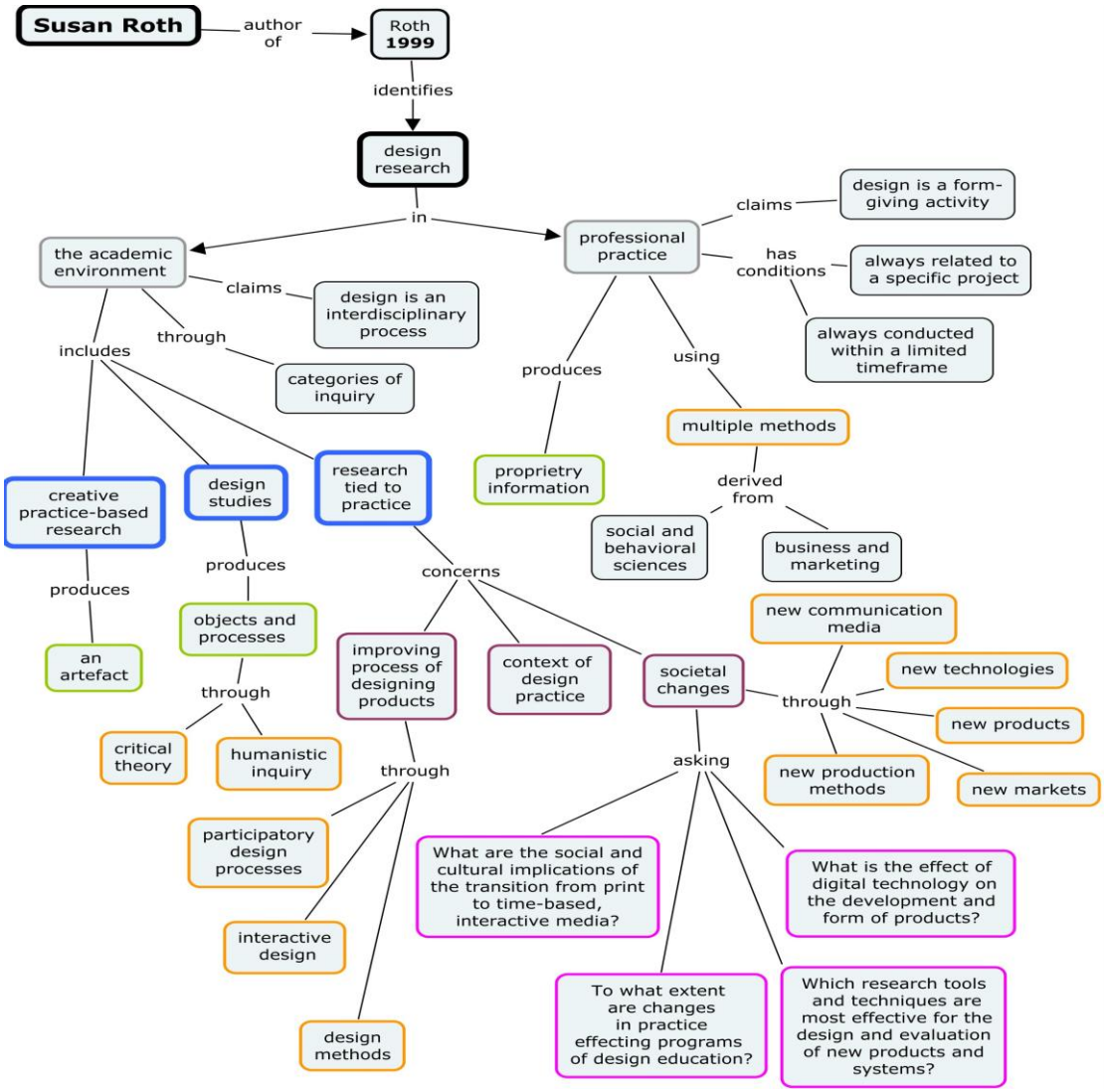

Figure 18: C Map outline based on theory by Roth, 1999

In considering ways to productively unravel and map the complex terrain of design research theory, it became evident that an investigation and analysis of every theory and variation of approach would be impossible within the temporal limitations of this project. In reviewing the texts analysed for this chapter up to this point, and comparing some of the more detailed analyses of various design science and design technology models, a decision was made to consider at least one methodological approach that was recognised across a number of design research models in more detail. This might serve as a way of exploring the possible formation and articulation of sub-categories within other

more abstract 'higher level' categories where details of methodological approach were not always specified, defined or more fully discussed, and where very different understandings, even of the same term, seemed to exist between different theories. The recognition of the importance of phenomenology as a radical position that contested scientific positivism while acknowledging the importance of empiricism, and informed developments in constructivism, led to the decision to conduct a more specific investigation and mapping of writings about phenomenology and design research.

Phenomenological Approaches

Phenomenology is identified in a number of the design-research theories considered in this thesis project. Margolin locates phenomenological approaches as one of two possible ways of investigating design methods, the other using behaviourist approaches. Phenomenology is recognised by Archer (1981) as one of three sub-disciplinary areas of design research activity, and by Cross (2006) as one of three specified methodological approaches to design research. Cross provides a very specific definition of phenomenology in design research, as being focussed on the study of form or the configuration of artefacts (p. 101). Phenomenology is also recognised among various approaches to dialectical inquiry by Buchanan (2006, 2007), whose theory is discussed in more detail in Chapter Five. However, it is clear even from the examples given by Archer, Cross and Margolin that their understandings of the focus of phenomenology in design research are very different.[61] The need to better understand such differences of interpretation was behind the motivation for selecting two texts – by Seamon (2000) and Wang and Wagner (2007) – that are concerned with specific models of phenomenology in design research.

Seamon's paper (2000) is focussed on phenomenology 'as it might be used to explore environmental and architectural issues' (p. 3). Phenomenology is defined by Seamon as:

[61] Archer's category of phenomenology includes sub-categories of design history, design taxonomy and design technology, while Cross defines the phenomenological approach in terms of the study of the form and configuration of artefacts, involving subjects such as the forms of materials and finishes, the development of design morphology, the efficiency and economy of artefacts and the relationships between form and content. It would seem that these differences are based on the different themes or subject areas that a particular author identifies as being investigated through phenomenology.

The exploration and description of phenomena, where phenomena refers to things or experiences as human beings experience them. Any object, event, situation, or experience that a person can see, hear, smell, taste, feel, intuit, know, understand or live through is a legitimate topic for phenomenological investigation […]. The phenomenologist pays attention to specific instances of the phenomenon with the hope that these instances, in time, will point toward more general qualities and characteristics that accurately describe the essential nature of the phenomenon as it has presence and meaning in the concrete lives and experiences of human beings. (pp. 6–7)

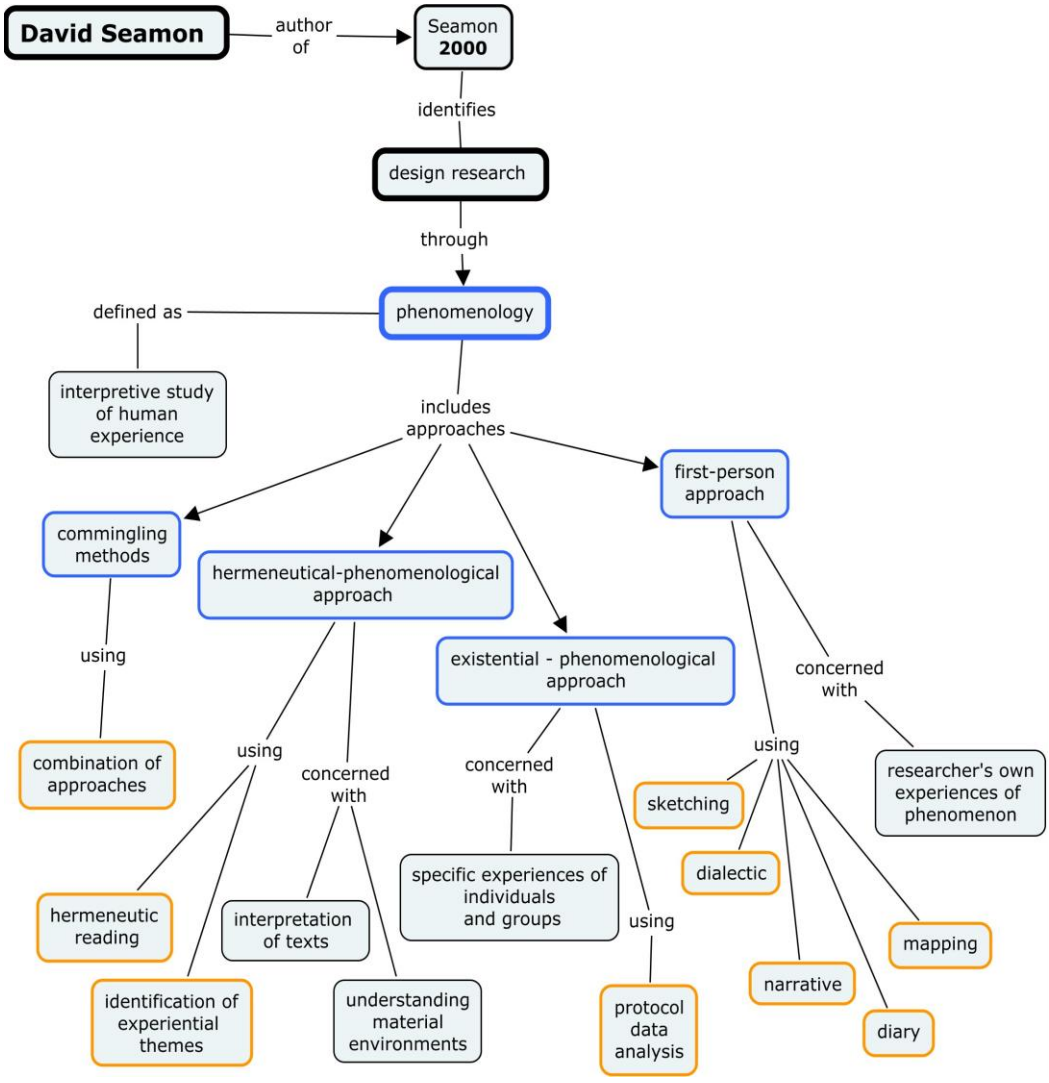

Figure 19: C Map outline based on theory by Seamon, 2000

The radical empiricism of phenomenology is also acknowledged in this text. Seamon discusses how idealistic and realistic perspectives in conventional

philosophy and psychology were challenged by phenomenology. He identifies Martin Heidegger's notion of being-in-the-world, based on a recognition that objective and subjective notions 'that assume a separation and directional relationship between person and world' (p. 10) do not exist in the actual world of lived experience. Seamon also considers the significance of intentionality, 'the argument that human experience and consciousness necessarily involve some aspect of the world as their object, which, reciprocally, provides the context for the meaning of experience and consciousness' (p. 10).

In considering the history of phenomenology, Seamon acknowledges that there are many different understandings and uses of this approach.[62] While the roots of phenomenology are based in the discipline of philosophy, it is an approach that has been influential in a number of different disciplinary areas, including that of design research. The way phenomenology has informed a wide range of inquiry is related to the understanding that 'phenomena have an existence prior to their description by means of language, and so the only access to them is by a spontaneous *phainesthai* or unveiling' (Wang and Wagner, 2007, p. 5).

Seamon's analysis of the 'complex, multi-dimensional structure' of phenomenological approaches to design research identifies four distinct approaches:

- First-person research, where the researcher uses his/her own first-hand experience of a phenomenon as a basis for examining its scientific characteristics and qualities
- Existential–phenomenological research, where the specific experiences of particular individuals and groups within actual situations or places forms the basis for generalisations
- Hermeneutical–phenomenological research, through the interpretation of texts, where a text can be any material object or tangible expression imbued in some ways with human meaning. This approach is concerned with discerning the themes and meanings that illuminate the 'integrity, complexity and essential being of the phenomenon' (von Eckartsberg, 1998, p. 50)

[62] Phenomenology as the philosophical tradition concerned with the study of phenomena through the structures of experience developed in the first half of the twentieth century. Key figures included Edmund Husserl, Martin Heidegger, Maurice Merleau-Ponty and Jean-Paul Sartre. Phenomenology addresses the meaning things have in our experience or 'life-world' (*Stanford Encyclopaedia of Philosophy*). Consequently, the meaning of phenomenology has come to be interpreted in different ways over the century of its development.

- Commingling methods, where approaches from the other three categories are combined

This typology draws from different historical orientations in phenomenology. The third approach, hermeneutical-phenomenological, indicates the phenomenological underpinnings of hermeneutical analysis.

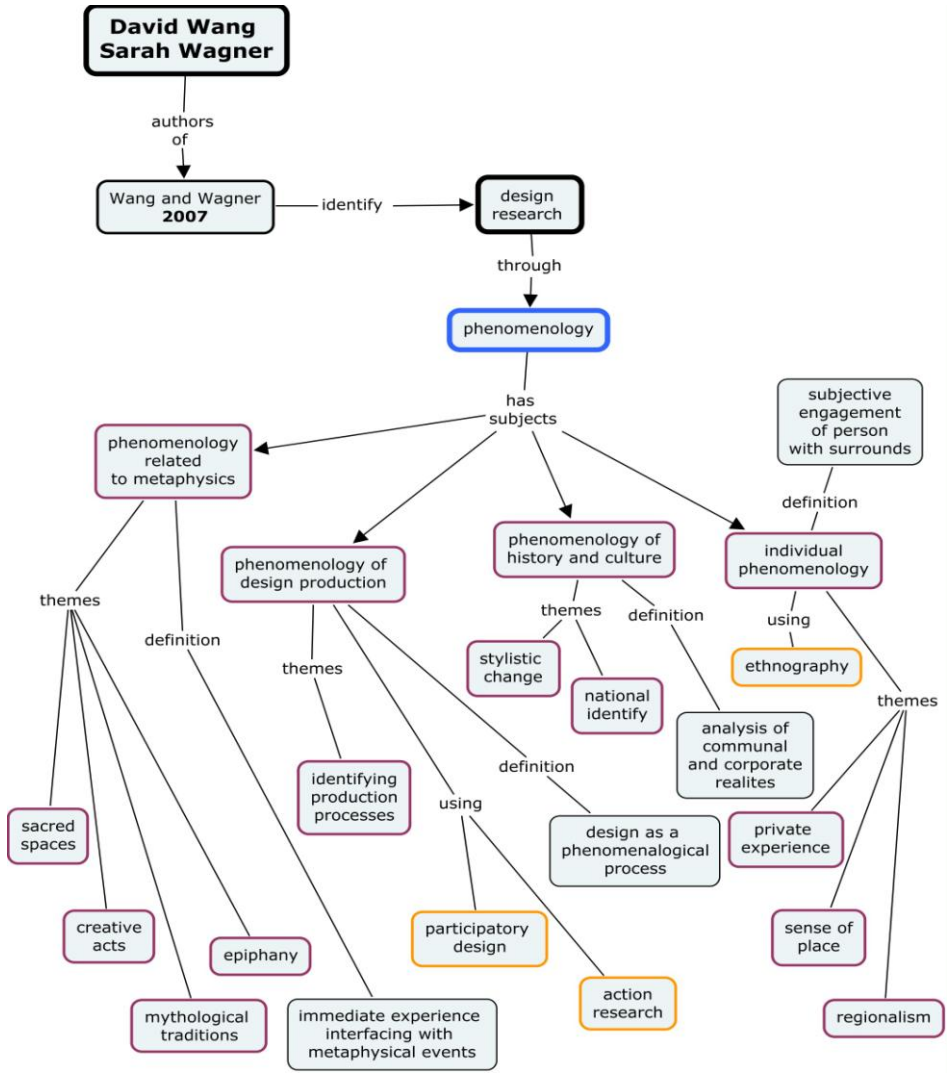

Figure 20: C Map outline of theory by Wang and Wagner, 2007

A second paper by David Wang and Sarah Wagner (2007), which claims to map phenomenology for the design disciplines was also analysed. This paper locates phenomenological studies relating to design within four thematically based categories as an 'overall geography of phenomenology' (unpaged). These include:

- Individual phenomenology
- Phenomenology of history and culture
- Phenomenology of design production
- Phenomenology related to metaphysics.

This model focuses on areas of phenomenological study rather than phenomenological processes or methodology. However, some partial correlations can be made between Seamon's and Wang and Wagner's models. However, both Archer's and Cross's categorisations could be modelled as nested parts within Wang and Wagner's broader schema. For example, the development of form in automobile design, as an example of design morphology, can be seen as part of design history (Archer), which is part of a broader phenomenology of history and culture (Wang and Wagner).

Wang and Wager	**Archer**	**Cross**
Individual phenomenology	Design experience	Making informal knowledge explicit
Phenomenology of history and culture	Design history	Development of design morphology
Phenomenology of design production	Design technology	Forms of materials and finishes; efficiency and economy of artefacts
Phenomenology related to metaphysics	Design taxonomy	Form/content relationships

Table 4: A comparison of phenomenological categories in theories by Wang and Wagner (2007), Archer (1981) and Cross (2006)

Understanding these different determinations of phenomenology in design research theories requires an awareness of the history and development of phenomenology, and the different ways it has been conceptualised. Van Manen (2002) has written extensively about the complex and fertile philosophical tradition of phenomenology and its influence on the development of various related philosophical movements including existentialism, post-structuralism, postmodernism, feminism and cultural critique (unpaged).[63] He identifies six

[63] He writes that significant contemporary figures such as Foucault, Derrida and Rorty have been influenced and inspired by earlier phenomenological writings by Husserl, Heidegger, Blanchot, Levinas, and others.

different domains of phenomenological inquiry into human meaning. These domains are defined as:

- Orientations in phenomenology in various traditions such as transcendental, existential, hermeneutic, historical, ethical, and language phenomenologies
- Sources of meaning or phenomenological inquiry drawing from areas such as history, language, aesthetics
- Methodology or phenomenological inquiry understood in terms of the philosophical or methodological attitudes associated with the *reductio* and the *vocatio*[64]
- Methods and procedural dimensions, which can be explored in terms of empirical methods and reflective methods
- Writing, recognising the inseparable link between phenomenological inquiry and the practice of writing
- Epistemologies of practice or the forms of phenomenological knowing that inform or animate our actions, which Max van Manen (2002) identifies as: knowledge as text, knowledge as understanding and knowledge as being. (http://www.phenomenologyonline.com/inquiry/68.html)

The hermeneutical position nominated by Coyne and Snodgrass can be considered in terms of phenomenological knowing in and through design, and draws from Gadamer's writings on phenomenology. Gadamer recognised Heidegger's bringing together of Husserl's phenomenology and hermeneutics. Drawing from van Manen's analysis, Seamon's model is based on procedural orientations towards phenomenology in design research. Wang and Wagner's approach is oriented towards different types of sources of phenomenological meaning, as are the approaches by Archer (1981), Cross (2006) and Margolin

[64] There are two methodological approaches in phenomenological inquiry and writing: the *reductio* (the reduction) and the *vocatio* (the vocative dimension). Max Van Manen writes: 'The method of phenomenology is radical reflection. The reflective method is supposed to emulate lived experience and this requires several forms of the first aspect of phenomenological methodology, the reductio: The bracketing or suspension of our everyday "natural attitude". This emulation occurs linguistically through writing in the context of the second aspect of phenomenological methodology, the vocatio. The intent of writing is to produce textual portrayals that resonate [with?] the kinds of meanings that we seem to recognize in pre-reflective experience. The vocative dimension expresses this concern with language.' (2002, unpaged)

(2002), although these various models identify sources of meaning in design at different levels of granularity. The importance of phenomenological thinking in the development of the 'second generation' of design methods that followed the Design Methods Movement is recognised by Margolin. The reframing of hermeneutical approaches by Coyne and Snodgrass, to disrupt the dualistic positioning of design science and creative practice, indicates an ongoing process of re-conceptualisation and change through phenomenological thinking in design research and theorisation. These issues are not fully explored in Seamon's or Wang and Wagner's models, which are focussed on categorising types of phenomenological approach in design research rather than with a deeper consideration of the potential of phenomenological thought in the discipline of design. Coyne and Snodgrass's recognition of a reflective phenomenological method (the hermeneutical circle) in Schön's notion of reflective practice could also be productively explored in relation to Scrivener's model of creative project research. This may offer a framework for developing a more coherent positioning and greater methodological richness and understanding about research through practice in design. However, this has the potential to become another project in itself, and is noted here as an area of potential future research stemming from this thesis inquiry.

Conclusion

This chapter outlines the analysis of texts by eleven design research theorists, considered in terms of originary models of design research that have been informed or influenced by other disciplinary frameworks. However, there is no distinct moment identified here when design research theories switch from frameworks and methodological approaches drawn from other disciplines into more distinctly designerly ways of researching. Rather, as the discourses and practices of design research developed, reacted against and adapted to or drew from different circumstances and understandings, there has been an ongoing exchange between design and research approaches from other disciplines. This is recognised as being vital for an inter-discipline such as design that engages across different contexts and types of problems and works across natural, technical and social frameworks. While design research approaches were at first conceptualised dualistically, either through scientific, objective frameworks or through artistic, subjective approaches, the limitations of this perspective were challenged over time, first by phenomenological thinking and then by the inclusion of research frameworks drawn from the social sciences, humanities, and technological and business inquiry. These frameworks have been discussed

in relation to threshold moments in the emergent history of design research including the Design Methods Movement, design science approaches, constructivist approaches, technology-oriented models, design studies and creative-production models. While some of the texts and models that have been analysed address single or dualistic models, others begin to chart broader overviews and mappings of the field of design research. While the main focus of this chapter is the description and contextualisation of a series of texts and the identification of the main aspects of particular theories, some comparative analyses between different theories and approaches is also included. This comparative analysis is extended further in Chapter Six. The theories identified and analysed in this chapter provide a basis and context for the second set of nine texts described and analysed in the next chapter. These include theories by Buchanan (2005, 2007), Dorst (2008), Jonas (2007), Krippendorff (2006), Love (2000, 2001), Manzini (2007), Nelson and Stolterman (2003), Poggenphol (2000) and Saunders and Chan (2006). This selection of texts is characterised as being developed from conceptualisations drawn from within the discipline of design, rather than from other disciplinary frameworks, or for trying to articulate frameworks that encompass the whole field of design research rather than a singular or dualistic methodological position.

Chapter Five

Designerly Research Frameworks

Introduction

'Designerly Research Frameworks' presents an analysis of nine texts, published since 2000, which introduce more recent theories and understandings of design research. While a number of these models draw from concepts presented in theories considered in the previous chapter, as a group they more clearly reflect a shift away from conceptualisations of design research reliant on models from other disciplines to more cohesive 'designerly' frameworks drawn from issues, approaches and understandings generated from within the discipline of design. This reflects a growth in confidence and understanding, reflected in the developing discourse of design research. It is also evident in a shift away from earlier, dualistic frameworks to more complex representations that attempt to map the whole field of design research. Some texts in this chapter reveal further conceptual shifts – extending beyond design-centric approaches to engage with 'distributed' notions of design, recognising design's inextricable engagement, effect and potential to cause, change or mitigate human impacts on the world. Such approaches recognise design as implicit in the development of complex human systems and wider ecologies. In this context, while it is recognised that design possess a disciplinary core made up of its particular histories, practices, knowledge and methodologies, its identity and role has changed, influenced by social, technological and environmental developments, to be more widely recognised as an integrative, trans-disciplinary field.

This chapter describes and discusses key ideas in these texts, contrasting them with some fundamental concepts identified in the texts analysed in Chapter Four and relating them across the selected texts in this chapter. In the initial consideration of this group of nine texts, it was difficult to identify common groupings or a logical sequence of discussion based on similarities or parallels between concepts or theoretical approaches across the various theories. The relative currency of many of these texts also made it harder to gain an historical

perspective on these emergent theories. The authors of these theories have taken a number of very different positions and have employed diverse strategies for differentiating areas and identifying categories or approaches across the field of design research. However, the purpose of comparison is not just to identify commonalities, but also to understand differences of approach and, more particularly, the underlying issues that inform such divisions or distinctions. Relationality can be recognised through distinctions as well as commonalities. Thus a hermeneutical approach involving the reading, re-reading, interpretation and comparison of texts has led to a narrative of overlaps, shifts and distinctions, as well as of commonalities, in the identification of emergent patterns across the theories considered in this chapter. This process of analysis, pattern identification and category development is further extended in Chapter Six.

Notions of the Artefact

A number of these models of design research are based on notions of design as a practice concerned with the conceptualisation and production of objects or artefacts. This focus is underpinned by a scientific approach that is materialistic (Meyer, 2009, p. 5). While early definitions of the term artefact, associated with design science, were based on a notion of functional objects that were created by human beings for practical purposes, later considerations focus on the meaning of things (semantics) to include abstract conceptual structures as systems and discourse. Notions of the artefact as text, recognised in the previous chapter, shift from design artefacts as industrial products to include non-material forms and outcomes, such as plans (designs) and methods (Järvinen, 2000). This shift reveals not only a change in focus from design outcomes to research outcomes, but in the meaning and scope of artefacts. Scrivener's notion of research in design through creative production results in the production of 'original artefacts'. He explains his use of the term artefact as 'taking a broad view […] it could be a tool or technique for doing something, e.g., picking up fragile objects, or a tool, technique or method for designing such tools or techniques' (2000, p. 14). One of Järvinen's two categories of 'reality based' design research is concerned with the utility of artefacts, where artefacts are defined broadly as things made by human beings (2004, p. 124). Järvinen also recognises methods and models within a broader definition of artefacts, as outcomes of design research.

Shifts in understanding and emphasis given to the place and definition of the artefact in design underpin some of the changes in thinking that are evident in the more recent theories about design research analysed in this chapter. Buchanan (1985) recognises the role of objects in design as rhetorical rather than utilitarian or functional devices: 'Design is an art of thought directed to practical action through the persuasiveness of objects and, therefore, design involves the vivid expression of competing ideas about social life' (p. 7). He acknowledges the significance of objects in terms of their human meaning rather than just their physical or functional attributes. This position stands in contrast to earlier industrially oriented, modernist approaches to design that emphasised the overriding importance of function, evident in credos such as 'form follows function'.[65] The notion of artefact is further interrogated and extended – as a [?]'taxonomy of design artefacts' – by Klaus Krippendorff (2006) (see Figure 21).[66] He identifies a 'trajectory' of artefacts, describing an ongoing historical process of 'phases of extending design consideration' (pp. 5–11). In this model, classes of artefacts build upon, rearticulate and add new value to earlier realisations. The taxonomy begins with industrial products, and moves through a range of classes of artefacts that become less material as they become further embedded in language, a process Krippendorff calls the semantic turn: 'Mass production became inscribed in mass media of communication, fulfilling industries' dreams of supplying universal markets for their goods and services' (p. 6). Krippendorff's taxonomy includes categories of:

- Products
- Goods, services and identities
- Interfaces
- Multiuser systems and networks
- Projects
- Discourses

[65] Louis Sullivan, in 'The Tall Office Building Reconsidered', published in *Lippincott's Magazine* (1896), wrote: 'It is the pervading law of all things organic, and inorganic, of all things physical and metaphysical, of all things human and all things super-human, of all true manifestations of the head, of the heart, of the soul, that the life is recognizable in its expression, that form ever follows function.' This functional approach has been associated with Lamark's theory of evolution, which suggested that anatomy is structured according to function and use; for instance, giraffes are tall so they can reach the leaves of trees. This theory has been discredited, and evolutionary development has come to be considered in terms of Darwinian theory where variation of form precedes function as determined by selection. This has very different implications for any ecology of design.

[66] Klaus Krippendorff is the Gregory Bateson Professor for Cybernetics, Language, and Culture at the Annenberg School for Communication, University of Pennsylvania, Philadelphia, USA.

His theory, like Buchanan's, is based on the premise that humans do not just respond to the physical properties of things, such as form, function and structure, but to the individual and cultural meaning of artefacts. This taxonomy reflects shifts in the understanding of design made evident through changes in the conceptualisation of and values ascribed to the nature of artefacts. Artefacts are recognised in a number of design research models as an outcome of design research. In this context, the significance of Krippendorff's taxonomy is as an artefactual framework that acknowledges historical contingency through technological, social and conceptual shifts. The historical reorientations evident in Krippendorff's dynamic taxonomy of artefacts stand in contrast to more formal ontologies of physical artefacts that are being developed in information science frameworks, even where computational ontologists have begun to recognise and develop formal specifications for non-physical artefacts such as software (see, for example, Garbancz, 2005, 2006, 2006b). The relationship between the material nature of designed artefacts and language proposed by Krippendorff is not dialectical, but relates the articulation of meaning in and through artefacts. These changes are also associated with the development of new technologies that have also led to changes in the form and nature of artefacts. Krippendorff recognises words themselves as artefacts, claiming that etymology shows that words, as human constructs, change in meaning as they are adapted to different situations and individual circumstances.

Human-Centeredness

Krippendorff is concerned with human-centred design approaches. Gill defines human-centeredness as 'a new technological tradition which places human need, skill, creativity and potentiality at the centre of the activities of technological systems' (Gill, 1991, cited in Glasson, 2003, p. 1). Krippendorff distinguishes a human-centred approach to design research as a 'science for design' that is not focussed on rigid methods, but on the development of design discourse. While the approach he describes involves the use of systematic accounts of successful practices using forms of evaluation and self-reflection, Krippendorff's term 'science for design' signals an approach that is distinct from those proposed by Cross or Gasparski (see Chapter Four). 'Science' in the context of Krippendorff's theory, is engaged with the ongoing development of the body of design knowledge, rather than being concerned with general theories, systems or methods. He nominates this approach as a way for design to redesign itself through discourse, by finding ways to talk about design, its effects, what it can do and how it might proceed. He calls this shift in design

'the semantic turn', which emphasises meaning in design in contrast to material objects or functions. Discourse as organised ways of talking, writing and acting is associated with communities of people.

Krippendorff suggests that discourse is both generative and performative: 'Discourses direct the attention of community members, organise their actions and construct the worlds they see, speak of or write about' (p. 10). Such generativity involves opening up discourse to new vocabularies and metaphors that can introduce new modes of expression, 'bringing new ways of conceptualising the world and encouraging new practices' (ibid.). This notion of discourse is also associated with the documentation and dissemination of knowledge: 'it needs to be re-articulatable so that its users can understand, practice and speak about these changes' (ibid.). Krippendorff's focus on discourse is evident in the development of the body of design knowledge that has developed through design research and publication. This shift, from a focus on the object or outcome of design and the methods associated with its realisation, to the development of design discourse and the production of design knowledge, is significant. The recognition of discourse as a human artefact challenges another longstanding design dualism – that between practice and theory. Discourse has both conceptual and material dimensions, evident in the histories of ideas and in mnemotechnic forms such as writing, images, video and sound recording. Design discourse encompasses design artefacts as outcomes of design practice and the articulation of tacit knowledge that informs such practices. Discourse generally precedes and often antecedes theorisation, leading to new or revised theories and informing new practices.

Krippendorff's model of a science for design identifies five categories based on research 'concerns'. These categories indicate strategic approaches to design research in that they include both conceptual and methodological dimensions. They are:

- Human-centeredness
- Stakeholder potentials
- Spaces of future possibilities
- Validation of semantic claims
- The advancement of design discourse.

Within some of these categories further subdivisions are identified. For example, the area of human-centeredness includes sub-categories of dialogical ways to design, designing design strategies, designing original artefacts guided

by narratives and metaphor, designing self-evident artefacts and redesigning the character of artefacts.

Categories not only identify and differentiate classes of ideas, terms or things, but are used to mark divisions or co-ordinations within a conceptual scheme. Categorisation implies both commonality and distinctions between sets of things at a similar level of abstraction. Any comparison or correlation of sets across different categories will require some common basis as well as differentiation, although the level of correlation will vary between different sets of things. In addition, the formation of categories through language and the vagaries of definition also impact on approaches to categorisation. Another problem of categorisation exists in relation to older philosophical categories and technological and ethical shifts that challenge such longstanding ontological perspectives. Within the heterogeneous domain of design, where phenomena are not so easily defined or clearly theorised, there are significant difficulties in establishing any consensus on forms of categorisation.

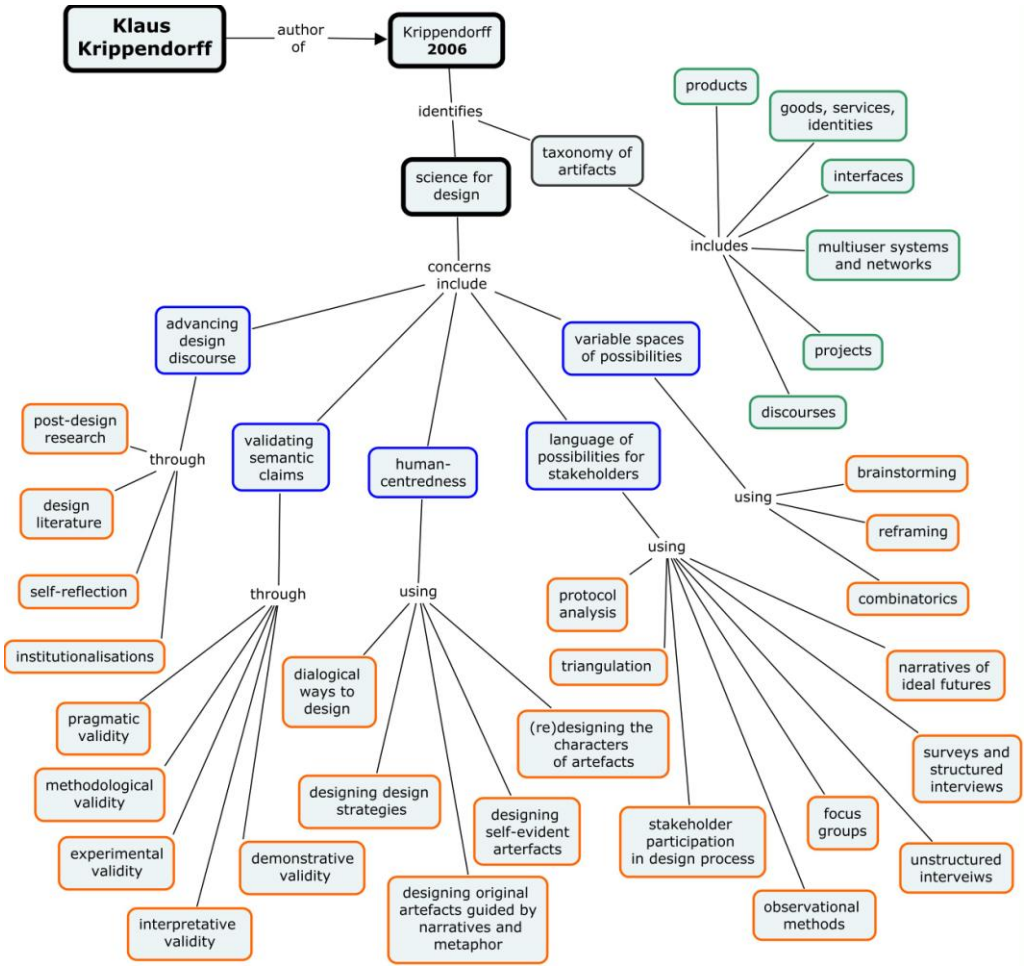

Figure 21: C Map outline based on theory by Krippendorff (2006)

Within Krippendorff's schema, the design of methods and strategies for the design of artefacts are recognised as a set of human-centred design approaches. However, these more detailed methodological categorisations cannot be directly correlated or compared to Krippendorff's taxonomy of design artefacts, as one system is concerned with the categorisation of strategies for research into the use or development of artefacts, while the other identifies classes of types of artefact. These are ontologically distinct in that the first approach is concerned with procedures or methods of research, while the second is concerned with artefacts as the objects of design or outcomes of design research.

Krippendorff's human-centred model can be contrasted with the theory by Elizabeth Sanders and Peter Chan (2007). Sanders and Chan describe their theory as a map of the design research landscape. They recognise this terrain has been the focus of significant development over the past few years and is currently 'a confusing mess of competing and complementary approaches that share common or related goals – to drive, inspire or inform the new product and/or service development process' (unpaged). Sanders and Chan make a fundamental distinction between what they describe as 'research-led' and 'design-led' research approaches. Within the 'research-led' category they identify 'user-centred design' and 'emotional design' as key approaches. These categories appear to be based on Donald A. Norman's concepts of 'user-centred design' (1988) and 'emotional design' (2004).

User-centred design is described by Norman as design based on the needs of the user, in contrast to being based on what he considers to be secondary concerns, such as aesthetics. This user-centred approach focuses on the needs, wants and limitations of the user at each stage of the design process. User-centred design is still widely used in areas of IT and engineering design. While the terms are sometimes used interchangeably, human-centred and user-centred designs have different meanings (see Gasson, 2003). The user-centred design approach is reductive, and was eventually reconsidered by Norman in his book *Emotional Design* (2004). He proposes a framework for analysing products in what he suggests is a more holistic way, recognising their attractiveness, behaviour and the image they present both to the user and the owner. These different aspects of a product are identified with different levels of human reaction, which Norman has described as visceral, behavioural and reflective:

> These three levels translate into three different kinds of design. Visceral design refers primarily to that initial impact, to its appearance.

Behavioural design is about look and feel – the total experience of using a product. And reflection is about one's thoughts afterwards, how it makes one feel, the image it portrays, the message it tells others about the owner's taste. (2004b, unpaged)

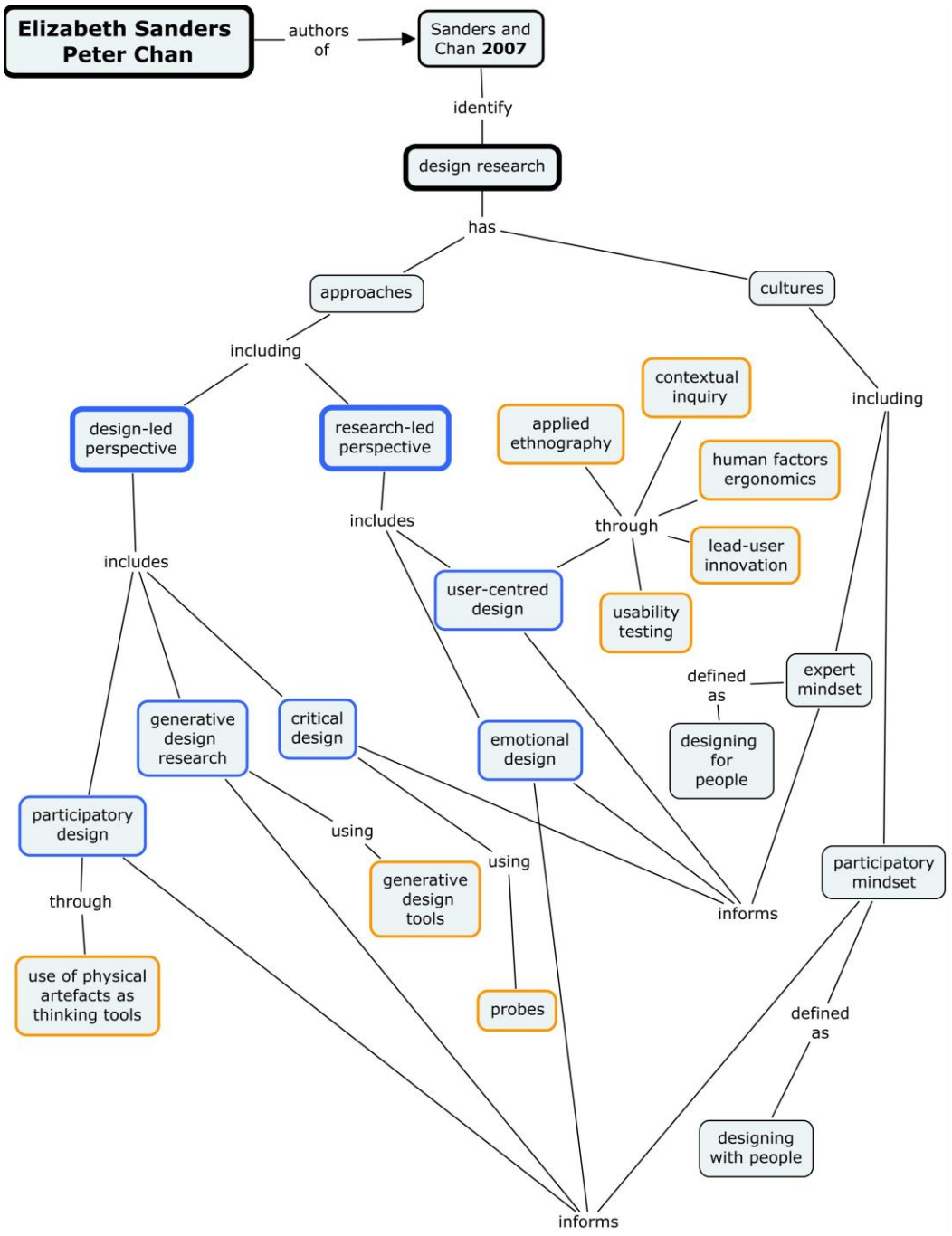

Figure 22: C Map outline based on theory by Sanders and Chan (2007)

This approach was seen as a shift from Norman's earlier position, concerned with functionality of the artefact, to an account influenced by psychology and business theory that takes account of the responses of the person as purchaser or owner of the artefact. This revealed a shift from a utilitarian approach to a position that recognised the role emotions play in the way human beings understand the world and learn new things. Norman proposed that any affinity felt by a user for an object that appeals to them was due to the formation of an emotional connection with the object, and that such connections could be understood as a set of three emotional levels that were based on a model of attitudes drawn from cognitive psychology (Ellis and Young, 1996). An attitude, in this context, is a hypothetical construct that represents an individual's degree of like or dislike towards something. This model emphasises the interrelationship among knowing, feeling and doing, described as affect, behaviour and cognition, or visceral, behavioural and reflective, in Norman's terms.

Cultures of Design Research

Norman's theory reflects another variant of the dual knowledge thesis, contrasting an objective, user-based approach with one based in emotion and subjectivity. Sanders and Chan draw from Norman's user-centred and emotional design models, but also introduce another polarity in their theory. They identify different 'cultural' approaches to design research, based on 'expert' or 'participatory' engagement. The expert model, they suggest, positions users as the subjects of research or 'reactive informers', while users are regarded as participants or co-creators in the participatory models. According to Sanders and Chan, 'user-centred' design is one of a number of approaches driven by this 'expert mindset', while 'emotional design' is linked, in the Sanders and Chan model, to the 'participatory mindset'.

Historically, the development of participatory design was associated with computer and information system design. The focus of participatory design was defined initially as working directly with users and other stakeholders. Over time this approach has expended and now includes 'a rich and diverse set of perspectives and experiences' (Suchman, 1993, vii). Participatory approaches can also be associated with what Creswell has described as a transformative research paradigm, based on the understanding that 'inquiry needs to be intertwined with politics and a political agenda' (Creswell, 2003, p. 9). Transformative research is posited on a reformist agenda that seeks a better

understanding of a 'greater diversity of values, stances and positions' (Somekh and Lewin, 2005, p. 275). This transformative approach has also challenged dualisms of objectivity and subjectivity (in the social sciences) and functionality and emotion (in design) by recognising communal and relational positions that exist outside of such binary positions. These are based on multiplicity, interaction and cultural engagement rather than forms of (objective and/or subjective) individualism. The significance of such transformative and collaborative cultures of design research is also recognised – in different ways – in theories by Manzini (2007) and Poggenpohl (2000).

Manzini proposes a theory of design research for sustainable social innovation (2007) that includes three areas of engagement through 'local initiatives', which he identifies as collaborative networks, creative communities and cosmopolitan localisations.[67] While Manzini doesn't use the term 'artefact,' a number of the activities he identifies as subcategories of these particular initiatives can be related to Krippendorff's taxonomy of design artefacts (see Figure 21). Both models engage with an expanded notion of design that encompasses both material and non-material outcomes of human agency and recognise a multiplicity of strategies in design research. However, the philosophical positions that underpin these models, evident in their understanding of the role of artefacts, are distinct. For example, Krippendorff's human-centred model includes a range of approaches towards artefactual production, including individual and mass-market strategies.

Manzini's model takes a particular approach to sustainable design that exemplifies a shift away from the earlier design aim of creating products built to give a sense of individual wellbeing to one that engages with local initiatives to promote community well-being, institutional change and technical innovation. The model by Manzini provides a conceptual framework that moves beyond product-oriented, eco-design strategies such as recycling – which are still engaged with the production of objects for well-being – to a model based on collaborative economic models, such as open source, and a recognition of the physical, social and spiritual degradation associated with mass production and consumption enabled by unsustainable design.

[67] Ezio Manzini is Professor of Industrial Design at the Politecnico di Milano, where he is Director of CIRIS (the Interdepartmental Centre for Research on Innovation for Sustainability) and coordinator of the Doctorate in Design. Manzini is also recognised as a pioneer of sustainable design.

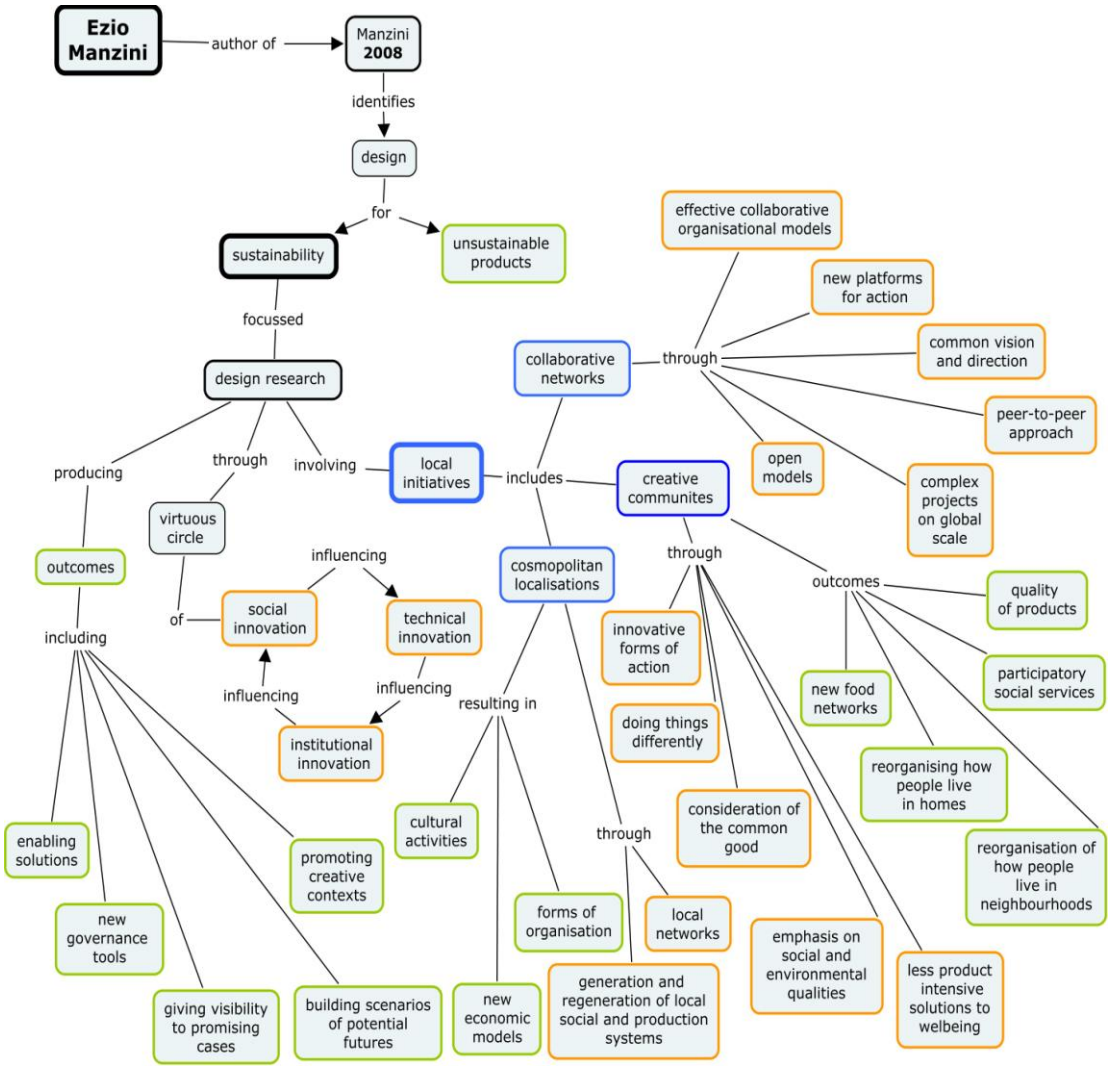

Figure 23: C Map outline based on theory by Manzini (2007)

Manzini's model does not engage with the economic, environmental or social issues associated with large-scale industrial production – the case studies given by Manzini focus on small community projects or artisanal examples. However, his reconfiguration of the relationship between technical, institutional and social innovation – whereby technical and institutional change can be driven by social need, rather than by dominant economic and institutional agendas – indicates a different philosophical position and introduces a new set of research topics, processes and methods to the design research agenda. Manzini's model can be related to Margolin's 2002 position (discussed in Chapter Four) that recognises the impact of non-sustainable, industrially oriented models. Manzini's theory could also be considered in relation to other design research fields such as IT design, which led the development of open-source software approaches and online social networks and which has also informed the development of

participatory design approaches. Manzini's model is focussed on engaging and empowering locally based communities.

Scrivener	Järvinen	Krippendorff	Manzini
Original artefacts	Artefacts	Products	Quality of artefacts
Problem-solving artefacts	Models		
	Methods	Goods, services and identities	Innovative actions
			New food networks
		Interfaces	Links between peers
		Multiuser systems and networks	Forms of organisation
			Participatory social services
		Projects	Cultural activities
			Reorganising how people live in homes/ neighbourhoods
		Discourses	New economic models
			Building future scenarios

Table 5: Chart comparing conceptualisations of design artefacts and design research outcomes by Scrivener, Järvinen, Krippendorff and Manzini

There are parallel developments happening in the corporate sector, with a growing awareness of the importance of corporate social responsibility in some companies. For example the Human-Centred Design Toolkit is a free Toolkit for Non-Government Organisations (NGOs) and Social Enterprise developed by IDEO and the Bill and Melinda Gates Foundation 'to inspire new solutions to difficult challenges within communities of need' (http://www.ideo.com/work/item/human-centered-design-toolkit/). IDEO is a global design and innovation consultancy developing design products, services, environments and digital experiences. The company has become increasingly involved in management consulting. The Bill and Melinda Gates Foundation is a family foundation developed by Microsoft pioneer and billionaire Bill Gates and his wife. The Foundation aims to help disadvantaged people improve their health and change their situations (http://www.gatesfoundation.org). IDEO's approach recognises human-centred design as 'a process used for decades to create new solutions for companies and organizations' (ibid.). They claim that the development of the toolkit refocusses this approach to help companies 'enhance the lives of people' (ibid.), describing this process as:

> Specially-adapted for organizations […] that work with people in Africa, Asia, and Latin America. Human-Centred Design (HCD) will help you hear people's needs in new ways, create innovative solutions to meet these needs, and deliver solutions with financial sustainability in mind. (ibid.)

The recognition of the potential of design thinking to create transformational change in communities is common to both Manzini's and IDEO's models. However, IDEO's model is focussed on design as problem solving and is framed as an extension of their corporate design-thinking approach. They draw on a range of methods, including those used to develop new design solutions for companies and organisations, for the development of guidelines and methods for corporations wanting to engage with global social issues. This is a design strategy concerned with problem solving that uses design methodologies and the language of collaborative design 'to tap into a deep reservoir of opportunity' (http://www.ideo.com/thinking/approach). Methods proposed include observation, prototyping, building and storytelling. Manzini's model is proposed as a basis for design research, rather than for design problem-solving. While social innovation seems to foreground both approaches, the IDEO/human-centred approach is oriented towards general guidelines for design practice for social development while the Manzini sustainable social-innovation approach is focussed towards research for developing greater knowledge about and strategies for sustainability.[68]

There is little immediate correlation between Manzini's model for design research and the approach taken in the mnemotechne project. Manzini's focus on social and institutional innovation seeks to set a new agenda for research to be realised through particular areas or subjects of inquiry, processes and outputs with a sustainable focus. This thesis inquiry is concerned with interpretation, the investigation of theories and their contexts and relationships in terms of past and current approaches to design research. While this research has a broader aim, to assist design researchers' understanding and engagement

[68] Consideration was also given, during the theory selection process, to the writings of Tony Fry, who is among the most radical design theorists engaged with sustainable design. (See Appendix One). Fry's arguments are rooted in philosophical discourse. Much of his writing is concerned with rethinking the ontological limitations of industrial and post-industrial conceptions of design, rather than focussing on design research. The abstract and deconstructive approach in his work made it difficult to map using the methodology developed in this thesis project. While Fry's ideas are recognised as an important part of the corpus of design theory, any mapping and relating of his ideas to other design research theories presented significant challenges, due to the discursive nature and form of his critique.

with the complex field of design research methodology, the reconceptualisation of forms of knowledge and the representation of complex systems are not recognised by Manzini as forms of research for social innovation, although an argument could be made that such engagement is critical to rethinking and refocussing design towards sustainability through research.

Institutional Contexts

Many models of design have been based on research into particular cases or processes of designing that have then been proposed as general or universal frameworks (Dorst, 2007). Similarly, theories of design research based on the particular interests or experiences of design research of an author are sometimes proposed as general theories without recognising the contextual location and specificity of an author's approach in terms of personal-, institutional- or domain-specific agendas. Very few of the design-research theory texts reviewed for analysis in this project articulate research frameworks in relation to specific institutional agendas. While there are numerous papers presented at design conferences about research programmes in design schools, they generally tend to focus on description of curricula or examples of successful projects, rather than discussing underlying research philosophies and approaches. In contrast, Poggenpohl (2000) has written about the faculty research agenda at the Chicago Institute of Design.[69] She describes this as an approach concerned with internal rather than external perspectives on design: 'Long known as a school with a substantial interest in methods, the focus on theory, method and tools – in contrast to other possibilities such as design science, or history and criticism (as external perspectives on design) – reflects the nature of departmental and faculty interests' (2000, p. 144). This model engages with a specific context rather than a general framework for research.

Poggenpohl defines research as the social construction of knowledge through analytic action, theory and purposeful action. She identifies analytic action theory with the approach taken by the German philosopher Jurgen Habermas, who recognised the limitation of models focussed on actions by individual actors. She writes: 'Recognising that analytic action theory is helpful to clarify the structures of purposeful activity, Habermas extends the theory to include actor-world relations important to the social negation of meaningful action'

[69] Sharon Poggenpohl has taught at the Rhode Island School of Design, Illinois Institute of Technology (IIT), and Hong Kong Polytechnic University. She is also the editor and publisher of the interdisciplinary journal *Visual Language*.

(Poggenpohl, 2000, p. 150). Poggenpohl outlines an approach based on a research agenda with five domains of interest, plotted against three research foci. The domains correspond to thematic areas and include users and contexts, the language of media and communication, interactive systems, strategic design and design systems. The research foci are identified as theory, method and tools.

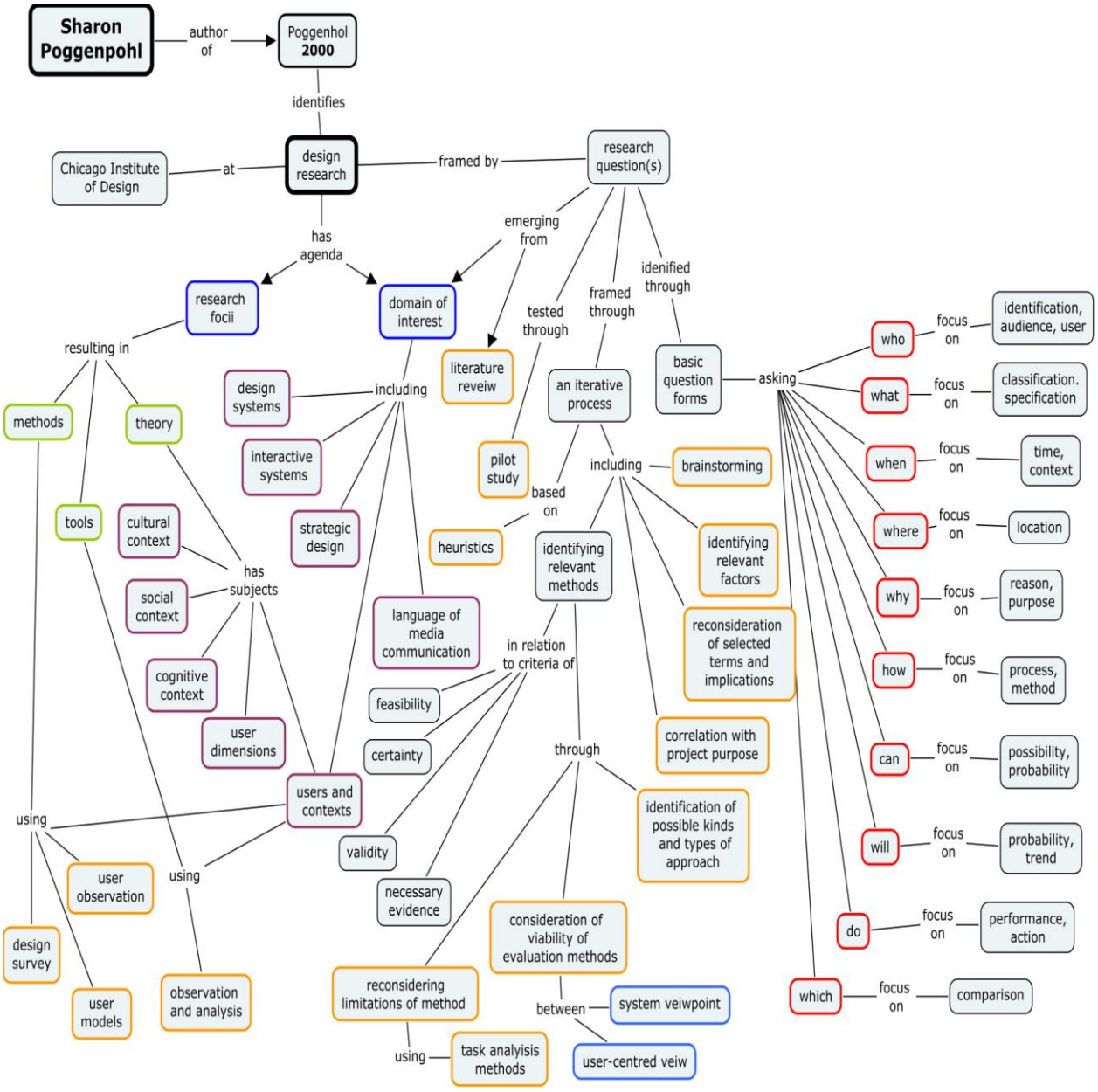

Figure 24: C Map outline based on theory by Poggenpohl (2000)

Poggenpohl defines theory as 'abstract principals that explain a set of facts in relation to one another' (p. 145). She describes method as systematic procedures, techniques or modes of inquiry, and tools as instruments that assist in the performance of an operation (ibid.). Theory, method and tools, she suggests, are interrelated, and can vary by standing in either weak or strong relationships to one another.

Another distinctive issue recognised in this model is the framing of research questions. Poggenpohl identifies ten question types that are related to areas of focus and methodological approaches (p. 147). This focus on question formulation can also be considered in relation to Järvinen's (2000) identification of generic research questions in relation to particular methodological approaches (see Chapter Four). Poggenpohl's approach is more generalised, in that she links interrogative terms such as who, what, where, when and why with types of research subject or activity. For example 'what' focuses on classification and identification, while the term 'when' indicates time, sequence and context. While she goes on to identify generic research strategies, such as qualitative, quantitative and comparative approaches, and associates them with the ten research activities and questions, these are not claimed as exclusive relationships.[70] Quantitative strategies are associated with eight types of research activities, while some activities are associated with more than one strategy: For example possibility/probability, which she links to the question 'can?', could use either a comparative or a qualitative approach. Poggenpohl's model is concerned with research about and through designing, and the investigation and development of theories, tools and methods related to designing. In contrast, the mnemotechne project engages with a relational analysis of design research theories and is research for and about design, in the broader sense of design as a discipline. However, Poggenpohl's consideration of types of design research questions, which engage with a broader conceptualisation of design research beyond the institutional specifications of the first part of her theory, extends a notion of question types and research typologies.

Meta-theories

Poggenphohl's highly contextualised model can be contrasted with the approach taken by Terrence Love in the development of his proposed 'meta-

[70] To assist legibility this level of detail is not represented in the C map of Poggenpohl's theory reproduced in this chapter, but is included in a fuller C Map in Appendix Four.

theoretical structure for design theory', which was articulated in various forms through a number of papers published between 2000 and 2002 (see Figure 25). With a background in engineering design, Love calls for a means of 'structuring existing concepts and theories to bound the unnecessary growth in abstractions and terminology so that it is clearer to design researchers which concepts, theories and theoretical strands are pragmatically more useful or better justified and what their relationships are to each other' (2000a, p. 299).[71] He proposes a meta-theoretical method as a way of simplifying and assisting this process. A meta-theory, in this context, is understood as an over-arching or unifying theory. Thus Love's model is based on a design science approach. Some consideration was given to including this analysis of Love's theories in Chapter Four in relation to other design science approaches. However, Love recognises that the decline of positivism has seen a shift in the focus of design research away from the 'object of design and the theory used to represent it' (Love 1998, cited in Love, 2000b, unpaged) to include a wider 'scope of epistemological explanation' (Love, 2000b, unpaged). It is this intention to engage with the broader epistemological understandings of design that led to placing the analysis of Love's theory in this chapter alongside other models that attempt to articulate the broader field of design research.

Love identifies the researcher and the sociological, historical and theoretical context of the research as part of design's expanded framework. He recognises a move beyond objective studies of the process of designing artefacts and associated theory generation. Love has based his meta-theoretical structure on a framework developed by the post-positivist philosopher of science Karl Popper. Popper's ontological framework was built on a concept of 'three worlds' (1976) – the world of physical and material objects, the subjective world containing the mind and its contents, and the objective world of theories, knowledge and problems. Love's meta-theory of design theory abstractions breaks this framework into four categories, which encompass a span 'from the most primitive forms of knowledge formulation, the naming of experiences, artefacts, objects, situation, etc., to the most sophisticated, reflective philosophical aspects of human understanding and knowledge' (2001, p. 4).

Three of these categories are further divided into subcategories, which are described in various ways across Love's various papers, but which, for this thesis analysis, have been recognised as subjects or themes, in keeping with Love's paper 'Theoretical Perspectives, Design Research and the PhD Thesis' (2000b). These categories also have some correspondence to the tripartite

[71] Terrence Love is a research fellow at Curtin University in Perth, West Australia.

schema of approaches or 'sub-disciplines' of design proposed by Archer (1981) and by Cross (2006), previously discussed in Chapter Four.

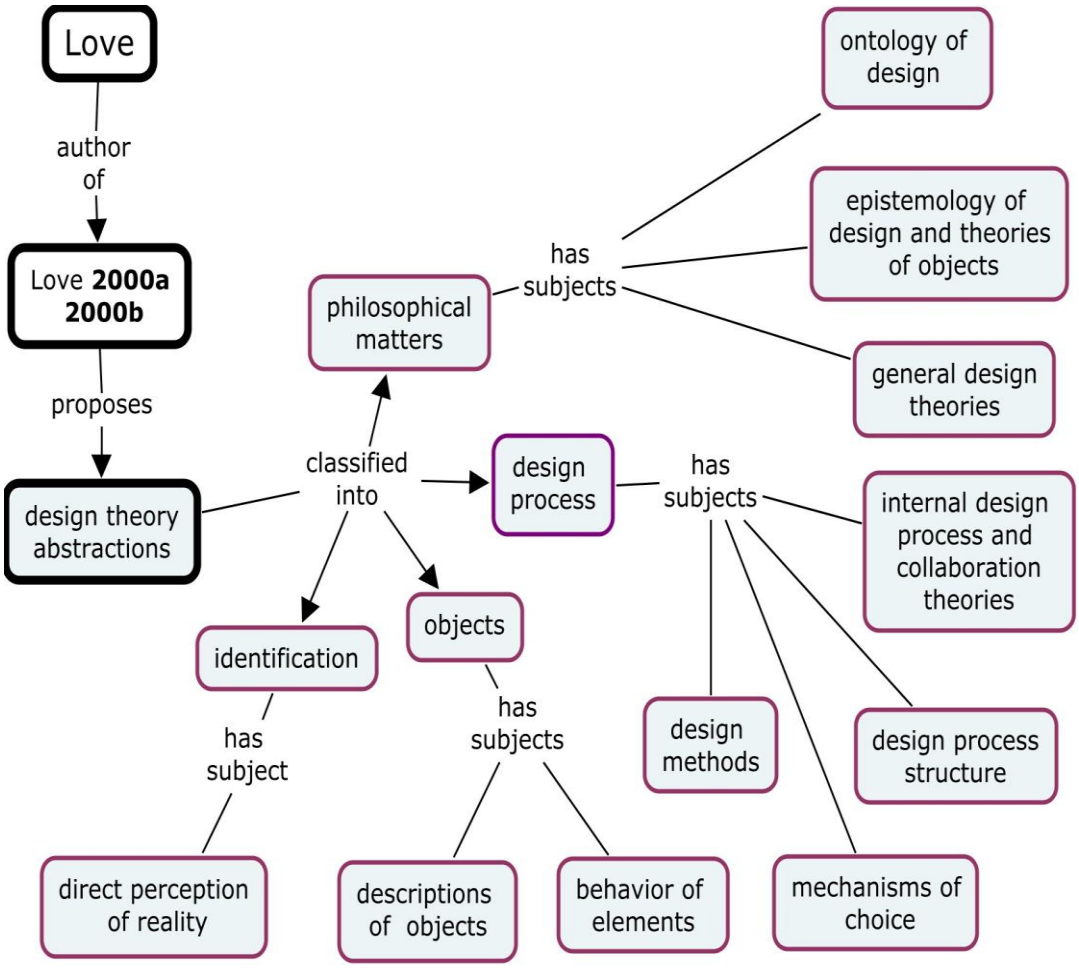

Figure 25: C Map outline based on theory by Love (2000a, 2000b)

Neither Archer nor Cross claim any basis for their earlier models in the work of Popper; however, there are clearly areas of conceptual overlap between Love's model and their earlier models of design research, although the terminology is not exactly the same. While Love does not discuss Cross's taxonomy, he does cite Cross in two of his papers (Love, 2000a; 2000b). However, while there are conceptual similarities evident in a comparison of these theories, the purpose and approaches behind the development of these particular models are different.

Both Cross and Archer attempt to articulate the field of design research from their own particular perspectives and experience. While Love claims his is a 'human-based position on design theory' and acknowledges that 'the scientific

viewpoint is but one paradigmatic perspective in which theorising about design might occur' (2000a, p. 294), his approach echoes the aim of design science to develop a systematic approach leading to a 'unified body of knowledge and theory' (2002, p. 345). He suggests that the value of his meta-theoretical analysis is that 'it provides a means to analyse, relate, position and validate concepts and theories that are in and from different theories and theoretical stances' (p. 302), an aim that might seem, in part at least, to have some similarities to this mnemotechne project.

Love's meta-theoretical categories	**Subcategories (Love)**	**Archer's sub-disciplines of design**	**Cross's Design research approaches**
Identification		Design phenomenology	Phenomenology
Objects	Description of objects		
	Behaviour of elements		
Design process	Mechanisms of choice	Design praxiology	Praxiology
	Design methods		
	Design process structure		
	Process and collaboration theories		
Philosophical matters	General theories of design	Design philosophy	
	Epistemology of design		Epistemology
	Ontology of design		

Table 6: Table showing categories from Love's meta-theoretical structure for design in relation to Archer's and Cross's models

However, Love makes a number of particular claims for his meta-theoretical framework that indicate a very different philosophical approach, which aims to develop a universal system that can be applied in all sorts of ways. For example, he proposes that the structure he has developed can be used to analyse and categorise different approaches to design (2000a). He 'decomposes' a model of 'design as information processing' (p. 308) and another of 'design as creative process' (pp. 310–11), and suggests that the method used will 'improve conceptual and linguistic clarity by decomposing differing design theories and concepts into their relevant contributions at each of the different levels of abstraction' (2000a, p. 308). While Love's reductive approach to organising different 'metaphors of design' (p. 311) provides a systematic structure to enable

comparisons between different approaches, it does not allow for the articulation of difference and results in a system that standardises terminology and thought.

Love has extended the scope and proposed application of this meta-theoretical hierarchy further, suggesting that it can be used as 'a foundation for knowledge management tools' (2001) and as a way of informing the construction of 'a coherent cross-disciplinary body of theory about designing and designs' (2002, p. 345). That is, he proposes it could be used as an ontology or a universal system of classification of design knowledge.

Another application is nominated by Love in relation to design research; he suggests it can be used as a set of nine epistemologically different sub-sets of theoretical subjects for design research (2000b, p. 3). He notes that subjects of design research at each level of the taxonomy 'may have a wide range of physical or object characteristics, regardless of their similarity of attributes as theoretical abstractions. In research terms, this means that a large number of research ontologies, epistemologies and methodologies may be associated with each level' (ibid., p. 4). For this thesis analysis Love's theory has been modelled as taxonomy of design research themes or subject areas. This thematic approach was seen as being a more feasible theory to model than some of the other claims Love makes in other texts detailing his purportedly unified 'meta-theory'. While research subjects or themes are identified in a number of design research theories by other authors, it is not possible to correlate them fully to Love's meta-theory. An example is given of a comparison of Love's general categories of design research subjects with Poggenpohl's thematic schema, undertaken as a way of testing the generalisability of Love's categories. Italicised statements from the Poggenpohl model indicate thematic areas which cannot be correlated with Love's theory.

Poggenpohl's 'internal' perspective identifies a specific institutional context and research focus. She states that 'external perspectives on design' are not part of her research agenda, and specifically excludes research approaches such as design science or design history and criticism. This particular focus is evident in the way the categories she identifies map to Love's meta-theory across the areas of 'objects' and 'design processes' while they don't relate to Love's lower- and upper-level categories of 'identification' and 'philosophical matters'. While some of Poggenpohl's 'domains of interest' can be mapped to Love's meta-theory, correlation with the category 'language of media and communication' is less certain because this category is based on notions of reception and

interpretation, rather than use.[72] Her focus is on communication rather than function. While this may reflect the different backgrounds and professional contexts of Poggenphol (communication design) and Love (engineering design), it also illustrates some of the problems in trying to develop a meta-theoretical hierarchy for design that is based on broader, external frameworks and purports to universality in being able to represent all design approaches.

Poggenpohl also identifies 'theory' as one of three research foci. It is difficult to try and map Poggenpohl's specified theoretical categories, developed in relation to research about users and contexts, to Love's taxonomy. Her emphasis on context – be it cognitively, socially or culturally oriented – maps across a range of Love's meta-theoretical categories, rather than directly to a single category. While Love notes the limitations of the 'positivist emphasis on the research object and its associated theory' (2000b, p. 1), and the expansion of design research to include issues/areas of identification, the design process and philosophical matters, this particular version of his meta-theoretical hierarchy seems to overlook the significance of context across different levels of the taxonomy. This is a fundamental problem for any ontological schema in a situated activity like design.[73] 'Situatedness' is a term that recognises the environmental context, the knowledge and experiences of the designer and the interactions between the designer and the environment during the design process (Gero, 2004). The recognition of the particularity of each design situation and each designer's level of knowledge and experience emerged in response to criticisms of early AI in Design approaches that sought computerised solutions through universal design problem-solving methods. While generalisable methods are fundamental to scientific practices, where repeatability is an important way of validating results, they are less relevant to most areas of design, where the validity of a design is related to the quality of what it does or the way it can be used or what it means within a particular context, or where the value of a design is seen as its variability, originality or innovation, rather than its repeatability.

[72] A distinction between reception and interpretation is made here to acknowledge different theories of media communication, such as reception theory, that acknowledge the experiences and location of specific viewers in the material world and how those viewers have actually read and understood media texts, distinct from classical theories of spectatorship that tend to generalise an audience so the spectator is both historicised and idealised.(Wagner, Reception Theory, Film Reference Website: http://www.filmreference.com/encyclopedia/Independent-Film-Road-Movies/Reception-Theory-RECEPTION-STUDIES-AND-CLASSICALFILM-THEORY.html, unpaged).

[73] Upper-level categories in computational ontologies are the top layers in a classification schema that identifies the main groups and sub-groups of a categorisation.

Love Upper level	**Love** Levels of knowledge formulation	**Poggenpohl** Domains of interest	**Poggenpohl** Theories of users and contexts
Identification	Conception and labelling of reality		
Objects	Behaviour of elements	Language of media and communication	Cognitive context Social context Cultural context
	Mechanisms of choice	Users and contexts language of media and communication	User dimensions Cognitive context Social context Cultural context Use
Design process	Methods and techniques to support designers	Design systems language of media and communication	User dimensions Cognitive context Social context Cultural context Use
	Design processes	Strategic design	User dimensions Cognitive context Social context Cultural context
		Design systems	User dimensions Cognitive context Social context Cultural context
Philosophical matters	General theories of designing and knowledge management		
	Epistemological perspectives (knowledge theories and management)		
	Ontological issues (theories of knowledge, knowledge management and designing)		

Table 7: Table comparing Love's general taxonomy of theoretical subjects for design research with Poggenpohl's highly specified theoretical areas of research about users and contexts

Anatomies

Kees Dorst (2008) outlines what he describes as an anatomy of design research, identifying the 'object of our studies' – that is, the focus of design research – as understanding the design activity itself.[74]

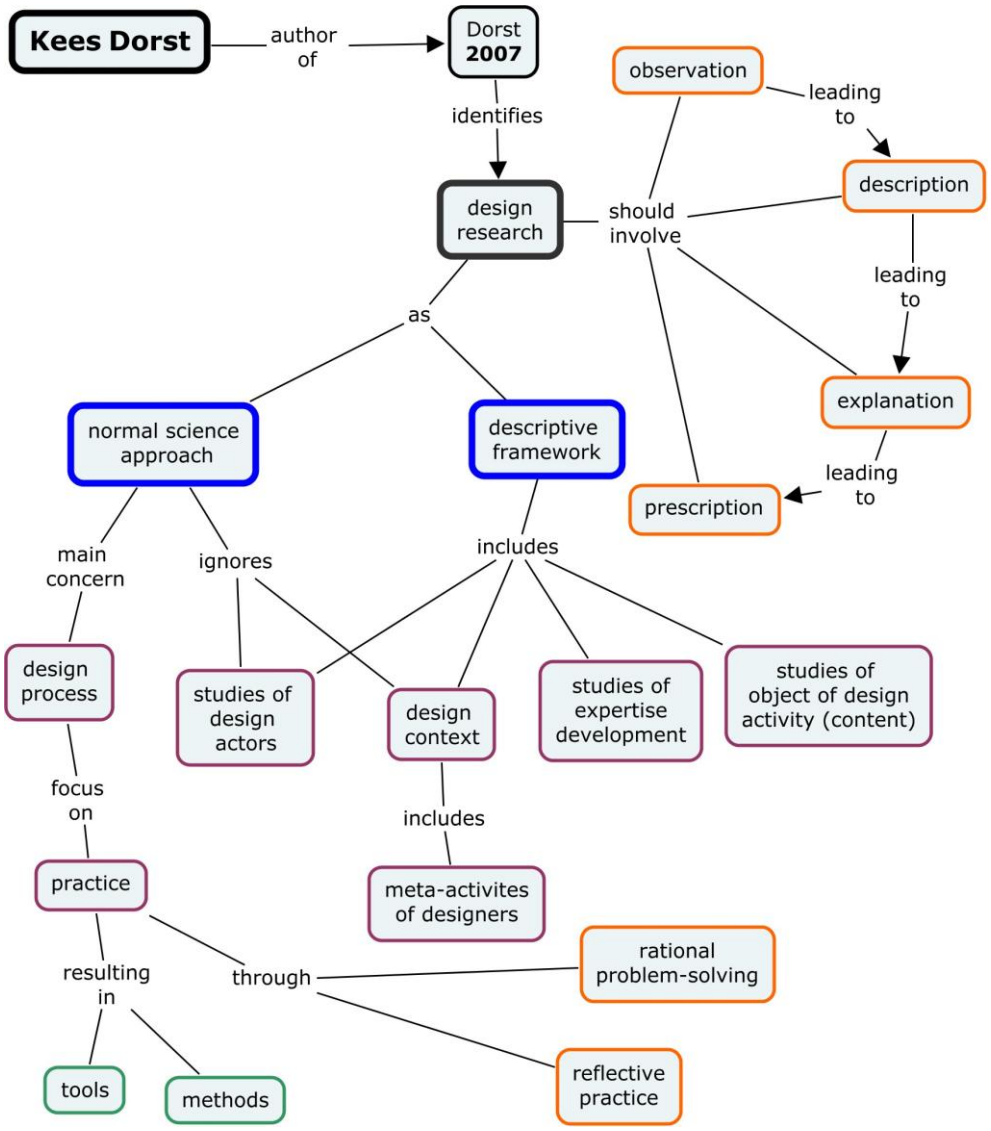

Figure 26: C Map outline based on theory by Dorst, (2008)

Dorst proposes a 'descriptive framework', identifying four key areas: the object or content of design activity (as design problem and emerging solution); the actor, or designer, design team or company; the context in which the activity

[74] Kees Dorst is Professor of Design at the Faculty of Design, Architecture and Building at the University of Technology, Sydney, and senior researcher at the Department of Industrial Design at Eindhoven University of Technology (Netherlands). He is the author of four books and many papers on design and design research.

takes place; and the design process (as 'the structure and dynamics of activities that is being studied' (Dorst, 2008, p. 2).

Dorst's 'anatomy' describes areas of design research in relation to design activity. In considering Dorst's categories in relation to Love's framework it is possible to make some correlation between Dorst's areas and Love's top-level categories. This is in the area of design methods. However, it is difficult to systematically place Dorst's other categories in relation to Love's more detailed schema. Dorst recognises that the main focus in the development of design research over the past forty years has been on the design process. He criticises the claims made for the need and effectiveness of such formalised processes: 'the design methods and tools that are being developed inevitably focus on enhancing the efficiency and effectiveness of design processes […] this total ignoring of the design content, the designer and the design context allows us to claim that we are constructing models, methods and tools that will be valid for every designer, dealing with every kind of design problem, in any situation' (p. 2). The closest correlation between Dorst's and Love's respective schemas occurs in this area of design process, including 'theories and practices of collaboration' as a sub-field of design process. Dorst regards the issue of people as 'designing human beings' as a distinct and significant area of investigation that he suggests should be recognised beyond general theories of design process or notions of collaboration as a design method.

Dorst, like Poggenpohl, recognises the importance of context as the particular conditions that frame any situation in which design is being conducted. This also seems to map across, rather than directly to, Love's meta-theoretical hierarchy. Dorst's positioning of design research to support the understanding of design activity is proposed as a challenge to design-science approaches that focus on observing and generalising design processes, resulting in abstract theories and models of designing. Dorst writes:

> The art of design is to deal with these other aspects of the design activity, the ones that the process model so conveniently ignores […]. That is the price one pays for 'bracketing' elements of the design activity. Putting things between brackets (and ignoring them for a while) is all very well if you just want to create and abstract a theory or model, but when you then try to apply this theory or model all the elements of the design activity you have 'bracketed' come back to haunt you. (2008, p. 2)

Dorst introduces a notion of the 'art of design' as a way of contrasting the experience-based, tacit, professional practice of design with the sort of process-based approaches (design methods) that have been produced through research and proposed as general models of designing. Dorst suggests that although such models are sometimes taught in design schools they are rarely followed by designers in the field. Thus other aspects of design activity remaining outside the process model are still part of a mysterious and unarticulated art. Dorst recognises that these approaches cannot be generalised. In contrast to Scrivener (2000), Dorst considers both 'rational problem solving' – as a goal-oriented problem-solving process – and 'reflective practice' – as a process of learning – to be prescriptive process-oriented approaches that have come to dominate the design research agenda. He wants research to focus more on the 'why of design activity', to provide broader explanatory frameworks for design activity as a whole (p. 3). It is important here to distinguish this call for explanation from tendencies towards generalisation. This issue can be related more closely to Coyne and Snodgrass's sense of design research as leading to understanding rather than formalised, scientific forms of knowledge.

In a later version of this theory, Love (2002) does acknowledge an aspect of disciplinary context in proposing a revised meta-theoretical hierarchy as a way of structuring 'a unified body of knowledge and theory about design and designing' (p. 345). Love's notion of the 'behaviour of contexts' is formulated to help identify 'the relationships between theories about designing and designs and theories of other disciplines' (p. 349) with the areas of 'environmental studies, Geography, History, Physics, Social Psychology, Sociology, Management, business studies and systems' recognised as 'disciplines that address this area of theory' (p. 350). Here, Love's approach to the 'behaviour of contexts' is located in relation to other disciplinary perspectives based on the natural and human sciences.

Love acknowledges that there are cultural factors and prior theories in specific areas that influence and limit the development of cross-disciplinary design theories. However, his analysis and model is based on a reductive approach that demands fixed definition of core concepts (2002, pp.353–56) and the separation of design from other activities (pp.357–59). Krippendorff (2006) has been one among a number of design theorists who have criticised such attempts to standardise definitions of design terms, recognising the dynamic value of language and its adaptation by different groups and cultures. Love is also concerned about other design areas that lack definition. He criticizes the 'indeterminate epistemological foundations' of a discipline in which 'all and

every activity is design' (p. 358). He suggests that the fuzziness of the use of the terms design also contributes to the indeterminacy of core concepts in the field. However, his approach to differentiating between designing and associated activities 'such as "drawing", "researching" and "thinking"' (p. 357) is to condemn designers who see such activities as 'symbiotically so close to their designing activity they are unwilling or unable to identify them as different' (p. 357), by claiming they lack 'individual skill at reflective practice or subjective contemplation – supported by linguistic traditions' (p. 358). The difficulty here is Love's assumption that there must be a single approach to drawing or thinking or researching. For example, a graphic designer who sketches a landscape as a way of collecting visual information, a draftsman producing an architectural plan and a designer thinking into and developing an emerging concept through sketching are three, among many, very different approaches to drawing. While the graphic designer is collecting information, which could be seen as research or documentation, and the draftsman might be seen to be using drawing to present a design or plan, the processes are more complex, involving processes of selection and interpretation, technique and evaluation. In the instance of concept development through sketching, drawing is an integral part of a methodology that is both generative and critical, and that leads to 'the production of a design' (p. 357).

Love's work in this area has been difficult to understand and correlate with other models of design research. While he recognises and clearly articulates many of the problems and limitations arising from the heterogeneity of the field of design, his response has been to develop a meta-theory based on a post-positivist but scientific framework, in terms of which he proposes different design theories and research approaches can be categorised and understood. His approach shifts from recognising a number of important issues in terms of the problematic of design and its multiple identities to proposing an overarching and generalised meta-theoretical schema. Attempts to correlate other design research theories analysed in this project to Love's schema were only partially successful. This was due, in part, to the ambiguity around Love's categorisations, as he reinterprets these categories for a range for different purposes, from a universal schema to structure design theory (2000a) to a way of identifying subjects of design research (2000b) to a way of conceptualising theoretical perspectives for PhD students (2000c) and as a way of categorising design knowledge (2001) and constructing a coherent cross-disciplinary body of theory about designing and design (2002). The potential of this formal and reductive approach to adequately represent different theoretical perspectives concerning design research is limited. Nelson and Stolterman (2003) have

recognised that reductionist approaches tend to identify differing frames of reference for the same complex thing as paradoxical and dualistic:

> According to this approach the right way to think is to stay within one frame of reference and act as if the image is a true undifferentiated form. This is the accepted approach even when the truth of the image is more complex and comprehensive. (p. 93)

Another reductionist tendency, they suggest, is to deal only with pure systems designed solely from within one frame of reference and from one perspective. Nelson and Stolterman (2003) describe this as scientific systems theory. This approach rejects 'the need for concepts such a frames of reference and perspective in their inventory of acceptable systems concepts' (p. 93). It also dismisses the possibility of multiple, paradoxical images generated from a singular form. Nelson and Stolterman liken this approach to systems science, which aspires to a distilled worldview, in contrast to systems thinking, which they recognise as engaging with compound worldview. Nelson and Stolterman's criticisms of systems science are pertinent to and would seem to best locate the limitations of Love's approach.

The relationship of design and its development as a discipline to other disciplinary areas has been critical to its evolving identity. In Chapter Four a number of theories that drew from other disciplinary frameworks that informed and influenced different perspectives and practices of design research were discussed. In this chapter, Love's model was not framed in terms of relationships with research approaches from other disciplines, but in terms of an underlying epistemological framework that drew from scientific perspectives.

Philosophical Orientations

Two theories of design inquiry that are underpinned by concepts drawn from philosophical traditions and classical epistemologies of knowledge have also been considered in this chapter. These theories were not included in Chapter Four as they are theories that attempt to map the field of design research and draw from philosophical thinking to explore and reconceptualise ways that design research can be understood. These philosophically informed theories do not use other disciplinary methodologies and frameworks to classify design research, but draw from and extend frameworks that underpin Western thought, considering them in relation to the forms and practices of design and

its research. The theories are presented in texts by Nelson and Stolterman (2003) and Buchanan (2005, 2007). These authors have not proposed these models as formal ontologies nor claimed their models of design research as meta-theories, although, strictly speaking, like a number of other theories analysed in this thesis, they are meta-theoretical in that they are theories about design theory. Both Buchanan, and Nelson and Stolterman, draw from frameworks of knowledge based in ancient Greek philosophy, which have been rethought and adapted to the field of design research. They aren't proposing design research through an adaptation of philosophical methodologies in the way that Seamon has proposed using phenomenological approaches, but they articulate the field of design and its research in relation to older and deeper ontological orientations in Western thinking. This approach recognises the problematic and historicity of design's dual knowledge thesis and its basis in positivist notions of subject and object. In returning to earlier philosophical frameworks that pre-date modernity and the separations that took place in the development of science prior to its appropriation in design, these authors are able to draw from conceptualisations that suggest more complex understandings of being in the world and different understandings of methodological approaches for developing design knowledge.

In two essays (2006, 2007) Richard Buchanan discusses three 'strategies of inquiry' that emerged in the twentieth century and continue to evolve and influence the field of design research.[75] He describes them as 'strategies' in that they offer broad perspectives on design, products and other relevant areas of human inquiry. He emphasises that connections, rather than what is connected, signify a strategy (2007, p. 59). Inquiry, Buchanan suggests, becomes more tactical as these connections are explored in research. His model has three main categories: dialectic, design inquiry and design science. Dialectic is described by Buchanan as the explanation of design and the products of design within a larger whole or system, emphasising the social and cultural contexts of design. According to his theory, dialectic has three distinct forms: idealist dialectic, materialist dialectic and skeptical dialectic. Design science, in Buchanan's model, attempts to explain design and its products by trying to identify the 'basic elements or mechanisms that underlie the complexities of the material world and the workings of the mind' (2007, p. 57). Buchanan's third strategy –

[75] Richard Buchanan is Professor of Information Systems at the Weatherhead School of Management at Case Western Reserve University in Cleveland, Ohio. He was previously Professor of Design and Director of Doctoral Studies at Carnegie Mellon's School of Design. He was founder of the journal *Design Issues* (with Victor Margolin) and has emerged as a leading figure in the development of design discourse internationally. He received his PhD, in philosophy, from the University of Chicago.

design inquiry – is concerned with the understanding of design through the exploration of the human experience of designers or those who use products. Within this category Buchanan identifies two distinct lines of investigation: productive science or poetics, as the discipline of making within the framework of products and their use, and rhetorical inquiry, which he defines as focusing on the imagination and communicative power of the designer.

Buchanan's model draws from Aristotle's categorisations of philosophical approach, dialectic, logic and rhetoric, and Aristotle's five categories of knowing or 'virtues of rational thought', identified by Aristotle in Book V1 of the *Nichomadian Ethics*. These included *episteme*, or knowledge that is based on certainty through disinterested understanding; *techne* or the method or process of making; *phronesis* or practical wisdom – that is, the ability to consider action with a view to effect change; *sophia* or wisdom; and *nous*, which is intellect or perception (Meyer, 2009). Aristotle also distinguished between making something (*poesis*) and acting, agency (*praxis)* – concepts that can also have relevance to Buchanan's model.

In relation to Buchanan's three strategic approaches, design science is clearly linked to logic and *episteme*, as knowledge based on disinterested understanding through observation, objective analysis and a synthesis of elements. His notion of dialectic in design is concerned with explaining design within its social and cultural contexts. Aristotle saw dialectic as a way of testing probable knowledge through debate, in order to learn. This dialectical approach would appear to be linked to *phronesis* or practical wisdom and *praxis* or agency, in that the outcomes Buchanan identifies with this dialectical strategy are the understanding of value and political knowledge. Productive science or poetics is closely linked to the Aristotelian notion of *poesis* or making something, where the value is the product. The concerns of this approach, identified by Buchanan, are materials, product forms and associated ways of designing, producing and distributing - features that are all associated with material processes. Rhetorical inquiry, focusing on the imagination and communicative power, is the third approach to philosophical inquiry identified by Aristotle. Rhetoric was also seen as a tool for practical debate and was used as a means for persuading an audience using probable knowledge to resolve practical issues.[76] Buchanan identifies practical thinking, argument and persuasion as key methods in rhetorical inquiry in design.

[76] Buchanan has written extensively about design and rhetoric. See Buchanan, 1989, 1995, 2001.

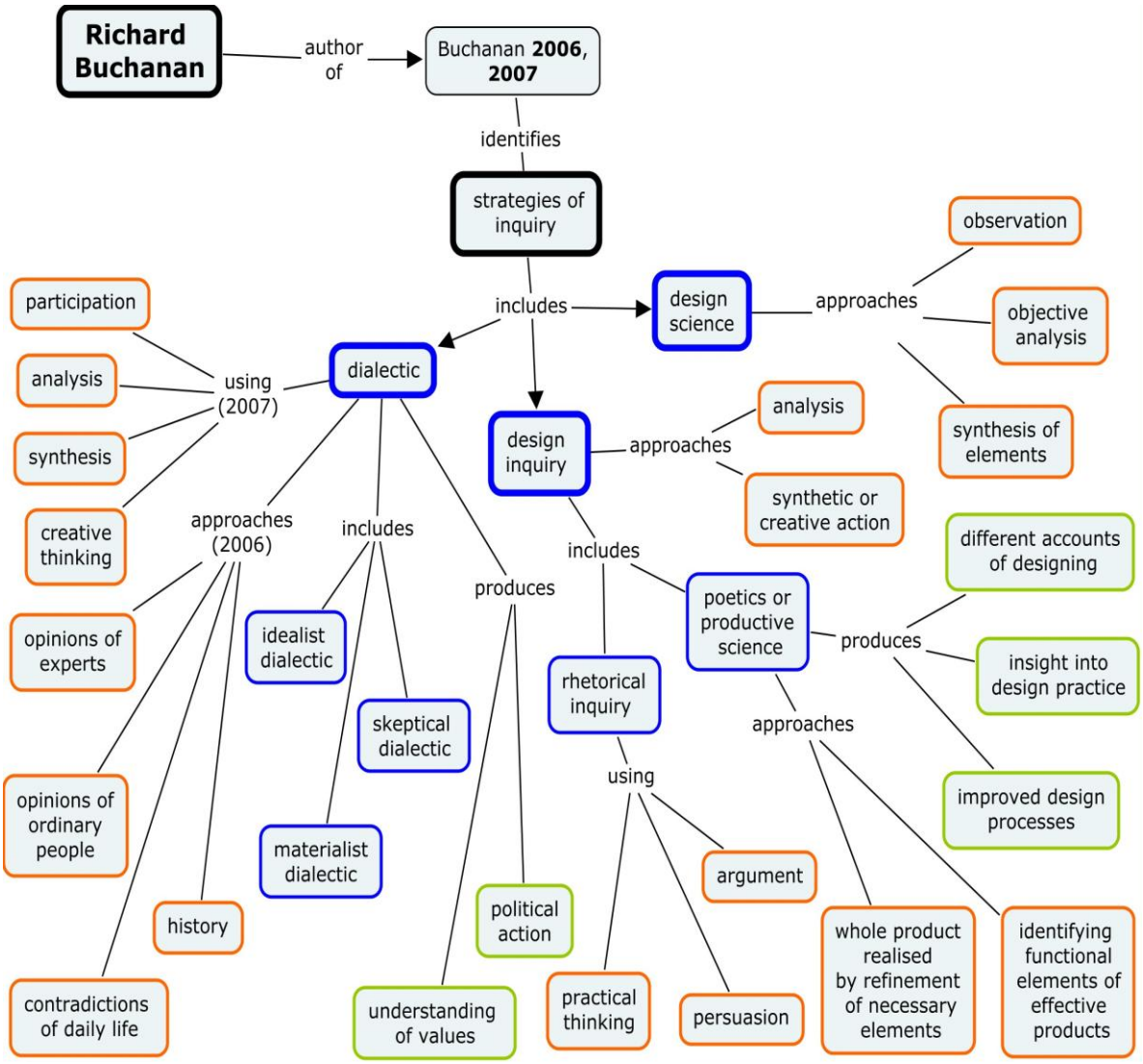

Figure 27: C Map outline based on theory by Buchanan (2006, 2007)

Within these three strategic approaches Buchanan also identifies subjects and areas of concern in design research, and locates these using key references (not included in the schematic C Map outline reproduced in this chapter). While Buchanan's model includes one commonly recognised category – design science – the other two categories are particular to his model and do not map directly to other design research theories analysed in this project.[77] Buchanan's categories begin to establish a broader ontological framework of design research that

[77] While the term 'design inquiry' is also used by Nelson and Stolterman (2003), Buchanan's specific notion of design inquiry as the exploration of human experience, composed of poetics and rhetorical inquiry, is quite different in definition and meaning.

draws from classical knowledge categories, relating them to current design research practices.

Harold Nelson and Eric Stolterman describe their book *The Design Way* (2003) as being about the cultural traditions within which the designer acts.[78] The book is not focussed on design research, per se, but on the culture of 'inquiry and action that infuses design thinking' (p. 2). While their book is not specifically focussed on design research, a number of references have been made to this book in other texts about design research and in related discussion forums. The significance of systems thinking and second-order cybernetics, which inform *The Design Way*, has become more widely recognised as an approach to design research, and is critical for this mnemotechne project. Systems-thinking approaches recognise complexity as a critical and distinctive factor, and value the dynamic interactivity of relationships rather than reductionist approaches that use 'logical dissection as a means of studying the elements, components or qualities of things in isolation from their intact whole' (p. 72). Processual relationships are considered rather than static components. This relational approach is also recognised as being fundamental to the aim and method of this research project.

Nelson and Stolterman (2003) distinguish design action, or designing, from design inquiry or research (see Figure 28). They recognise that each form of inquiry, be it intuitive, artistic, scientific or logical or a composite of these approaches, will lead to a specific body of knowledge: 'The chosen form of inquiry influences both what constitutes knowledge and how knowledge is gained. Each particular approach is based on some fundamental assumptions concerning what it means to create knowledge' (p. 38). Design inquiry, according to Nelson and Stolterman, requires a compound approach, composed of 'true, ideal and real' approaches to gaining knowledge (ibid.). These notions of 'true', 'real' and 'ideal' are drawn from philosophical concepts of reality raised in Plato's theory of forms or ideas and from Aristotle's theory of ethics.

[78] Dr Harold G. Nelson is President and Co-founding Director of the Advanced Design Institute (ADI). He was Nierenberg Chair of Design at Carnegie Mellon University, 2009–10. He works as a consultant to corporations, governmental agencies and educational institutions in the areas of: organisational design competence, leadership development, and social systems design and systems/design education. He is past president of the International Society for Systems Science and is a member of the Design Research Society. Dr Erik Stolterman is Vice President and Director of the Advanced Design Institute (ADI) and is Professor at the School of Informatics, Indiana University, Bloomington, where he is the Director of the Human-Computer Interaction Design Group and program.

The theory of forms was developed by Plato (427–347 BC) in his middle-period dialogues, particularly in *Phaedo*, *Symposium* and *The Republic*. This theory asserts that abstract forms (or ideas), rather than the material world that we know through the senses, are the highest and most fundamental kind of reality. The things that we ordinarily see in the world, according to Plato, are shadows of these ideal forms. As these forms exist outside the physical realm, they are immaterial and unchanging, and, as they are generalised rather than specific, they become universals. Plato proposed that these forms are the only objects of study that can provide genuine knowledge. This rationalist approach is based on the claim that knowledge, as justified true belief, can only be gained by transcending the changeable physical world to access a permanent rational order that recognises the universal in the particular. 'Knowing, then, is an act of making the observable world intelligible by showing how it is related to an eternal order of intelligible truths' (Silverman, 2003, unpaged).

In philosophical ethics, a virtue is a state of a character. Aristotle recognised two types of virtue: intellectual virtues that pertain to reasoning, or virtues of the mind, and moral virtues that are based on ethical reasoning, or virtues of character. Intellectual virtues are in turn divided into two sorts: those concerned with theoretical reasoning, and those based in practical thinking (Kraut, 2010). Both Plato's theory of forms and Aristotle's theory of ethics inform Nelson and Stolterman's approach, but these theories are not followed in a literal way. Nelson and Stolterman recognise that inquiry using scientific approaches seeks discoveries and truth, moving from specific particulars to the universal through the method of induction. Here induction is a method of reasoning by which a generalisation is formed from a number of instances. Nelson and Stolterman note that something particular can also be deduced from the universal. That is, through deduction general principles can be applied to specific instances. They define science as a process of discerning abstractions that apply across categories and taxonomies of phenomena, in distinction from particulars that are singular and unique (p. 33). They recognise design as a process that moves from the particular, general and universal to 'the ultimate particular' that is a specific design. However, the creation of the ultimate particular or design cannot be based on scientific induction or deduction: 'Cars, houses and social organisations are not regarded as natural artefacts discovered through empirical investigation, but are artificial creations. They are true in the sense that they exist, but not in the way a scientific law is regarded as being true. They are not, deterministically, the only possible house, car or social organisation possible' (pp. 29 and 30). Design, they suggest, engages with the ideal and the real as well as with what is truthful. They identify that 'the true' comes from accurate

descriptions, explanations and empirical observation, and uses abstract reasoning and logic. 'The real' is a result of action taken through judgement and formed by intention (p. 35). Scientific and analytic approaches that are reductive are not designed to deal with 'the real' in any holistic sense: 'design is, by definition, too complex and rich to be fully understood during the process of creation. We cannot predict with any accuracy how any real design will serve the world and in turn how it will change it' (p. 45). The real, Nelson and Stolterman suggest, is a concept that distinguishes design from other traditions of inquiry and action: 'The real must be approached through judgement, augmented by science based tools and methods' (p. 45). They claim there should be symmetry between the real and the true rather than a polarity; that is, the relationship should tend towards unity rather than compromise. The third approach to design inquiry they identify as 'the ideal', which they define as being 'devoted to the realm of norms and values focussed on knowledge about how the world ought to be in respect to some higher order or idealistic system' (p. 380).

The authors suggest that design inquiry is an emergent, compound form of inquiry that is inclusive of these three forms, the true, the real and the ideal: 'When used together the resulting approach to knowledge acquisition is much more synergistic, comprehensive and integrative than the individual approaches taken in summation' (p. 41). This particular model is proposed by Nelson and Stolterman as a dynamic, systems-based approach to be used by those engaged in design inquiry, rather than as a model that presents an overview of different approaches within the field of design research, as the model proposed by Buchanan does. They do recognise that there are different historically based approaches, but propose they should be engaged with synergistically rather than reductively, considering that the many different ways of engaging in inquiry have been 'designed' rather than discovered (p. 35). Recognising that every form of inquiry will influence the resulting body of knowledge, they acknowledge the significance of different design frameworks: 'Each particular approach is based on some fundamental assumptions concerning what it means to create knowledge' (p. 38). For example, they identify consensus, representation, dialectic, progress, mechanism, teleology (purpose) and probability as being based on a rational approach concerned with truth and guided by strict rules on how to go about finding knowledge.

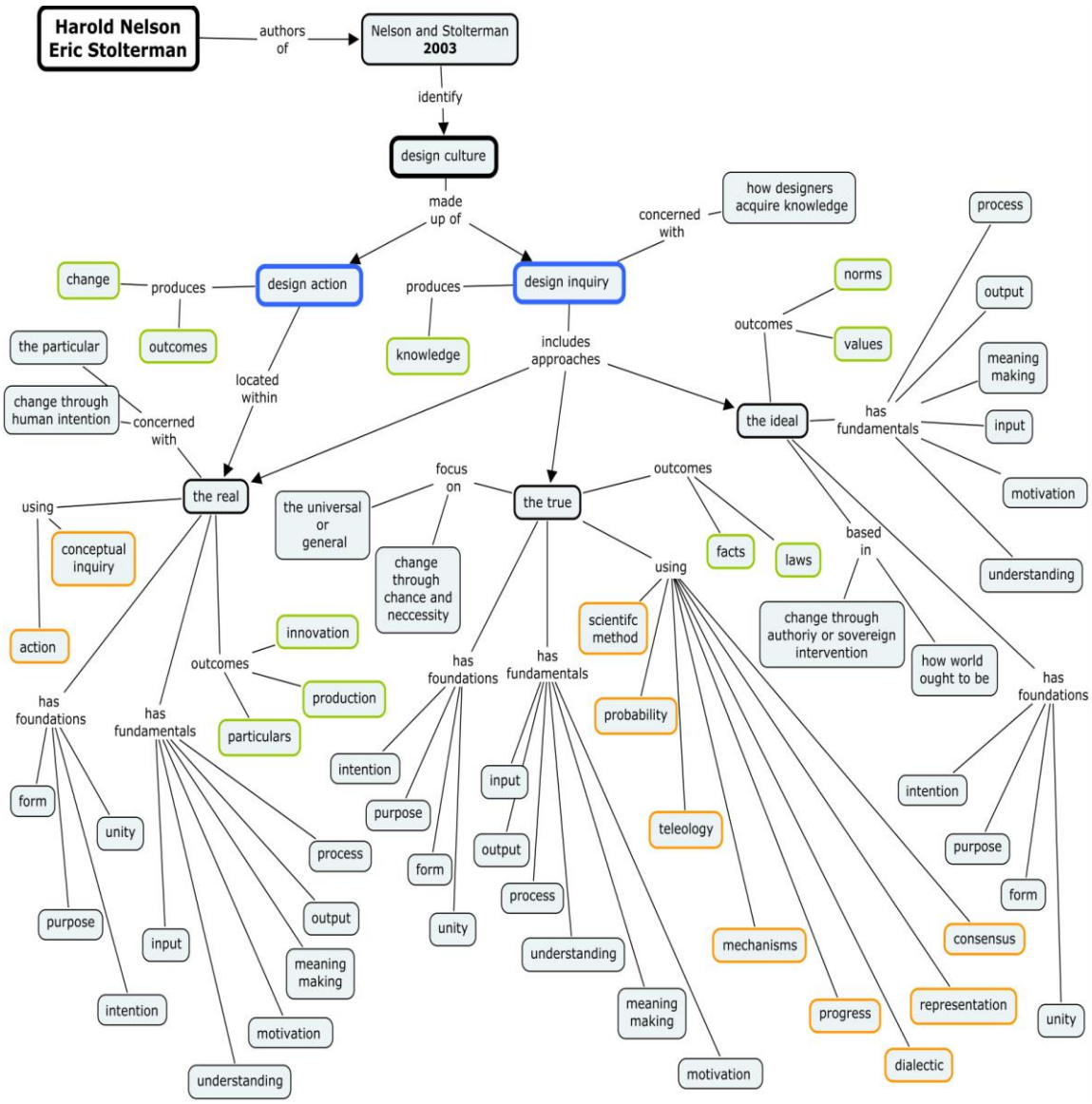

Figure 28: C Map outline based on theory by Nelson and Stolterman (2003)

Nelson and Stolterman also recognise that design has extended beyond the confines of craft tradition and material culture. They propose that design approaches can now be used in complex, unstructured situations that cut across traditional disciplinary boundaries due to the development and maturation of systems thinking (p .71). They differentiate a number of specific systemic processes, focal areas or descriptive dimensions of systems dynamics and types of systems (these concepts are not represented in the C Map above, but are evident in the fuller C Map in Appendix Four). In contrast to a formal approach, such as that taken by Love, they suggest that the categorisation of systems cannot be restricted to a single classifying logic. Determining the category of a

system is dependent on the tradition or traditions of inquiry used to describe or explain that particular system's concepts. They suggest that a system's design 'palette' is used to consider and affect the design of design inquiry. Nelson and Stolterman's systems approach recognises that design can deal with complexity because of its different philosophies, methods and techniques. Recognising that different forms of inquiry lead to different bodies of knowledge, and that design problems do not have singular solutions, they argue that design as an approach must recognise its own strengths in this diversity. Rather than copying science or engineering approaches, they suggest that design needs to develop and recognise its own forms of inquiry, for its own purposes. Based on philosophical concepts about forms of knowing, their model of design inquiry recognises the ideal, the real and the true as fundamental ontological categories of design.

Historically Informed Frameworks

The final text and theory analysed in this chapter is by Wolfgang Jonas (2008a).[79] His model, titled Paradigmatic Clusters in Design Research, has been developed, as a work in progress, from an analysis of design research theories, with a focus on historical epistemic shifts in design research (see Figure 29). It was published as part of a Design Research Network discussion, on 7 March 2008, and the structure of this model was co-developed with members on the discussion list. Some of the analysis that underpins this model is discussed by Jonas in other papers and articles – for example, his interpretation of the Frayling/Archer tripartite model of 'about', 'for' and 'through' design in relation to an analysis done by Alain Findelli (1998), and in another model developed by Jonas (2007), which also takes a systems-thinking approach. In earlier work Jonas engaged with the problem of disciplinary foundations for design, which he described as a 'paradox endeavour', to design a foundation for a groundless field (Jonas, 2000). He has recognised the limitations of models from the formal sciences, the natural sciences and the humanities as models for design, and the confusion of existing design theories, suggesting that design needs tools to help manage this discursive complexity. The sub-structure of Jonas's model is based on an analysis of design research approaches that lead to a category structure that systematically articulates a number of different levels of abstraction – moving from more general paradigmatic groupings to philosophical

[79] Wolfgang Jonas is Professor and Researcher in Design at the University of Kassel, Germany. His background is in naval architecture and he has worked as a consulting engineer for companies in the automobile industry and for the German standardisation institute DIN. His research is in areas of systems theory and design theory.

underpinnings to methods and key references. The headings of these levels include: the name of the cluster (or paradigm), the name of the research programme, underlying theories, basic assumptions, claims, methods, and authors of relevant texts and references.

Frayling/Archer model	Jonas's cluster or paradigm	Research programme
For design	Cognitive processes	Cognitive problem-solving
		Knowledge processing
		Generative processes
	Communicative processes	Rhetorical processes
		Communication processes
	Semiotic processes	Semantic processes
		Semiotic processes
		Language-like processes
		Emotion-creating processes
Through design	Projective processes	Humanistic
		Design-led
	Human-centred processes	Human-centred activity
		Innovation processes
		Interaction processes
	Democratic/social processes	Radical-democratic endeavour
		Socially responsive task
		Critique
	Sustainable processes	Design's endeavour of sustainability
		Evolutionary tasks
About design	Subject matter of research	Philosophical subject matter
		Scientific subject matter

Table 8: Table identifying part of the structure of Jonas's model (2007/2008) in relation to the Frayling/Archer tripartite model of design research

Jonas's model presents a detailed, systematic and temporally nuanced analysis as an overview of the field of design research. It is based on a consideration of historical developments in design research rather than in the framework of an external discipline or from a personal position or an institutional perspective. In this sense it can be described as an empirical model in that it attempts to map past and current approaches to design research. This position allows for the

recognition of design research approaches that have drawn from other disciplines, as well as designerly approaches.

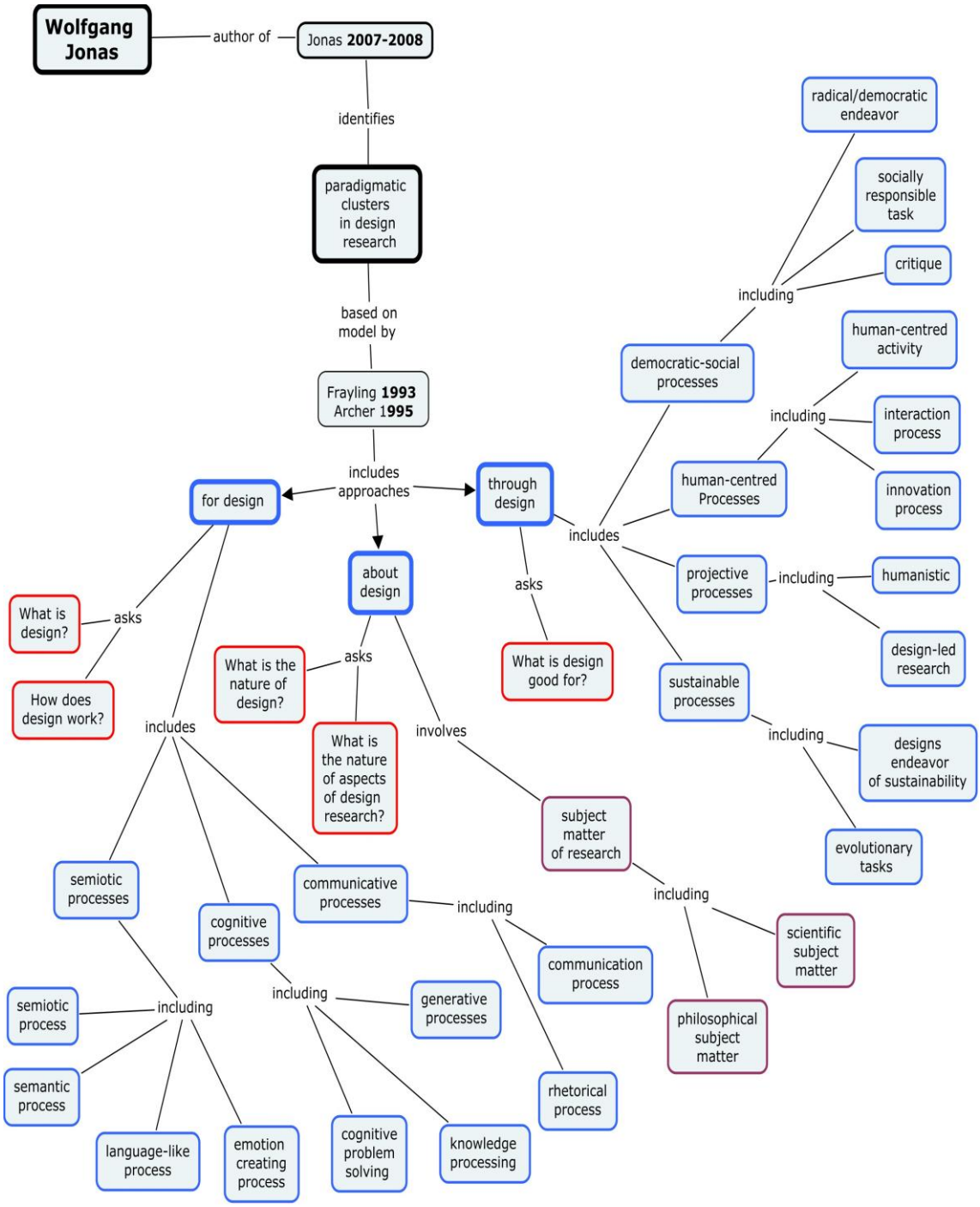

Figure 29: C Map outline based on theory by Jonas (2007-08)

This model recognises the diversity of design inquiry and represents the range of different methodological approaches to design research. Rather than

valorising or criticising a particular approach, he seeks to articulate different 'clusters' so they can better be considered in relation to one another. He does not attempt to exclude or to homogenise theories into a pre-existing ontological framework, but rather represents a range of different approaches, and variations within particular clusters, as an inclusive system.

This approach shifts the discourse away from long-standing oppositions such as art/science, theory/practice or research/profession, to present a pluralistic overview through which many different theoretical and methodological perspectives can be compared and related. The significance of the originary Frayling/Archer model to Jonas's theory is that it represents three fundamentally different ways of conceptualising and performing design research that can be associated with analytical, strategic and thematic approaches. These three approaches provide the basis for a model that recognises different types of design research at different levels of abstraction drawn from an analysis of research activities across the discipline rather than according to external frameworks.

Critically, Jonas's approach is also underpinned by second-order cybernetics, in recognising the temporal and conceptual shifts and relationships between different ways of conceptualising design research and its various methodological practices and related bodies of knowledge. Jonas's model is among the most comprehensive models of design research identified in this analysis of design research theories.[80] This comprehensiveness lies in its inclusivity, its basis in the study of design's research history and its ongoing developments. It presents a theory drawn from an analysis of research and thinking in the field, rather than through a priori frameworks or personal experience. Above all, it is an approach that recognises a history of design inquiry that is dynamic and continues to evolve.

Conclusion

The analysis and discussion of design research theories in Chapters Four and Five identifies a number of different research frameworks, the approaches taken in developing these models and some of the assumptions that lie behind particular strategies. Some broader historical tendencies and developments are

[80] The C Map reproduced in Figure 29 is only a partial model of Jonas's theory. Like most of the C maps in Chapters Four and Five, the map has been simplified so that it can be more easily read. Fuller C Maps of this and other theories are available in Appendix 4.

recognised in the structuring of the chapters – for example, the fundamental shift from early frameworks that drew from other, non-design disciplines to design-centred frameworks that inform later theories and models. While there are some categories such as design science or design methods that are common across a number of different theories, the various definitions and diversity of assumptions associated with these terms by various authors make even these more widely recognised design research approaches less cohesive than they might otherwise seem to be. The variations of terminology and position, which include 'a science of design', 'scientific design', 'design science' and 'a science for design', indicate some, but by no means all, the possible interpretations of types of relationships between design and science in design research. Other common categorisations are used in a number of theories or groups of theories, for example the category of phenomenological research, but such correlations are more difficult to articulate beyond terminological correspondence, as differences in understanding and definition and the comparative levels of such categorisations are often quite diverse. That is, the underlying conceptualisations and approaches to theory development taken by different authors are particular, and their understanding and use of terms is different. Nor are these particular interpretations or positions always explained or located. For example, phenomenology is one of three upper-level categories of methodological approach in Cross's 2006 model, while the more highly specified area of Marxist phenomenology is used as an example under a second-level category of materialist dialectic within Buchanan's 2007 model of strategies of design inquiry.

The specialised models of phenomenological approaches in design research by Seamon and by Wang and Wagner indicate that even within the field of architectural design research a particular methodological approach can be understood and conceptualised in different ways. The identification of such mirage-like points of terminological congruity and/or conceptual overlap is not insignificant. These points indicate fertile ground for further investigation to better explore the origins, influences and fundamental assumptions behind these different positions. Such revelation could help inform design researchers and assist them in more precisely positioning and articulating their own research projects and methodological positions. However, such investigation does not offer any immediate answer to the incommensurability of these different frameworks and categorisations.

Following this initial analysis and mapping of the twenty theories outlined in Chapters Four and Five, a further cycle of hermeneutical analysis was

conducted, with a focus on comparing theories. This considered the way theories were structured and the different strategic approaches that underpinned the organisation of different theories. This was not associated with particular epistemological framings of design research, but with the different ways authors approached theorisation. For example, a number of theories are organised in categories based on types of research themes. In Chapter Six this comparative analysis and search to identify underlying approaches to theorisation is discussed in more detail.

Chapter Six

Design Research Models

A Relational Analysis

Introduction

> The question of what we know is really the main guide, since we can only impose structure when the field is well understood, or when we wish to test a well developed theoretical framework. Consequently allowing the structure to emerge through the process of analysis is desirable when the research is exploratory and aimed at theory development. (Wilson, 2002, p. 11)

The close reading of theories and the comparison of structures, concepts and terms across the twenty selected design research theories discussed in Chapters Four and Five considered the content and context of each text and the ways different theories were structured. This initial phase of analysis enabled the description and identification of concepts and points of conceptual overlap and divergence between theories. The results of the next cycle of this hermeneutical analysis, involving further analysis, comparison and search for patterns of approach across the selected group of theories, are outlined in this chapter. This second cycle of interpretation focused on identifying underlying strategies taken by particular authors that have influenced forms of categorisation in their respective theories. These strategies have then informed approaches to conceptualisation and resultant theoretical structures within particular theories.

Structures and patterns were compared across the theories analysed, and correlations were made between different models that shared common approaches. Through this process, broader patterns of approach began to emerge. This chapter outlines this pattern identification process which led to the recognition of four broader frameworks. The conclusion at the end of this

chapter discusses the potential significance of these and of other frameworks identified across smaller numbers of theories. The identification of these four underlying approaches to theory building, despite the very different epistemological positions about design research held by the different theorists, is a key finding of this research. These patterns reveal approaches to the ways research is conceptualised that are shared by particular theorists, through a reflexive, hermeneutical process of analysis. A further correlation between these identified approaches to the articulation of design research frameworks, with theories about research made by research educationalists, is presented in Chapter Seven of this thesis. The value of these broader frameworks is that they are recognised as a way of organising information about design research theories that would be more accessible and useful to design researchers who want to access information about design research approaches and methods. The value to design researchers would be in terms of insight to help identify a particular researcher's position and in identifying pathways that a researcher might use to access information and better understanding about the contexts, limitations and potentials of different methodological approaches.

Perspectives

While certain authors have outlined the rationale behind their design research theory building, most did not discuss the ways their particular theories were developed. This sort of reflexivity or way of observing the observation of design is recognised by Jonas (2002, unpaged) as characteristic of an upper- or meta-theoretical level. Many authors do not articulate the underlying framework they use to conceptualise research, and have tended to frame theories as observations of the field of design research based on personal experience, belief or institutional agendas. This approach can be associated with Jonas's description of a 'second level order of theory generated from observations' (ibid.). In her studies of researchers' attitudes to research, Angela Brew (2001) recognises that, while individual researchers are able to articulate their own ideas about the nature of research, there is a lack of any systemic investigation into the ways research, per se, is conceptualised. Brew's comments, made as a researcher of research, suggest this lack of theoretical reflexivity is a broader issue, not just confined to design research theorists or design researchers.

Across the design research theories analysed, Järvinen (2000, 2000b) was one of the clearest of authors in articulating the rationale behind his strategies of categorisation. Järvinen (2000) argues that because a researcher first tries to

formulate a project through research questions, the selection of research methodology should be guided by such questions and, therefore, any taxonomy of research should associate type of research approach with types of research questions. This articulation in Järvinen's writing suggested a possible starting point for further analysis. Did other design research theorists consider relationships between types of research questions and research approaches? A consideration of other theories that articulated types of design research determined by research questions led to the identification of a number of other theories – a cluster – that used questions or inquiry orientation as a way of identifying and categorising types of research approach. E. B. Swanson and N. C. Ramiller (1993) have suggested that a clustering of relationships can suggest higher-order themes. While particular design research theories within an identified cluster can present very different perspectives on design research, they can be related through the way the theory is structured, and this shared approach can be the basis for new types of categorisation. Two authors may propose very different theories of design research; however, if their theories are organised or explained through the use of research questions they can be seen to share an inquiry-oriented approach based on a common acknowledgement of question types as a way of indicating different types of research. For example, Järvinen's notion of artefact-evaluating approaches concerning the utility of artefacts in an information-systems design approach asks, 'How effective is this artefact?' (2000, p. 126), while Roth's notion of investigation into concrete and specific situations (akin to Friedman's notion of clinical research) asks, 'Which visual attributes are most effective and appropriate for a specific message and audience?' (1998, p. 22). Both these question orientations are concerned with evaluation of artefacts, although Roth's is framed in terms of research into specific incidences, while Järvinen's is framed in terms of investigations into utility. The next four sections of this chapter address the clusters of relationships and categories of approach identified in this comparative analysis and pattern recognition phase of this thesis inquiry.

Strategic Models

The term 'strategic' has been used to describe models where categorisation is based on research perspectives (Punch, 2000) or research approaches (Järvinen, 2000). Strategic categorisations tend to sit at upper levels of abstraction in a theory, as they indicate broader paradigmatic and/or methodologically based groupings. Thomas Kuhn's definition of a paradigm as an 'implicit body of intertwined theoretical and methodological belief that permits selection,

evaluation and criticism' (1996, pp. 16, 17) recognises the intertwined philosophical and procedural dimensions of a paradigm. Theory and methodology are linked to belief, so the ground of fact or facticity is relative, rather than absolute and universal. Kuhn recognised that in the early stages of disciplinary development 'different men confronting the same range of phenomena, but not usually all the same range of phenomena, describe and interpret them in different ways' (p. 17). This is certainly evident in the emergent discourse of design research. While different grounds of factual knowing constitute a paradigm and, critically, different paradigms are incommensurate, the body of belief associated with collections of facts is not always clearly explicated in the emergent field of design research. The term 'strategic' recognises an approach that encompasses both paradigmatic and methodological dimensions. It was used to identify this broad category of research approach because there is a wide diversity in the terminology and levels of granularity or detail used by design research theorists in defining categories of design research in terms of paradigmatic or methodological orientations. Issues arising from the use of paradigmatic frameworks and terms drawn from other disciplinary approaches also contribute to this heterogeneity. For example, while a number of theories recognise design science as a fundamental and therefore a paradigmatic category within design research, there are many different definitions and interpretations of design science, and many variations and combinations of the words 'design', 'science' and 'methods' in terminology used to identify this approach, a point previously discussed in Chapter Three of this thesis. Niedderer and Roworth (2007) have identified a similar pluralism in relation to 'design-based', 'arts-based', 'practice-based', 'practice-led', 'practice-centred' or 'studio-based' research and 'evidence-based' or 'reflective' practice (p. 6), these being some of the terms associated with the use of creative practice in research, an approach that certain theorists identify as paradigmatically distinct, for example Scrivener (2000) and Roth (1999). This issue is not related to building rational argument between paradigms, which, given the fundamental incommensurability that defines the notion of paradigms, would not be possible, but to the fuzziness of language, belief and theorisation that exists in design research discourse, even amongst researchers and theorists who may assume they are working within a similar paradigm. Dorst (2006) has recognised the notion of discourse in design and the elements of human thought contained in discourse as being comparable to Khun's notion of paradigm, but with one critical distinction. While a paradigm is defined by revolution, radically distinguishing one framework from another, Dorst suggests that discourse recognises changes in meaning and traces shifts in conceptualisations within a domain.

Attempts at correlating specific concepts across different theories that are based on strategic approaches are more problematic. For example, a comparison of theories by Buchanan, Margolin and Scrivener, which have one common point in that they all recognise forms of design science as a distinct paradigmatic category of design research, would require Buchanan's categories of 'dialectic' and 'design inquiry' to be considered in relation to Margolin's 'design studies' and 'project-oriented research' or Scrivener's 'creative practice-based research'. While there are some recognisable overlaps or relationships between certain categories that could be productively explored – for example, between Scrivener's practice-based and Buchanan's poetics or productive-science approaches, other categorisations are based on very different sorts of conceptualisations of design research, which draw from very different histories and contexts and sit at different levels of abstraction. Categories that are unique to a particular theory may lack the robust academic or social validation that would be necessary for wider acceptance as a formal paradigm. Academic or social validation in this context would be recognised as the process whereby discourse communities arrive at a general consensus about the value or acceptability of particular concepts or approaches. Such communities initially help to frame and subsequently may be framed by such paradigms.

At this current stage in the development of design research discourse, there are still many differences of opinion as to the definition, extent and significance of particular paradigms beyond the originary paradigm of design science. This is not to suggest that certain nominated paradigmatic categories are not significant or productive, but rather that there is no general consensus as to an epistemological framework that can satisfactorily represent these different areas. Kuhn's notion of paradigm can be seen as a strategic approach in that the paradigm frames a plan of action through a set of particular permissions or agreements in relation to selection, evaluation and criticism. By nominating a more general 'strategic' category, a cluster of types of theories, based on methodologically oriented categorisations of design research, can be recognised. Theoretical differences may not necessarily be paradigmatic differences, in Kuhn's sense of the term. Categorising a grouping of theories as strategically oriented does not address problems of incommensurability between theories and avoids the creation of more highly specified, logic-based categories. However, this should not be regarded as a failure of this research project. Rather, it should be recognised as a pragmatic decision that recognises the value of a broader category that can accommodate differences over rigidly defined, reductive categories that might exclude diverse and potentially significant

points of view. The identification of this loose cluster of theories is a way of beginning to identify, interrogate and correlate theoretical strategies by recognising a particular type of theoretical orientation based on methodological approaches to design research. In addition, while there is considerable fuzziness within this 'strategic' category, the borders of the category are quite distinct. While the conceptualisations that define particular design research paradigms and methodologies, set across different theories, cover a wide range of approach and are often at very different levels of granularity, it is possible to distinguish theories conceptualised in terms of a strategic approach from theories based on research themes or question types.

Punch (2000) suggests the term 'perspective' articulates the paradigm, meta-theory or philosophical assumptions behind a piece of research. Mackenzie and Knipe (2006) have noted that while researchers are not always aware of the paradigmatic frameworks in which they operate, an understanding of paradigmatic assumptions is necessary in order for the researcher to identify their position and question procedural decisions. They describe the researcher working within an accepted and unquestioned paradigmatic framework as being immersed in the medium of research with a 'naturalised' understanding. That is, the researcher's position is regarded as being the approach to the way research in a particular discipline or institution is conducted, without regard for the epistemological assumptions or associated procedural conventions upon which this form of research is based. Even when such conventions are recognised, a researcher may still hold naïve 'naturalism' by assuming or believing that they will deliver the correct outcomes. A naturalised approach does not encourage the articulation, let alone a questioning of assumptions and associated procedural conventions, nor does it enable the extension of conventional approaches or the development of new research procedures. Within the 'science of the artificial' (Simon, 1969) that is design such naturalised assumptions must be vigorously contested. Thus the conceptualisation and categorisation of design research theories based primarily on strategic frameworks – however diverse and heterogeneous they might be – could assist design researchers in engaging with and questioning paradigmatic and methodological assumptions.

Thematic Models

Research themes, defined as distinct subject areas or objects of concern, are another widely used approach for the categorisation of types of design research.

For example, thematic areas are identified by Love (2000b), Wang and Wagner (2007), Manzini (2007) and Krippendorff (2006), and research concerns are recognised by Cross (2006), Margolin (2005), Buchanan (2007), Dorst (2008) and Gasparski et al. (1995). In a number of theories, research themes sit as sub-categories, under or related to particular strategic approaches, indicating links between the paradigm or methodological perspective and particular subject areas of research. For example, Margolin (2002) identifies manufacturing, product improvement and teamwork as subjects of project-oriented' research, while he proposes minimisation of waste, efficiency of resources, fundamental changes in production, changes in consumption and 'thinking of the world situation' as themes of sustainable design research. Love goes so far as to suggest that themes are directly related to paradigms: 'Themes can be viewed as different paradigms under which design researchers have investigated design activities, and proposed theories and models to represent them' (2000a, p. 297). However, this position is problematic because a particular research theme can be approached from a number of different perspectives and using very different research procedures. For example, research into design practice, which is a thematic area identified in a number of theories, can be conducted through design science using a wholly systematic approach (Cross, 2006b) or, using humanities-based approaches, through design studies (Margolin, 2002). Dorst's descriptive framework (2008), which has a strong thematic focus, recognises that research subjects can be approached from more than one methodological angle, noting that studies of design process have considered design practice through rational, problem-solving approaches and through reflective practice. Roth (1999) takes an approach that links research themes and sub-themes to particular methodological or strategic approaches. For example, her thematic category of 'research tied to practice' links to sub-categories including improving the process of designing products'. She associates this area of concern with three distinctive approaches, including interactive design, participatory design and design methods.

The ways different authors conceptualise and describe themes varies considerably across theories. These differences include: dimension – the range from broad themes to specific subject, choices of terminology and definition, and level of granulation, where some authors provide detailed descriptions and/or examples of particular themes while others provide little more than single terms. Many of these distinctions are underpinned by differences in terms of paradigmatic assumptions. For example, Love's thematic area of 'objects' is broken down into 'descriptions of objects' and 'behaviour of elements', while Margolin's thematic area of 'design products' can be considered in terms of

'product identity' and 'product interpretation'. Love's thematic concept, terminology and forms of sub-categorisation are based on a scientific notion of the designed object that can be reductively defined and analysed. Margolin's 'design studies' framework takes a cultural studies approach, where the products of design are made by and thus are meaningful to human beings. Roth (1999) has proposed three different types of design research or 'categories of inquiry'. These include the concrete and specific, defined by a specific situation, the conceptual, which extends beyond a specific instance to an entire class of situations, and the theoretical and philosophical, which examines design practice and its artefacts in a broader context (pp. 21–22). However, these categories would seem to draw directly from the scientific categories of clinical (concrete and specific), applied (conceptual) and basic (theoretical) research, which are part of a particular paradigmatic framework rather than a typology of research themes or types of subjects of research.

Thus, while a category of design research themes must remain a loose one, it is nevertheless an approach that is used by a number of theorists to differentiate different types of research. It may be an accessible and useful category, in that researchers are often required to articulate research projects thematically or topically. For example, the application to the Master of Design degree programme at AUT University asks applicants to identify the 'topic which you want to explore or investigate at an advanced level' in their application (ARDEN website, 2010, http://arden.aut.ac.nz/postgraduate). Being able to identify and better locate a design research topic or theme in relation to groups or collections of topics and to be able to consider a topic in relation to possible strategic approaches may also be valuable in helping researchers identify their own position and reflect further on the best methodological approach. However, given the potential of design research to engage across a wide range of contexts, issues and problems, and the pace of social and technological changes that design researchers are engaging with, a comprehensive typology of design research based on research themes would be vast.[81]

Output-based models

A third and smaller cluster of theories identify types of research outcomes. In most of these theories there is a correlation between the research perspective or

[81] The list of over 600 research themes proposed by the Scientific Committee of the 2006 DRS Conference in Lisbon gives some idea of the scope and diversity of thematic approaches to design research. See http://www.iade.pt/drs2006/wonderground/chef_s_sugestions.html

strategy and the form of research output. In particular, Järvinen (2000) has investigated what kinds of research output can be expected from applying different research approaches. His work draws on studies conducted by March and Smith (1995) that identify four 'design science products', which are: constructs, models, methods, and instantiations or artefacts realised in an environment. These are supplemented by a further type or outcome for symbolic or mathematically based research approaches that result in proofs. He correlates these output types to his model of research approaches. Järvinen claims that understanding this relationship between output types and strategic approaches has value not only for researchers, but for companies investing in research and for the communication of research to stakeholders. However, the identification of typologies of outputs and the correlation of these outcomes to research approaches are not developed systematically in most other theories. In a number of instances, types of research outputs are included as examples rather than as a formal typology. The research outcomes identified by Manzini (2007), proposed as a radical and sustainable contrast to traditional industrial design outcomes, are examples of this approach. Outcomes identified by Manzini, such as participatory social services, new food networks, collaborative organisational models, etc., can to some extent be correlated with the more general categories of outputs (constructs, models, methods, and instantiations or artefacts) identified by Järvinen, which were developed from an information science perspective and thus tend towards general rather than specific categories. Other theories, for example those of Dorst and Poggenpohl, also identify methods as types of outputs. Poggenphol's category of theory as output can be related to Järvinen's notion of construct. However, the notion of 'tools', recognised by both Dorst and Poggenpohl, is less immediately correlated, as tools tend to sit between methods and artefacts. Scrivener (2000) recognises the production of original artefacts as both the main focus and the main outcome of practice-led research. Scrivener's notion of artefacts developed through a problem-solving process would also correspond to Järvinen's category of instantiations of artefacts, although the nature and categorisation of Scrivener's creative practice-based artefacts would not conform to a notion of artefact as research outcome that represents an idea in the form of an instance of it.

The theories of practice-led research, outside of Scrivener's, that are considered in this thesis give little detailed consideration to design artefacts as research outcomes. This is in spite of the dominance of artefacts in traditional ontological constructs of design (Meyer, 2009). Forms of artefactual taxonomies are found in areas such as museum studies, where classes of objects are defined mainly in relation to their history and provenance, for example in the *Categories for the*

Identification of Works of Art (CDWA) from the Getty Museum, and in areas such as engineering design, where they are defined in terms of their facture or form of making and function. Krippendorff's analysis of design artefacts takes a different perspective. He is concerned with shifts in the human understanding of what artefacts mean, not with what things can do in a functional sense. That is, while an artefact may be designed for a particular purpose, how it is valued and understood by people who purchase the artefact, and the way it is eventually used by them, can be quite different. Krippendorff's taxonomy of design artefacts also reflects the growth in awareness that our enjoyment of an artefact, for example a bed in an hotel, is not just associated with the comfort of that artefact, the bed, but with the whole experience of the hotel in which the bed is located and that forms the context of any enjoyment of the bed. Such contexts can involve the branding and consistency of the hotel chain, as well as the level of service provided by personnel, and the management and financial systems that support the running of the hotel. Thus the use of the hotel bed is tied to the broader design context of the hotel. The analysis of design artefacts proposed by Krippendorff may be useful for researchers who are considering the possible form of the outcome of a research project. His model leads out from a specific and historically prescribed notion of the artefact as a functional solution or as a vehicle for expressing the designer's artistic ability to more complex social, technological and methodological considerations of design and meaning. Richer articulation of types of artefactual outputs would be useful in any broader categorisation based on types of research outputs.

Given the requirements placed on research students and researchers, to identify types of research outcomes in formal research application procedures, a framework through which types of research outputs might be correlated with research approaches could be useful and accessible, provided such correlations are not overly prescriptive. However, this would appear to be an area of theoretical focus that has not been subject to the same level of consideration or discourse development as other ways of conceptualising design research. It also offers further opportunities for analysis and inquiry.

Inquiry-Oriented Models

The fourth and smallest cluster of approaches to theorisation identifies research questions in relation to types of research approach and outputs. The group includes theories by Järvinen, Poggenpohl, Jonas and Roth. While this question- or inquiry-oriented approach is not used as widely in other design research

theories analysed in this thesis, the value of question formation is recognised by many writers on research. Clouse (2005) suggests that a project's focus is sharpened when an issue is made more concrete in the form of a research question. He suggests that question formation informs an assessment of the sorts of theories and methods that could be used to help obtain the best results when answering the questions:

> Research questions serve as stems for a series of puzzles to be solved in the research process. The significance of the project often is apparent from a review of the question alone, and the question prompts the methods required to obtain a meaningful answer. Well-posed questions prevent methodologic shortcomings in research design or omissions in data acquisition, even from retrospective data review. A good question deserves to be answered: both positive and negative findings are useful outcomes, making your research efforts successful and publishable, no matter what you find. (Clouse, 2005, pp. 279–80)

Poggenpohl recognises research questions as powerful ways to locate knowledge contribution (2000). She identifies a set of ten questions based on question terms, such as who, what, when, where and why, and considers the particular focus of each form of inquiry. She links this typology to qualitative, quantitative and comparative research strategies. Roth (1999) identifies a series of example questions that could be associated with three different strategies of inquiry. Järvinen recognises that formulation of the research question is a primary activity in the research process (2004, p. 130). He suggests that when the objects under study are different, the sorts of research questions posed will be different. This presents an opportunity for linking research themes to question types. Järvinen's taxonomy associates research approaches with types of research questions and outputs. The generic nature of his questions, such as 'How effective is this artefact?' or 'Do observations confirm or falsify a theory?', allows such questions to be related to a range of thematically different projects, but even more closely linked to strategic approaches. This point of focus might provide a useful 'inquiry-focussed' entry to information about design research approaches for researchers, helping associate specific research questions with more generic ones, and then with relevant methodological approaches. However, the limited number of models that conceptualise design theories in terms of design inquiry, and the different approaches they take to identifying question formation, mean that any relationships between theories within such

an inquiry-based framework, within the scope of the design research theories analysed in this thesis, will inevitably be limited.[82]

A key research question underpinning this mnemotechne project asks, How might different ways of reflecting about design research be understood in relation to one another? This question can be associated with Roth's category of 'theoretical and philosophical' inquiry. However, it bears no similarity to the types of questions she gives as examples; for instance, her question, 'Is universal cross-cultural design possible?', seeks to identify possibility rather than relationality. Relationality implies the existence of many different perspectives, rather than proof of the existence of one or another perspective. While the mnemotechne project research question might be considered in terms of Järvinen's conceptual-analytical category, which is concerned with assumptions about theory, his example question, 'What kind of theory concerning a certain part of reality could be derived if certain assumptions and premises are valid?' (p. 126) is concerned with identifying a particular theory rather than relating different theories. Poggenpohl's theory, which identifies more generic types of questions built on different question forms and linked to a range of possible methodological approaches, offers the most relevant approach to categorisation for the research question posed in this thesis. She identifies the question form 'how' with a focus on process, method or operation. Although she does not specify that this might include a comparative strategy, she recognises that 'how' questions are usually associated with qualitative approaches.

Other Approaches

In addition to the four types of conceptualisation identified above, a number of other approaches were recognised and considered within specific models and across groups of theories. Some of these approaches to theory conceptualisation offered no immediate correlations with approaches taken in other theories, but suggested ways of conceptualising or describing design research that could be useful in clarifying and positioning particular models and ideas. However, such approaches were not discernable across a number of theories, and so cannot be proposed as clusters or shared frameworks. As these approaches were identified during this second phase of comparative analysis they are discussed here in

[82] The MAPS project being developed by Wolfgang Jonas and Rosanne Chow (2006–10), discussed in Chapter Two, uses a question process to help design research students to locate their projects and identify relevant methods. The MAPS project gives some indication of the potential of using query as a way of engaging with design research project development through discourse.

terms of their possible value as perspectives that could extend and better link or differentiate conceptualisations across different theories. A second group of categories that are based on more general conceptualisations of research that are also recognised across other disciplines are also considered in this chapter and discussed as potential forms of categorisation for a resource about design research. These are clearly not discipline-specific categorisations, but may be useful as a way of correlating and contrasting design research with that of other disciplines.

Definitions, Norms, Characteristics and Claims

The authors of the design research texts analysed generally provided some level of description or qualification about concepts or categorisations in their theories. Some, but by no means all, provided short definitions that give some indication of how they understand and use a term. For example, both Archer and Cross provide short definitions of key terms, while Buchanan, and Coyne and Snodgrass, provide descriptions of the nature or features of particular approaches. However, definition itself cannot be used as a category, as it qualifies the meaning of a term, rather than standing as a sub-set or part of the concept that the term represents. Some authors have used different strategies to identify or qualify particular aspects of key research approaches that could be considered or used as sub-categories.

Scrivener (2000) uses the term 'norms' to identify typical features of the research approaches discussed in his theorisation of practice-based research. These norms identify key features of 'technology research projects' and 'creative production projects', which are the two types of design research recognised in his theory. The identification of norms helps clarify Scrivener's understanding of design science and creative-practice approaches. These norms identify a set of beliefs that Scrivener has associated with each approach. They are systematically articulated, providing a clear distinction between the two approaches. However, the term 'norms' suggests a level of shared consensus; that is, it is based on an assumption that such beliefs and understandings are normalised and widely shared by other members of the design research community. A consideration of Scrivener's generalised notion of technology research projects and Järvinen's more detailed analysis of different types of technology projects suggests that there are very different ways of approaching technology research projects and that Scrivener's 'norms' could be contested within the design research community. Thus, while the identification of norms

associated with design research strategies provides a clarification of beliefs associated by an author with particular approaches, they are, like the categorisations of approaches themselves, contestable.

Gasparski et al. (1995) identify 'characteristics' associated with each of the nine different conceptualisations of design science articulated in their theory of design research. Characteristics are features or attributes that help to distinguish one thing from another. In Gasparski et al.'s text the identification of characteristics helps to locate and distinguish design research approaches. For example, their concept of 'design theory' is characterised as theory based on mathematical models, while their concept of 'sciences of the artificial' is characterised as science related to the artificiality of man-made things, while 'practical sciences' are characterised by a focus on methods of design realisation, the investigation of principals and the diagnosis of practical solutions. Some concepts are more fully characterised or distinguished through broader sets of distinctions, while other concepts are shorter and more descriptive. The characteristics identified in this text work more as definitions that help distinguish one approach from another, than in-depth, systematic comparisons between concepts. In some instances they raise further questions – for example: What are the characteristics of a science of the artificial? What is the place of theories that are not mathematical models which are not addressed in this model?

In his model of paradigmatic clusters in design research, Jonas (2007/2008) has also included 'claims', defined as basic assumptions associated with each of the categories of design research he articulates. Claims identify the distinctions than underpin particular approaches, recognising the assumptions upon which a particular position is based. Claims, in this context, are similar to norms. Jonas has listed these claims concisely and consistently across the different sections of his model. These claims provide insight into why each approach is distinct – even across related sub-groups of processes. For example, within the grouping of 'cognitive processes', Jonas identifies the claim of cognitive problem-solving as meaning that 'Design is a mainly rational process. Models can be developed, problems can be solved' (unpaged); while 'generative processes' within the same cognitive processes cluster are based on claims that 'Designing is an algorithmic process' (ibid.). Jonas's approach articulates fundamental assumptions rather than descriptions or definitions. His model is consistent in providing similar types of information across the different clusters (a quality not evident in all theories analysed). As his model is more complex than Scrivener's, and goes beyond a dualistic positioning of design research approaches, his use

of normative claims is particularly effective in helping locate and define differences of approach between different categorisations. A more consistent and widespread articulation of norms or claims that underpin the various design research positions or categories proposed by theorists would help clarify the positions of theorists and assist in the project of developing understanding and advancing the discourse in the field of design research. Both Scrivener and Jonas attempt to articulate the underlying beliefs or basic assumptions associated with particular research approaches. This is more useful than definitions of terms in relation to strategic categorisations, as it helps make explicit the underlying beliefs that frame and distinguish particular approaches.

Methods and References

Another widespread feature of many of the selected design research texts is the identification of research methods and the association of methods with particular research approaches. Fifteen of the twenty theories analysed specify at least some of these methods. Among the most consistent examples of theories that identify and associate methods with particular research frameworks are those of Krippendorff (2006) and Jonas (2007).[83] Krippendorff not only identifies specific methods, but details the steps involved in using different methods, along with examples of projects in which these methods were used. This detailing helps describe and specify aspects of Krippendorff's theory and also clarifies his view of the value and appropriateness of particular methods. Jonas systematically identifies and associates methods or groups of methods with each research approach identified in his model, although as the theory is only presented as a working model he does not describe these in any detail. The methods Jonas associates with particular research approaches help to clarify shifts in methodological focus across these nominated groupings. For example, he associates first-order cybernetic methods with the area of cognitive problem-solving in design research, while he identifies second-order cybernetic processes with the category of 'design as a knowledge generating process in its own right', (unpaged) akin to research through design or design-based research.[84] Like

[83] These levels were not represented in the outline C Maps of these theories reproduced in Chapter Five, but can be seen in the fuller C Map models reproduced in Appendix 4.

[84] Cybernetics, as the science of principles of organisation in complex systems, is recognised as having had two historical phases. First-order cybernetics emerged after the Second World War, associated with the work of Norbert Weiner (1948) and concerned with the study of control and communication in closed systems. Second-order cybernetics emerged in the 1970s, with a focus on self-organisation, cognition and the role of the observer in modelling the system (Heylighen and Joslyn, 2001). More recently, third-order cybernetics, which looks to how the various dimensions of cybernetic systems co-evolve, has been recognised.

Krippendorff, Jonas also refers to relevant projects, although he does this through citation rather than providing detailed outlines of particular projects.

Different understandings are also evident in the definitions and uses of the term 'method' in different theories. For example, Järvinen defines research method as 'a set and sequence of steps to perform a task' (2000b, p. 262). He does not recognise interviews and participant observation as research methods, but rather as techniques for collecting data. He suggests such techniques can be used in a number of different methods. This approach can be contrasted with that of Krippendorff, who identifies interviews and observation as methods used in researching 'the language of possibilities for stakeholders' (p. 222). Buchanan has also recognised that particular methods and techniques can be shared by different investigators engaged in very different types of research (2007).

Four other theories, in addition to the fifteen that identify research methods, propose broader or more generalised methodological approaches or strategies, which could potentially be broken down further or linked to specific methods, for example the theories of Dorst, (2008), Nelson and Stolterman (2003) and Järvinen (2000, 2000b). Dorst proposes that design research involves stages of observation, description, explanation and prescription – generic process stages that could be associated with particular types of research methods. Nelson and Stolterman also identify general methodic approaches associated with their categories of research inquiry. For example, research into 'the real' uses conceptual inquiry and action, while research into 'the true' includes the use of consensus, representation, dialectic, probability and scientific methods. Again, these generic approaches could be more closely broken down into associated research methods. Love (2000a, 2000b) is the only author from the twenty selected texts who does not identify methods in association with research approaches, an approach that is consistent with his self-identified focus on a meta-theoretical level. Methods, in categorisations of research and in formal ontological frameworks, are regarded as sitting at a lower level of abstraction. They are specific techniques for doing research, that is, methods are concerned with the operationalisation of research rather than its framing and conceptualisation.

While methods are associated with methodological approaches in many of the theories analysed, they are not named, described or practised in the same way, nor are particular methods always linked to a single methodological approach. For example, Cunningham (1997, cited in Järvinen, 2000b) has identified at least

nine different case-study types. Järvinen (2004) recognises three distinct purposes for which case studies can be used – each of which is associated with a different research intention and methodological approach. These include the use of intensive cases to develop a theory from intensive exploration; comparative cases, used to develop concepts based on case comparison; and the use of action research, to develop concepts to help facilitate change processes (Järvinen, 2000b). Järvinen concludes that because there are other case-study types belonging to different research approach categories, the case study cannot be assigned to one methodological classification. This suggests that any categorisation of design research methods would need to distinguish more clearly between broader categories of research methods and specific research techniques. It would also require flexibility in order to represent the different ways a particular research technique might be used within different research frameworks. However, at present the different use of terms and definitions of categories, such as methodology, method, tools, and techniques or the different terminology and levels of description of methodic approaches make correlation difficult. For example, the approaches described as 'phenomenological study' (Järvinen, 2000b), 'collect or generate narratives and metaphors' (Krippendorff, 2006), 'diaries, self reporting' (Roth, 1999) and 'design philosophy' (Margolin, 2002) are expressed in different design research theories. These ways of researching could all be associated with a phenomenological approach, but present different levels of formal and informal methodic articulation.

In the context of the analysis of the twenty texts, an overarching framework that might represent design research methods was not evident. Järvinen was the only author to specifically address the issue of a taxonomy for design research methods. However, his taxonomy is closely linked to the focus and structure of his theory of design research and is not easily related to the organisation of method in the other design research theories. The versatility of methods and their relationship to both the broader methodological framework and the specific context of a design research project suggest that a static taxonomy may not be an adequate way to represent design methods. The MAPS system being developed by Jonas and Chow (2008, 2010), which uses a discursive engagement with project articulation through the use of questions, leading to an identification of possible methods, introduces a dynamic, systemic approach that would seem to be more effective in this area. The issue of taxonomies of methods is considered in more detail in Chapter Seven of this thesis. Most research experts recognise that an understanding of the research paradigm, strategy or perspective is the basis for subsequent choices regarding methodology and specific methods (Mackenzie and Knipe, 2006). However,

many design researchers who work within a specified paradigm are unfamiliar with other research approaches or the richness and potential range of methods available for conducting design research. The ability to search for particular methods or groups of types of methods associated with particular research stages or purposes would be a useful feature in a design research information resource, as it would contextualise the methodic selection available to design researchers beyond normalised research techniques and approaches.

Finally, a number of authors identified key references and project examples as ways of contextualising and better locating aspects of theories (these references are not identified in the C Maps presented in Chapters Four and Five, as the inclusion of this level of detail made the C Maps complex and the basic structure of particular theories difficult to decipher. They are included in many of the C Maps presented in Appendix Four). Some twelve of the twenty texts analysed used referencing as a way of contextualising different research approaches. This academic convention was not used across all theories, but, where employed, was an effective way of more precisely locating the theoretical context of the proposed research approaches. More extensive referencing would provide a fuller contextual framework for negotiating the heterogeneity of design research theories. While different authors may interpret the same theory in different ways to support their particular frameworks, certain key reference texts seem to provide anchor points that could be used to tease out zones of overlap between theories. For example, Donald Schön's *Reflective Practitioner* (1983) is cited by Coyne and Snodgrass as an exemplar of an hermeneutical approach, by Margolin to reference studies of design practice as part of the area of design studies using humanities-based approaches, by Scrivener to reference creative practice-based research and by Jonas in relation to research into design as communication process. While these authors present very different frameworks of design research, Schön's writing suggests a starting point for exploring possible correlations between these different perspectives. However, such an approach would have to recognise that these authors' particular interpretations and applications of Schön's writing and ideas were distinctive. The centrality of texts like Schön's *Reflective Practitioner* and Simon's *The Sciences of the Artificial* are evident in the ways they are cited in different design research theories as key references that locate particular philosophical and methodological positions about design as practice. They have also had a profound influence on the development of design research. It is recognised that such positioning texts might act as poles or markers in a design research resource, to help locate meeting points or overlaps between different design research theories that seek to describe or categorise the field of design research and its different

approaches. A number of philosophical texts that have influenced approaches to design research and its discourse, for example writings by Dewey, Gadamer and Heidegger, could also be included in this way, as theoretical markers that link design research theory with more abstract ideas and other related arenas of discourse.

The inclusion of references to particular research projects – for example, in texts by Cross, Järvinen, Krippendorff and Jonas – is an approach that helps clarify particular research frameworks through cases. Cross (2006, p. 101) has recognised that exemplars are often used as a way of passing on design knowledge, be it in the form of products or in more explicit forms like writing. Dorst (2008) and others have recognised that much design knowledge is not generalisable, but is associated with variability and specific contexts. Case studies, which are often criticised in scientific domains because they are specific and not generalisable, are more appropriate in a field where replicability is not sought and difference is celebrated. The compilation and cross-referencing of design research projects as case studies is also recognised as another way of demonstrating and better communicating different methodological approaches and research outcomes in relation to particular theoretical framings, which would be a valuable inclusion in a design research resource.

Conclusion

The diversity of paradigmatic frameworks from which design research theories are drawn, and the different levels of abstraction through which they have been articulated, have contributed to the difficulty in relating different design research theories. The purpose of the second phase of analysis considering these theories was not to develop or impose a formal order on the field, but to see if any patterns or congruencies could be identified. Through an iterative process of analysing and comparing theories, four distinct orientations have been identified. These approaches are evident across groupings of theories – although some groups were larger than others. It must be emphasised that these commonalities were not ones of shared conceptualisations about design research or proposed categorisations, but were based on underlying approaches to theory building. The four categories included:

- Strategic models related to methodological approaches

- Theme-based models, where research subjects or themes are defined as distinct, recurring topics or subjects of design research
- Inquiry-oriented models based on types of research question
- Output-based models, where types of research output, defined as the type of intellectual or creative production, informs the structure of the model

The terms used to describe these four conceptual categories were identified through a study of the ways authors described their particular approaches to theory construction, a consideration of the emphasis and underlying approach of each theory, and the identification of the above approaches as clusters that were common to particular groups of theories. In addition, a number of specific approaches used in individual models were considered in terms of the way they contributed to the clarity of articulation of particular theoretical positions. The identification of normative claims, proposed by Jonas (2007) and Scrivener (2000), were recognised as offering significant potential as a way of qualifying and better specifying particular research perspectives or frameworks. Finally, a number of approaches based on more general academic research conventions (such as methods, references and case studies) were considered to see if they offered useful categorisations for structuring information about the heterogeneous field of design research.

Capurro and Hjørland (2004) have recognised the difference between the representation of information 'in domains that have a high degree of consensus and explicit relevance criteria', like science, and domains like design that 'have different conflicting paradigms, each containing its own more or less implicit view of the informedness of different kinds of information sources' (p. 395). They describe this type of domain-analytic approach as hermeneutic because any understanding is determined by 'the pre-understanding of the observer' (ibid.). The next phase of this research engaged with the question of whether or how the categorisations drawn from the analysis of these design research theories could provide useful and relevant ways for design researchers to access information about design research: 'With the statedness of a part of a community background in a system, the inquirer can match his/her questions and backgrounds of pre-understanding against it' (Capurro, 2000, p. 4). Such an approach introduces a notion of information hermeneutics, where both the pre-understanding of the information 'user' and the objectivised framework that organises the information system are recognised:

> We can consider the process of storage and retrieval of information hermeneutically as the articulation of the relationship between the existential world-openness of the inquirer, his/her different open and socially shared horizons of pre-understanding and the established horizon of the system. The information seeking process is basically an interpretation process having to do with the (life-) context and the background of the inquirer and with that of the people who store different kinds of linguistic expressions having a meaning within fixed contexts of understanding such as thesauri, key words and classification schemes. (Capurro, 2000, p. 4)

Traditional information-systems approaches have emphasised these 'fixed contexts of understanding' – as metadata schemas, vocabularies or ontologies. Within the field of design research, little attention has been paid to the pre-understandings of design researchers. Rather, emphasis has been placed on the researching processes of design (Dorst, 2007) or on computationally oriented approaches to creating formalised structures or ontologies for design information. In order to test the potential relevance of the categorisations identified in this chapter, two approaches were taken. The first, discussed in Chapter Seven, considers these categorisations in relation to more general theories and conceptualisations of the nature of research as an activity. The second, discussed in Chapter Eight, discusses experiments conducted during this research project into the development of semantic structures based on these categorisations that might be used to organise information about design research in more relational ways. These two approaches – the correlation of research findings with relevant literature, and the testing of the findings through practical application – were identified as two ways of testing the findings of these approaches. According to Gadamer, the validity of an interpretation can be gauged not only through the degree to which it gives rise to new insights and meanings, but also in terms of the way it stands up to the test of its practical application. Snodgrass and Coyne (1992) also recognise the value of application as a way of testing interpretation: 'The assessment of the validity of a metaphor or model proceeds by an appeal to its potential deployability, arrived at by projective anticipations and not by objective logic or subjective intuition' (p. 69). The value and potential of the research findings - that is the four research perspectives identified and discussed in this chapter - are considered in the next two chapters of this thesis.

Chapter Seven

Recent Research Frameworks

Typologies of Method

Introduction

In this chapter, some research and theories about the nature of research as an activity are considered in relation to the clusters and congruencies that were identified in the analysis of the design research texts outlined in Chapter Six. This process was followed to test the findings – that is, the patterns identified in the analysis of design research theories – by investigating whether there were any other frameworks that might support this analysis or reinforce its validity. Validity in this situation is not proposed as truth or the discovery of some hitherto unseen, logical order in the field of design research. Rather, it is an attempt to understand the nature of these patterns as systems, akin to what Jonas (2000) has identified as bifurcations or additional sequences of states, within both the theory of design research and the broader system of theoretical discourse about research.[85] This correlation is recognised as a patterning system and not an indication of any generalisability into other domains.

Categories of Research

This next phase of the research process has involved a review and correlation of frameworks used to describe approaches to research, extracted from literature about the activity of research as an activity concerned with the methodical search for knowledge (Bunge, 1999) and literature about research training

[85] Bifurcation is the splitting or branching of possible states that a system can assume because of changing parameters.

(Brew, 2001). This process was conducted to investigate whether broader understandings about research as a process, or recent research into ways that research might be conceptualised outside of disciplinary domains, had any correspondence with the ways design theorists might conceptualise design research. A distinction can be made here between frameworks of design research that draw from other disciplinary models, or knowledge frameworks that are extrinsic to design, such as the design studies/humanities framework proposed by Margolin, and the various approaches to design science and conceptualisations of design research that might be influenced by other values or orientations towards research as an activity. This is a distinction between understandings of design research developed through or in relation to particular disciplinary frameworks, and individual understandings of the activity of research in a phenomenological sense, and how such understandings might influence ways of theorising.

Angela Brew's research and scholarship has investigated the nature of research and human knowing. Brew (2001) notes that while individual researchers are able to articulate their own ideas about the nature of research, there is a lack of any systemic investigation into the ways research, per se, is conceptualised. This means that many commonly held assumptions have not been properly examined. In her research Brew identifies a number of widely held beliefs about the nature of the research experience. These include the widely held notion that conceptions of research are determined by disciplinary differences and that methodology or type of research determines a researcher's conception of research.

Brew's findings contest this position and suggest that there is a difference between conceptions of research expressed by disciplinary groups or 'academic tribes' (p. 272) and the ideas of individual researchers. She proposes that disciplinary allegiance is only one factor in a complex set of circumstances. Brew's work in this area suggests that a further consideration of the ways that research is conceptualised by researchers might give some insight into the ways design researchers might approach research and knowledge about research. The notion that such conceptualisations might also influence the ways design research theorists might approach theory construction was also explored, through a comparison of the patterns of conceptualisations found in the analysis of theories of design research with findings in current research-education literature about researchers' conceptualisations of research.

Conceptualisations of Research

Gerlese Akerlind's research and scholarship has focused on mapping the nature of academic research practice as experienced by academics themselves. In the introduction to her paper 'An Academic Perspective on Research and Being a Researcher: An Integration of the Literature' (2008) she recognises that while there is a substantial body of research looking at the ways academics understand teaching and being a university teacher, there is 'relatively little equivalent literature addressing academics' understanding of research' (p. 17). She notes that much research into understanding academic teaching has been conducted through phenomenographic studies, and identifies a small but growing body of literature about academics' views of research using this approach.[86] In addition, she notes an emerging body of non-phenomenographic literature exploring research students' and supervisors' conceptions of research. Akerlind has conducted an integrative review of literature, selecting and analysing ten texts to identify common themes and patterns in relation to academics' understandings of what it means to be a researcher. Both Brew (2001) and Akerlind (2008) recognise that researchers have very different conceptions about the nature of research, and this affects how they conduct research. This recognition that underlying ontological orientations, rather than specific disciplinary perspectives and their associated research conventions, may influence researchers' understandings and approaches to research was seen as being relevant to the mnemotechne project. It raised the question as to whether such 'underlying conceptions' might also influence the way that research theorists conceptualise research. Akerlind's empirical study identifies underlying variations in the ways these different studies (of academic researchers' understandings of research, conducted by researchers of research) were originally conducted. These variations are not because of methodological differences in the research approach to these studies, but because of 'implicit differences in the focus of both the interviewees and the researcher' (p. 22). She concludes:

> There is an implicit variation in the nature of the research question between the different studies, with some authors investigating academics' views of research primarily in terms of different views of the outcomes or products of research, others focussing on different views of the research process, others on different views of the purpose or

[86] Akerlind defines the phenomenographic approach as an empirically based 'search for variation in ways of experiencing a phenomenon, accompanied by a search for structural relationships between different ways of experiencing that emerge' (2008, p. 23).

> intentions underlying research, and others focusing on different views of the object of study in research. However, most of these studies have positioned themselves as simply looking at different views of research.' (p. 22)

In comparing and finding patterns across these different studies, Akerlind makes explicit what were previously implicit perspectives on research. She identifies four dimensions of academics' views of the nature of research as: research intentions, research outcomes, research questions and research process (p. 22).

Akerlind's four views have some close parallels with the four design research frameworks that were identified as common orientations underpinning certain groups of design research theories analysed in this thesis (see Table 8). These orientations, as discussed in Chapter Six, were not related to particular paradigmatic or disciplinary positions (which were often represented as or in categories of research in the design research theories), but seemed to be influenced by implicit understandings of research. This correlation between Akerlind's analysis and the findings of this inquiry, while not exact in every respect, are proximate, and support the categories identified in this investigation. Akerlind does not give any interpretation as to why these particular frameworks might exist in terms of the tacit understandings academics have of research, and no explanation is proposed in this thesis for the existence of similar perspectives in the analysis of design research theories, as this would involve a psychological or philosophical dimension beyond the scope of this inquiry.[87] However, Akerlind also presents an analysis of academic researchers' understandings of being a university researcher in this same study, and this reveals very different motivations for conducting research (associated with career requirements, personal achievement, understanding and social benefit), which appear to be related to individual orientations and values held by academics rather than to disciplinary frameworks. While the four orientations towards academic research understanding and the four types of research motivation identified by Akerlind cannot be directly correlated, such insights can be used to support the notion and approach of information hermeneutics, whereby individuals have different world views and perspectives that influence not only the way they understand phenomena such as research, but also the ways they might approach and navigate information about research.

[87] It does open up another interesting potential area for future inquiry.

The table below identifies and compares the frameworks and categories of research approach identified by Akerlind (2008), Järvinen (2000b) and Joseph (2010). It has been noted previously in Chapter Six that three of Järvinen's categorisations of research also correlated with the approaches identified in this thesis analysis. Järvinen''s reflexive approach led him to identify particular orientations to research amongst his research students, which he used as a basis for part of his theory organisation and articulation.

A comparison of these three schemas identifies strong correlations across all frameworks in two areas: research questions and research outcomes or outputs. In another set of categories – themes/intentions/objects – conceptualisations are not identical and sit at slightly different levels of abstraction, though some overlap exists. The broader concept of research themes can be related to objects of study. It would appear that research objects and research intentions are more specific than research themes, and might therefore be nested under this broader category.

Joseph, 2010	**From analysis of 20 design research theories**	**Akerlind 2008**	**From study of researchers' understandings of research**	**Järvinen 2000b**	**From student orientations to research**
Inquiry	Type of research questions	Questions	The nature of the object of study	Questions	Research questions
Thematic	Research themes	Intentions	Who is affected by the research	Objects	The objects under study
Strategic	Methodological approach	Process	How the research is undertaken	Approach	General expression of similar research methods
Output type	Types of research production	Outcomes	The anticipated impact of the research	Outputs	Abstractions of facts, concepts, descriptions or relations

Table 9: Comparing Akerlind's and Järvinen's research conceptualisations and those identified from the analysis of design research theories in Chapter Six

The categories strategic–process–approach can also be related, although once again the concepts sit at different levels of abstraction. The selection of the term strategic was made to emphasise the entwined philosophical framing and associated procedural aspects of methodological approaches. Järvinen defines research approach as 'a set of research methods that can be applied to similar research objects and research questions' (2000b, p. 251), recognising the relationship between forms and objects of inquiry and research procedures. Akerlind's term 'process' tends to suggest procedural or methodic aspects. Thus categories of approach and process could be seen to nest under the broader strategic category.

While there are differences in choice of terminology and scale between Akerlind's categories, developed from assessing attitudes across a broad range of researchers from the sciences, social sciences and humanities, Järvinen's categories, developed as part of a theory of information-systems research, and the categories derived from the analysis of approaches underpinning design research theories identified in this thesis project, there is enough correlation to imply some value in this comparison. This similarity of approach suggests there may be more general pre-understandings about approaches to research that can not only be correlated with the way some design research theorists have framed or modelled particular theories about design research, but with different ways design researchers may also understand or approach research.

These categorisations of research approaches, identified through the analysis of design research theories, and their correlation with the model proposed by Akerlind, were developed through the identification of shared patterns of common conceptualisations evident in the literature. These approaches correspond to the first two levels of Parsons and Stills' levels of systematisation of theories (1951), discussed previously in Chapter Three. That is, the categorisations developed initially by Akerlind from summaries of observations sit at a first level, while the relationships between different categories or taxonomies described in this thesis analysis sit at a second level, that of a systematisation of theories. Consideration was then given to how this type of categorisation could be extended to a fuller conceptual framework. As part of this process further consideration was given to the ways knowledge in the Western tradition is conceptualised and categorised, in that research is a process concerned with the discovery of knowledge, and thus the categorisations of knowledge, in terms of broader philosophical frameworks, would also need to be taken into account in the development of any relational information system that sought to compare or link different conceptualisations of design research. It

must be emphasised that this isn't proposing a formal ontological structure, but, rather, further consideration of the ways research in general is described and categorised as an activity.

Categories of Knowledge

Epistemology, as philosophy of knowledge, is closely linked to ontology and methodology: 'As ontology involves the philosophy of reality, epistemology addresses how we come to know that reality while methodology identifies the particular practices used to attain knowledge of it' (Krauss, 2005, pp. 758 and 759). Different epistemological understandings underpin different knowledge frameworks or paradigms. As discussed previously, Kuhn (1962) recognised that theoretical and methodological beliefs are implicitly associated with a paradigm and influence processes of selection and evaluation in research. While the nature and process of paradigm formation is contested, particularly by cyberneticists, it is generally recognised that philosophical assumptions about the nature of reality (which Kuhn has argued defined a paradigm) are crucial to understanding the overall perspective from which a study is designed and carried out. Brew writes:

> Whenever a process of inquiry is talked about or engaged in, what is said and done is dependent on underlying conceptions about the underlying nature of research. These influence the types of projects researchers feel comfortable in pursuing, the choice of methodology, the questions, ideas and issues pursued, and the ways in which the work is carried out. (2001, p. 283)

However, these underlying beliefs and conceptions are not always explicit or well understood by researchers.

The importance for researchers of understanding the selection of research paradigm is also debated by research experts. Mackenzie and Knipe note: 'without nominating a paradigm as the first step, there is no basis for subsequent choices regarding methodology, methods, literature or research design' (2006, unpaged). In contrast, Maxwell (1996) suggests that a focus on paradigmatic frameworks can undermine the work of novice researchers. He writes: 'a strong emphasis on perspectives and paradigms can leave beginning students confused and bogged down' (p. 59). Maxwell favours an approach whereby new researchers are introduced to research through a specific

paradigm. While he doesn't contextualise this position, Maxwell seems to assume that a methodological overview is too difficult and complex for students beginning research, and that they should go through a type of apprenticeship, learning through one approach. Punch (2000) takes a middle position, recognising that 'the perspective may not always be made explicit in a research project or proposal. That research may start from a perspective or it may develop from a pragmatic position needing answers' (pp. 111–12). These different positions can be associated with deductive and inductive approaches.[88] The understanding and explicitness of paradigmatic awareness would appear to be strongly linked to the experience of the researcher and the research domain in which they are working. Given the pluralism and the pragmatic or applied nature of much design research, Punch's position may be the most relevant to current design research practices. However, the historically dominant focus of design research on the process of designing (Dorst, 2007, p. 2) is being confronted by the enormous changes and challenges currently facing design practice. These challenges arise from shifts in understanding of the deontology of design, or what design should be (Meyer, 2008), in light of the profound and ongoing impacts of traditional design approaches, rooted in industrial strategies of mass consumption, or their romanticist antithesis based in the social and natural environment.[89] In this context, the ability of design researchers, be they experienced or emerging, to more critically recognise the normativity of their community of interests is paramount. As Mackenzie and Knipe have noted: 'Understanding paradigmatic frameworks helps researchers recognise their assumptions' (unpaged). This statement can also be inverted to acknowledge that recognising assumptions can help open the horizons of a paradigmatic framework.

As the previous discussion of design research theories has identified, the nomination of paradigmatic frameworks and the recognition of their assumptions is particularly difficult within the field of design research. Even within the most widely recognised framework – that of 'design science' – there is considerable diversity of definition, philosophical approach and types of research practices. It is suggested that the 'solution' to this particular problem of the definition and underpinnings of design is not to be found through a

[88] Deduction works from the general to the specific, that is, from theory to hypothesis, observation and confirmation, while induction moves from specific observations to broader generalisations and theories. Notions of deductive, inductive and abductive logic are discussed in more detail in Chapter Eight.

[89] In philosophy, deontology is concerned with moral or deontic theories that guide and evaluate the choices of what a person ought to do. They can be contrasted with aretaic theories of virtue that guide and assess what a person's character is or should be. (*Stanford Dictionary of Philosophy*, http://plato.stanford.edu/entries/ethics-deontological)

scientific approach, by attempting to create a 'unified' theory of design science, as Hubka (1987) tried to do, but is found by further investigation and understanding of design's various approaches as part of the history of theory or historiography of design research. Some initial work has been done on this in the area of design science (see Gasparski, 1995; Cross, 2000, 2006), but the history of design research, including that of design science and its influence on current theories and approaches, is another area that requires greater investigation by design historians and acknowledgement by design researchers.[90] Michel Foucault's notion of a 'history of systems of thought', whereby essential structures are exposed through processes of 'archaeology' and 'genealogy' to reveal the contingency of entrenched contemporary positions, may offer a methodology for such a project that would be more relevant than one based on dramatic, paradigmatic schisms. Foucault's notion of discourse as 'the complete structure of terms and relationships that lie at the basis of the thinking and discussions within an area of human activity' is recognised by Dorst (2006, p. 15) as having some parallels with Kuhn's notion of paradigm. But Foucault seeks to reveal and better understand changes in meaning within a domain over time, rather than focussing on revolutionary moments. The project of design research history, to better reveal the contingency of entrenched contemporary positions, remains another fertile arena for future research, and offers another fruitful way to relate and understand types of design research. This notion of discourse and historical contingency underlies the difficulty in trying to map dynamic design research methodologies and theories to fixed paradigmatic frameworks.

Paradigmatic frameworks that have been articulated in other related disciplines, notably the social sciences and information sciences, were considered to see if they might assist in clarifying or better articulating frameworks within design research. This approach was not intended as a way of framing design research through other disciplinary frameworks, but was based on the recognition that design, as an integrative discipline, was linked with, and has been influenced by, other disciplinary discourses and frameworks and broader epistemological shifts. Consideration was given to other disciplinary epistemologies to see if they might offer insight into paradigmatic frameworks and design research methodology.

[90] As the final editing is done on this thesis, in August 2010, yet another discussion about types of design research erupts on the PhD design listserv, and predictably someone claims that all the old models of design research are irrelevant and that we need new models, while they simultaneously misquote from an earlier theory, not realising that they have revealed their lack of understanding of the earlier theory and that they have already, unintentionally, changed the theory.

Mackenzie and Knipe (2006), working from the perspective of education and the social sciences, identify four fundamental paradigmatic frameworks. These are:

- The positivist or post-positivist paradigm, based on rationalist and empiricist philosophy, that originated with Aristotle, Bacon, Locke and Kant (Mertens, 2005, p. 8). This approach aims to test theories or describe experiences through observation and measurement, so as to identify, predict or control (O'Leary, 2004). Post-positivism moved beyond positivism in recognising that research is influenced by theories beyond, as well as including, the one being investigated. Such theories are understood to be provisional and changeable. This approach is often aligned with quantitative methods of data collection and analysis.
- The interpretivist/constructivist paradigm, which is concerned with understanding the world as human experience. It developed out of phenomenological and hermeneutical philosophy and is based on the understanding that reality is socially constructed (Mertens, 2005). Researchers working within this paradigm tend to use qualitative or mixed approaches.
- The transformative paradigm, which emerged during the 1980s and is based on the understanding that 'inquiry needs to be intertwined with politics and a political agenda' (Creswell, 2003, p. 9). It was posited on an action agenda for reform, and tends to use a mixed-methods approach to support better understanding of a 'greater diversity of values, stances and positions' (Somekh and Lewin, 2005, p. 275).
- The pragmatic approach, as defined by Mackenzie and Knipe, which focuses on the 'what and how' of research rather than any one system of philosophy or reality. According to Creswell (2003) the research problem is seen as central to pragmatic research. Methods are mixed and are chosen 'as those most likely to provide insights into the question with no philosophical loyalty to any alternative paradigm' (Mackenzie and Knipe, 2006, p. 6).[91]

[91] This problem-centred interpretation of pragmatism can be contrasted with Coyne and Snodgrass's perspective, which recognises that actions are part of a dialogue we have with a situation, and that the process of designing itself can be understood as a dialogue with a design

Positivist/Post-positivist	**Interpretivist/ Constructivist**	**Transformative**	**Pragmatic**
Experimental Quasi-experimental Correlational Reductionism Theory verification Causal Comparative Determination Normative	Naturalistic Phenomenological Hermeneutic Interpretivist Ethnographic Multiple participant meanings Social and historical construction Theory generation Symbolic interaction	Critical theory Neo-Marxist Feminist Critical race theory Frierean Participatory Emancipatory Advocacy Empowerment Change-oriented Interventionist Queer theory Race specific Political	Consequences of actions Problem-centred Pluralistic Real-world Practice oriented Mixed models

Adapted from Mertens (2005) and Creswell (2003)

Table 10: From Mackenzie and Knipe (2006): Paradigms: Language commonly associated with major research paradigms

Mackenzie and Knipe note the difficulty created by the use of different terminology in discussions of paradigms within the social sciences – an issue that has also been recognised in the discourse of design research. They address this issue by identifying terms used in key texts which are associated with the particular paradigms they have identified (see Figure 42). Terminological incommensurability is addressed by locating approaches in relation to particular frameworks, without undermining the specificity of a term or approach. This approach begins to highlight the problematic associated with the nomination of broader paradigmatic categories and more specific methodological approaches.

In considering this model by Mackenzie and Knipe and models by other research theorists (for example, Gephart, 1999) and the analysis of design research theories discussed previously in Chapters Four and Five, it is evident that some of the higher levels of categorisation identified in different

situation (1991, p. 125). This is quite distinct from problem-solving approaches within design science, yet alone the social sciences. Buchanan (2007) also associates pragmatism with dialectical forms of design research inquiry. This example highlights the difficulty of assuming there is universal agreement on the focus and scope of paradigmatic definitions, both within and across disciplinary domains.

strategically oriented design research theories can be related to these different paradigmatic categories. Further articulation of this type of framing could be useful to design researchers in providing a more detailed correlation between certain design research theories and broader and more widely recognised philosophical frameworks and belief systems, to create bridges between designerly approaches and other disciplines with which design must engage. However, there are a number of design research approaches that cannot be subsumed or represented in this social science model. For example, systems-thinking approaches that are increasingly used in design research, and recognised here in the theories of Nelson and Stolterman (2003) and Jonas (2000b, 2004, 2007) are based on very different philosophical conceptions of the world. These are grounded in a framework that recognises that the various components of a system cannot be reduced to isolated parts, but must be understood in terms of their relationships with each other and with other systems. While systems-science approaches emerged from scientific frameworks, as general-systems and control-systems theories or first-order cybernetics (Weiner, 1948, Von Bertalanffy, 1968), the extension and development of second-order cybernetics or systems thinking, which recognised both the engagement and affect of the participant observer in the functioning of any system (Bateson and Mead, 1973) and prioritised relationality within and beyond a single closed system, has been recognised as a significant shift in conceptualisation.

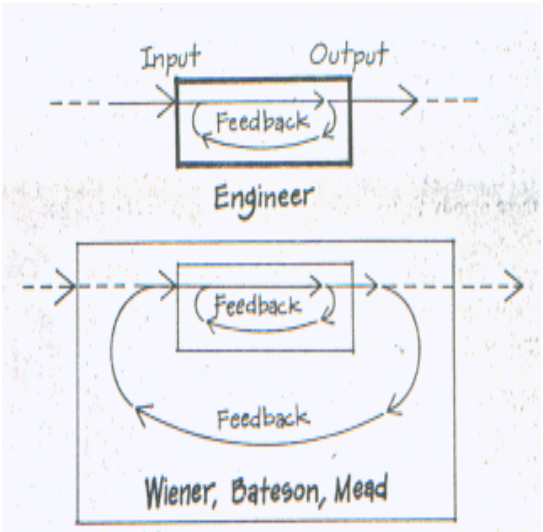

Figure 30: Diagram of first- and second-order cybernetics by Bateson and Mead (1973), from http://www.oikos.org/forgod.htm

Second-order cybernetics or systems thinking is seen as a distinctive approach that has informed the development of fields including ecology, sustainable

design, business and service design. One difficulty in categorising such developments is identifying when the shift of thinking or reconceptualisation within a field becomes distinct enough to describe a divergent approach as a distinct paradigm. This dilemma is related in part to different understandings and definitions of the term paradigm, but more particularly to different positions taken in relation to the history and development of human thought.

Kuhn's engagement with paradigms as 'universally recognised scientific achievements that for a time provide model problems and solutions to a community of practitioners' (1963, p. x), is not focussed on establishing a set of classifications of different perspectives, but on recognising conceptual shifts that lead to 'change in the perception and evaluation of familiar data' (p. xi). He also acknowledges that there are different phases in the development of new paradigms, recognising 'the transition from the pre- to the post-paradigm period' (p. 178); identifying phases where a number of theories or schools compete for domination in a field; then the recognition of 'some notable scientific achievement' (ibid.), which leads to the taking up of the new approach; and eventually a stage where the new framework itself becomes 'normal science'. In relation to design research theory, second-order cybernetics is an extension of systems science and thus links back to a post-positivist framework. The critical moments and perceptual shifts between these different world views are not as clearly defined as shifts in scientific paradigms, such as the way heat was understood and theorised after Black, or chemistry after Boyle and Boerhaave, or geology after Hutton (Kuhn, p. 15). Kuhn recognised the 'unfortunate simplification that tags an extended historical episode with a single and somewhat arbitrarily chosen name' (ibid.), and also the various people, ideas and inventions that often pre-figure or support such moments of change. However, the change in 'gestalt', or the new way a scientist sees and understands things after a paradigm shift has occurred, is also recognised in some of the different knowledge frameworks developed in the social sciences (p. 112). However, moments of paradigmatic change are not always as singular or dramatic in the field of design. While theories by Simon and Schön are recognised as critical moments in the development of design science, or practice-led design approaches, in the later part of the twentieth century, these ideas were not developed in isolation, but were part of a wider discourse intersecting with fields such as cognitive science (Simon) and professional education (Schön). Other key historical shifts, such as the change from nineteenth-century notions of design as aesthetic enhancement of industrial products to modernist notions of design and functionalism, can also be associated with key texts, for example Adolph Loos' essays in *Ornament and*

Crime (Loos, 1998). But, as Walter Benjamin revealed in *The Arcades Project*, these shifts are not just theoretical, technical or economic, but are cultural and part of the human imaginary (Benjamin, 2002). Cultural ideas and practices don't just shift paradigmatically; they are memes which are transmitted and respond to selective pressures: they spread, fade, re-emerge, mutate.[92] Design, its research, theories and practices are also cultural phenomena.

Design Research and Methodology

Methodology, defined as the comparative study of methods, goes beyond the selection of methods for realising a research project to engage with the theoretical frameworks that underlie and give rise to methods as systematic procedures or tools for conducting research. Bunge (1999) proposes the term 'methodics' as 'a collection of related methods' (p. 179), and distinguishes this term from methodology as 'the study of methods, the normative branch of epistemology; a knowledge technology' (p. 178). Methodology engages with the theoretical frameworks that underlie and give rise to methods as systematic procedures or tools for conducting research. Thus methodology involves the theoretical and comparative study of methods of inquiry, rather than just the study of research techniques within a discipline: 'Methodology is about method, not the same as method' (Mautner, 1996, p. 267).

Methodological approaches to design research include both those drawn from other disciplines, for example the phenomenological approaches discussed by Seamon (2000) that developed within the discipline of philosophy, as well as approaches that have emerged from within the discipline of design, for example human-centred design approaches identified by Krippendorff (2006). Many of the approaches that Mackenzie and Knipe (2006) identify from social science research literature within the various paradigmatic categories in Figure 42 are regarded, in the context of this thesis, as methodological approaches. For example, critical theory, neo-Marxism, feminism, Freirean and participatory approaches all sit within a transformative paradigm based on an agenda for social transformation. But each of these approaches has specific theoretical

[92] The idea of memes was introduced by scientist Richard Dawkins (1989) to describe cultural ideas and practices that can be transmitted from one mind to another through writing, speech, gestures, rituals or other media. Memes have been described as cultural analogues to genes. While etymologically distinct, the notion of memes can be associated with mnemotechne, which describes the medium or technology through which ideas and practices can be transmitted.

underpinnings and thematic concerns, and may involve distinctive procedural approaches or methods. Some of the approaches identified under the transformative paradigm include general terms that indicate broader approaches and aspirations rather than a theoretically distinctive agenda, for example 'emancipatory', 'advocacy', 'change-oriented', 'interventionist' and 'political' are generalised terms not tied to historically or theoretically specified agendas.

Mackenzie and Knipe recognise that general terms are often used by researchers to describe approaches to research. A researcher's identification with a paradigmatic framework helps locate him or her in relation to more formal approaches. This strategy of including both formal and informal terminology in relation to a particular paradigmatic approach was recognised as being relevant to the area of design research, where similar problems associated with variations of terminological specificity and granularity occur, with authors using both specific and general terms, as well as self-coined terms or terms adapted from other disciplines, to describe methodological approaches. A number of exploratory maps and tables were made, trying to visualise relationships between some of the strategically oriented concepts identified in different design research theories and the paradigmatic framework proposed by Mackenzie and Knipe. This exploration was investigating possible ways through which methodological approaches from particular design research theories could be related to broader paradigmatic frameworks and to groups of other related methodologies. It must be emphasised that the attempt to develop a table of paradigms and methodologies was not an attempt to create a unified structure for design research, but was meant to identify groupings of methodological approaches associated with broader research paradigms and to explore approaches that could be used to relate associated terms, concepts and approaches.

Architect and educator Jan Verwijnen wrote: 'in every research there is always an ontological perspective which sees or encapsulates (our being in) the world in a specific sense and there is an epistemological position which suggests that knowledge or evidence of the world can be generated by observing, participating or interpreting certain sources' (PhD design listserv. Re: Teaching Methodology. Tue. 26 March 2002). He has suggested that developing a sense of ontological and epistemological positioning is particularly important for design researchers because of the lack of a clear or singular theory or paradigm in relation to design. However, while this framework identifies a number of epistemological models in relation to broader ontological positions, it does not

and cannot contain or represent the full range of all the methodological positions identified in the twenty design research theories analysed in this project.

Positivist/ Post-positivist	**Interpretivist/ Constructivist**	**Transformative**	**Pragmatic**	**Systems thinking**	**Aesthetic**
Design science (Gasparski)	Phenomenology (Seamon)	Local initiatives (Manzini)			
	Design studies (Roth)				Creative practice-based (Roth)
Rational (Coyne and Snodgrass)	Hermeneutics (Coyne and Snodgrass)				Romantic (Coyne and Snodgrass)
Design science (Buchanan)	Dialectic (Buchanan)		Design inquiry (Buchanan)		
Design methods (Margolin)	Design studies (Margolin)	Sustainable design research (Margolin)	Project-orientated research (Margolin)		
Analytic reasoning (Nelson and Stolterman)				Synthetic reasoning (Nelson and Stolterman)	Imaginative, instinctive thinking (Nelson and Stolterman)
Cognitive processes (Jonas)	Communicative processes (Jonas)	Democratic/ social processes (Jonas)		Projective processes (Jonas)	
	Semiotic processes (Jonas)	Sustainable processes (Jonas)		Sustainable processes (Jonas)	

Table 11: Correlation of paradigmatic frameworks and some methodological approaches identified in selected design research theories

A number of methodological strategies identified in this analysis of design research theories do not sit neatly within these paradigmatic categories – some specific categories could be associated with or located across a number of the identified paradigmatic domains, for example aspects of Krippendorff's 'human-centred design' framework could be associated with constructivist, aesthetic, transformative and pragmatist approaches. It is claimed by some theorists like Krippendorff that human-centred design constitutes a new designerly paradigm based on humankind's interaction and agency through technology. Thus a number of methodological approaches are not easily represented in this paradigmatic table. Järvinen recognises that certain complex methodological approaches are better represented through notions of 'super-methodology' and 'sub-methodologies'. He suggests this is the case in areas like systems-design research, where the resulting artefact 'functions as a bridge between the technological research and the social research' (2004, unpaged). This may offer another way of thinking and correlating strategic approaches without the overlap and contradictions that exist between different definitions and categorisations of approaches in terms of paradigms and methodologies.

Design Research and Methods

Another confusion that is often evident in design research discourse is between methodology and methods. This issue was evident in the different groupings and identifications of method discussed in Chapter Six. The distinction between methods, as specified procedures, and methodology, as the study of methods, also needs to be considered in attempting any such categorisation. For example, phenomenology can be described as a methodological framework, while an unstructured interview is one of a number of methods that might be used in phenomenological research.

Methods are procedures for doing things. Research methods are the regular and specified procedures for doing research. In design research a distinction also needs to be made between design methods, as procedures for designing, and design research methods, as procedures for conducting design research. Friedman (PhD Design Listserv, Re: Design Methods (Questions for Jan Cocker). Mon. 25 March 2002.) notes that 'research methods are not always part of design methods. Research focuses on objects of inquiry. Some of these are directly related to design. Others inform design and still others may inform design via the process of design research' Thus, while design methods may be used as part of a particular design inquiry, for example an inquiry into the improvement of

an artefact or procedure where a result of the research inquiry may be a re-designed artefact, design research methods would not always be used as part of a process of designing. For example, investigations into the role of the designer or into the nature of design research would not use methods of designing as research methods. Rather, they would use types of observational or data-collecting methods and/or analytical methods for interpreting this information – processes that are not in themselves methods of designing. This issue is not based on a divide between practice and theory, but rather it is concerned with the different foci of research inquiry and design, and the 'design' of the research or study.

This issue is also complicated by the emphasis given to researching the process of design within the field of design research over the past forty years. This has resulted in the production of design methods as formalised procedures, as outcomes of research into the process of designing. Dorst (2007) has written about this aspect of design research:

> The field emerged from practitioners developing ways of working to help them cope with the problems they faced. These prescriptive statements were put into words and published as more formal methods and tools […]. The overwhelming majority of descriptive and prescriptive work in design research focuses on the design process, to the exclusion of everything else. Therefore the design methods and tools that are being developed inevitably focus on enhancing the efficiency and effectiveness of design processes […]. And apparently, this total ignoring of the design content, the designer and the design context allows us to claim that we are constructing models, methods and tools that will be valid for every designer, dealing with every possible design problem, in any situation. Within design research, the emphasis on the process of design is still overwhelming. (pp. 1–2)

Dorst notes that while formal design methods, resulting from design science approaches to design research, are taught in design schools, they are rarely followed in professional practice. He suggests the focus of design research needs to change, and nominates issues such as the role of 'the designer, the content of the design activity and the context in which that activity takes place' (p. 4) as areas in need of attention and investigation by researchers.

Methods are selected by a researcher because they are the best ways to produce data, analyse, understand, explore or answer a research question or issue. The

selection of methods is determined by a researcher's particular epistemological position and the framework of beliefs and understandings of the world that they bring to an inquiry, as well as the task at hand – that is, the research problem, issue or question being investigated.

While the identification of design research methods was evident in most of the theories analysed (see Chapter Six), authors provided different levels of articulation and definition and related similar methods to differently conceptualised categories of design research. This made any systematic organisation of design research methods drawn directly from the analysis and interpretation of the selected design research theories difficult. Consideration was given to taxonomies of methods drawn from other disciplines to understand how a categorisation of design methods might be approached.

Mackenzie and Knipe present an analysis of the four social science research paradigms in relation to 'primary methods' and 'data collection tools' (Figure 55). Their analysis is based on a fundamental distinction between quantitative and qualitative research methods that emerged during the development of research in the social sciences.[93]

This analysis recognises a distinction between primary methods and data-collection tools. This is akin to the distinction made by Järvinen (2000) between a research method, as a set and sequence of steps a researcher carries out in her singular study, and techniques for collecting data, such as interviews. Järvinen recognises that tens of different research methods might exist within a particular research approach, and cites Miles and Huberman (1994), who have recognised over twenty-seven qualitative research methods. These examples of different terms and differentiations made between types and groupings of methods indicate some of the difficulties faced in attempting to categorise or develop a typology of design research methods.

[93] Quantitative methodology is associated with positivist epistemology. It refers to the collection and analysis of numerical data. Qualitative methodology is associated with interpretative epistemology. It refers to forms of data collection and analysis based on understanding and meaning. The debate between quantitative and qualitative methodology arose in the 1970s, with a growing interest in phenomenological approaches and a backlash against the dominance of scientific or positivist methodology in sociology.

Paradigm	Methods (primarily)	Data-collection tools (examples)
Positivist/post-positivist	Quantitative. 'Although qualitative methods can be used within this paradigm, quantitative methods tend to be predominant.' (Mertens, 2005, p. 12)	Experiments Quasi-experiments Tests Scales
Interpretivist/constructivist	Qualitative methods predominate although quantitative methods may also be utilised	Interviews Observations Document reviews Visual data analysis
Transformative	Qualitative methods with quantitative and mixed methods. 'Contextual and historical factors described, especially as they relate to oppression.' (Mertens, 2005, p. 9)	Diverse range of tools – particular need to avoid discrimination, e.g., sexism, racism and homophobia
Pragmatic	Qualitative and/or quantitative methods may be employed. Methods are matched to the specific questions and purpose of the research	May include tools from both positivist and interpretivist paradigms, e.g., interviews, observations and testing and experiments

Table 12: Paradigms, methods and tools in social sciences research, from Mackenzie and Knipe, 2006

AI in Design researcher Udo Kannengiesser (2008) has recognised the 'conceptual ambiguities and miscommunication among design scholars' (p. 263/1) caused by such terminological confusion. He writes: 'Some design researchers use the term "method" interchangeably with a wide array of terms such as "notation", "model", "process", "technique", and "tool". Others seem to distinguish between these terms but without articulating what it is that differentiates them' (ibid.). In investigating the development of a typology of design research methods in this thesis project, consideration was given to models developed in other disciplinary areas, such as Wilson's (2002) in information science and Beissel-Durrant's (2004) in the social sciences. Consideration was also given to the categorisations of design methods from a design science perspective (Chandrasekaran, 1990; Kannengeisser, 2008) and from a systems-thinking perspective (Jonas and Chow, 2008).

Typologies of Method

Information scientist Tom Wilson (2002) has conducted an analysis of types of research methods from an information science perspective. He has proposed a typology of methods for a social information-science developed for what he has defined as categories based on the nature of such methods. He assumes that research methods in all disciplines are based on observation, and so a fundamental distinction is between direct and indirect observation, that is between things that may be directly observed by the researcher and those that may rely on the reported observations of others. The next level of Wilson's typology is based on whether the structure of the data-collection process is imposed in its totality by the researcher, for example the design of a self-completed questionnaire, or whether it emerges from the research process, for example through the analysis of transcripts and development of a conceptual structure from this analysis. Both direct and indirect approaches can be either imposed or emergent. From this classification Wilson then assigns research methods 'to fit the frame' (unpaged). For example, under the observation/indirect/emergent structure he identifies informal interviewing, analysis of organisational documentation, and analysis of personal diaries as possible methods.

Wilson suggests that this model offers a way of viewing a range of possible methods to assist making decisions about which method is appropriate in particular circumstances (ibid.). Selection of methods would also be influenced by the philosophical framework of the researcher, which in this particular model is limited to either positivist or interpretive approaches, and factors such as what the researcher knows about the area to begin with. Wilson notes:

> The question of what we know is really the main guide, since we can only impose structure when the field is well understood, or when we wish to test a well developed theoretical framework. Consequently, allowing the structure to emerge through the process of analysis is desirable when the research is exploratory and aimed at theory development. (ibid.)

He acknowledges that a typology of methods may not, on its own, enable researchers to determine methods for an investigation. Rather, it enables an interrogation of possible methods and helps identify the researcher's position: 'It may help us determine the approach and ask ourselves questions about the fundamental position we are adopting' (ibid.). Wilson's rationale has some

relevance to the potential for the development of a typology of design research methods, as its aim is to promote an interrogation of method, rather than a prescription. However, a key limitation of this typology is Wilson's basic assumption that all research method is observational:

> The starting point is that all research methods, in all disciplines, are based upon observation: astronomy began by people looking at the stars, then using optical telescopes to do the same thing, then using radio telescopes and other devices to see what the naked eye could not – we could go through almost every discipline and find that the original method of data collection of the relevant phenomena was observation; all that has changed, over time, is the sophistication of the instruments used to make observations where the naked eye cannot do so. However, in social research (and, hence, in information research), observation may be direct or indirect. That is, the researcher him- or herself, may watch what is happening, or may rely on the reported observations of others. (Wilson, 2002, unpaged)

This approach is scientific in that it takes an empirical position, where research involves the gathering of data using evidence that is observable by the senses or through technology, and uses this data to formulate and test theories and come to conclusions. While this fundamental assumption or perspective on research can be related to certain design research approaches, ranging from ergonomics to usability studies to market surveys, there are many other forms of design research that do not involve empirical observation. For example, there are design research methods, such as Krippendorff's 'dialogical ways of designing' that are grounded in discourse rather than observation. Practice-based research is based in action and reflection rather than observation. Wilson's typology of method offers a way of conceptualising empirical methods, but is limited by its dualistic underpinnings in positivism and interpretivism and by its assumptions that all research processes are formalised in a particular set of processes.

Gabriel Beissel-Durrant (2004) has worked on the development of a typology of research methods in the social sciences.[94] Like Wilson, she recognises that there are different positions about method taken by social science researchers, recognising that 'various approaches to such a classification are possible' (p. 1).

[94] Dr Beissel-Durrant is based at the ESRC Centre for Research Methods (NCRM) and Southampton Statistical Sciences Research Institute at the School of Social Sciences, University of Southampton, UK. Her working paper on a typology for research methods included a review and analysis of other social science typologies of method.

Her model is temporally based on the successive stages of a research project, which includes phases of: research design, data collection, data management and quality assurance, data analysis and evaluation, and application and dissemination. Beissel-Durrant calls this process a 'natural structure' of research methods and research-related terms (p. 5), a description that implies that this particular paradigmatic approach is normalised within this discipline, to the point that it is regarded as the 'natural' way to conduct research. There is a presumption here that all research involves data collection and a systematic and linear series of stages of data processing, analysis and application. This model exempts many other forms of research, including hermeneutical and systems-thinking approaches, which are cyclical or iterative rather than linear.

While these categories relate to functions, such as collection or evaluation, they are organised as steps in a systematic process. These six main categories are divided into sub-categories, with descriptors and 'connected terms' associated with specific methods. Beissel-Durrant acknowledges that these lower levels of categorisation provide flexibility, which is necessary because 'further developments in methods and changes in priorities of methods will develop over time' (p. 6). This approach, based on stages of a research project, avoids the distinction between qualitative and quantitative methods that tends to dominate much social science discourse. However, the limitation with Beissel-Durrant's model is that it is built on the assumption that there is one common methodic form, with a prescribed set of steps, used in all types of research. Thus Beissel-Durrant's model has limited relevance to a typology of design research methods, as it does not admit different research approaches and procedures. These fundamental stages of a social science research project would not map across the range of different research approaches evident in design research. For example, the iterative processes recognised in practice-led design research do not correspond to this generic and linear model of research method. Similarly human-focussed methods that involve feedback mechanisms and design prototyping would also not fit with Beissel-Durrant's model.

This consideration of typologies of research methods from disciplines outside design highlighted problems similar to those identified previously when trying to organise design research theories through paradigmatic frameworks drawn from other disciplines. While such models have some relevance to certain areas of design research, they cannot represent the heterogeneity of design research approaches, including the extent of formal and informal design research methods. However, some aspects of method typology formation used in the models by Wilson and Beissel-Durrant suggest some useful strategies. One is

based on the level of primary engagement by the researcher (Wilson). Another is based on phases of the research process (Beissel-Durrant). These suggest two ways of conceptualising method that could be useful in a system of organising design research method based on information hermeneutics, where different perspectives and approaches to characterising method would need to be represented.

Design Methods Typologies

Within the discipline of design, the main focus on the categorisation of method has come from the areas of engineering design and AI in Design, through an interest in the systematisation of design methods to guide designers in solving recurrent classes of design problems, and as a basis for computerised decision-making systems or expert systems. Here the focus has been on categorising methods of designing rather than categorising design research methods. Such formal typologies within the fields of information and computer science are described as 'ontologies'. This notion of ontology is distinct from philosophical ontology, which is based in metaphysics and concerned with the investigation of modes of being in the world. It is concerned with studies of the way a given language or science conceptualises a domain as the 'ontological content of certain representation' (Smith, 2003. p. 5). Such logic-based representations enable the organisation, reading and processing of information by computers.[95]

AI pioneer Balakrishnan Chandrasekaran's work on ontologies of tasks and methods is typical of this approach, which is based on a notion of design as a problem-solving activity. Chandrasekaran et al. (1998) identified an 'ontology of a problem solver', which is broken into five 'generic instances', one of which includes 'problem-solving knowledge'. Within this instance are located 'problem-solving methods', indexed according to the problem-solving goals to which they are applicable. These goals can range from general – such as 'explain' – to specific – such as 'diagnose'. This approach to method is able to be 'operationalised', where the description of the method 'can be used directly to implement a problem solver' (p. 13). Chanderaskeran et al. also suggest a second level of method ontology that would identify and characterise methods 'based on how they achieve their goals' (p. 14). This approach is related to a task structure (Chandrasekaran, 1990) that identifies a number of alternative methods for a task, with each of the methods setting up sub-tasks in turn. This

[95] Issues about the structure and problematic of computational ontologies in relation to design knowledge are addressed further in Chapter Eight.

focus on computerised problem solving was one of the primary interests of AI pioneers, underpinning the ideas of Herbert Simon and the project to develop generalisable methods within the Design Methods Movement. Automated approaches to problem-solving in design have been largely unsuccessful, other than in relation to technical (logic-based) problems or highly specified task areas. However, the critical reaction to the AI in Design project has led to a deeper consideration and articulation of some concepts that have been critical in the development of design discourse. For example, Rittel's (1972) concept of 'wicked problems' was articulated in response to computerised approaches to problem solving (see Chapter 3, p. 77 for a fuller discussion of wicked problems). The notion of 'situatedness' recognises that human understanding emerges from the interaction of people with the environment. It was a factor that generic, automated problem-solving approaches had ignored (Lueg and Pfeifer, 1997).

Udo Kannengeisser, who worked with AI in Design researcher John Gero at the University of Sydney's Key Centre of Design Computing and Cognition for several years, has developed an 'ontological basis for design methods' (2008) that recognises five fundamental approaches to design methods based on an analysis of the function, behaviour and structure (FBS) of design methods. These approaches are:

- Black-box approaches, where every task is specified by input, transformation and output, and where the method resides within a user who is sufficiently skilled to use the method. Hubka and Elder's (1996) 'elementary operations' in designing are cited by Kannengiesser, including 'commonsense approaches' like 'see', 'hear' and 'read', as well as more complex activities such as 'synthesise' and 'induct' (pp. 263 and 264)
- Procedural approaches, which take a workflow perspective, identifying a sequence of activities or steps. Every activity within a procedural approach can be viewed as an individual or sub-method (pp. 263 and 265)
- Artefact-centric approaches, which take an informational perspective, emphasising representations of generic or specific aspects of an artefact and their relations. These often take the form of guidelines, checklists and tables. Examples include morphological analysis (pp. 263–66)

- Formal approaches, which take an organisational perspective, assuming a computational tool as the agent performing the method. The details of the internal method are hidden for user convenience. Examples include CAD and CAM tools (p. 263)
- Managerial approaches, which also take an organisational perspective, but with a broader view of design agency as a system of interactions between human designers, stakeholders, tools and documents (p. 263). He relates these to Hubka's 'working principals' that give 'general instructions for appropriate behaviour for the designer' (Hubka 1982, p. 40). An example given is the method of brainstorming.

Kanengiesser has correlated this structure of five approaches with a list of types of engineering design methods identified in engineering design literature. These are described in terms of 'method functions' concerned with providing support for 'doing design'. They are articulated as generalised approaches to stages of the design process, such as synthesising, abstracting, generating, decomposing, composing, defining, selecting, modelling, analysing and testing. Such method functions provide meaningful labels for indexing individual methods (Chandrasekaran et al., 1988, cited by Kannengiesser, 2008). Kannengiesser emphasises that in order to be universal, functions have to be repeatable and reproducible. He concludes that these fundamental descriptions of method structures can be correlated with particular classes of design activity supported by methods (p. 263/7). This framework is proposed as an ontological structure that 'can serve as a framework for research within and across disciplinary boundaries based on the uniformity with which all design methods are represented independently of the specific discipline, school of thought, or level of detail' (p. 263/12).

The generalisation and applicability of this computationally oriented ontology of design methods to other disciplines – and to other forms of design research – is questionable. This conceptualisation is limited not only by a specific notion of design process in engineering design, but by the conviction that the knowledge and application of design methods can be generalised and mechanised in this way. The use of function, behaviour and structure as levels of method description provides a systematic way of categorising particular methods that moves beyond dualistic conventions, such as qualitative and quantitative methods. However, Kannengiesser's conceptualisation of method is materially

rather than processually oriented. His categorisation is based on the structure, behaviour and function of a method as if a method is an engineered artefact, rather than a human process. Meyer has proposed that the ontological study of processes needs to be more fully incorporated into design discourse (2009, p. 6). He suggests that processes should not be 'subordinated to things in any order of being or understanding' (ibid.), emphasising the importance of 'the network of dynamic processual relationships' (ibid.) and the significance of a notion of 'becoming' in design processes. He writes:

> Some of the basic propositions of process thought maintain that process is a fundamental category of ontology and that processes have a status that is at least equal to things in ontological discourse. Significant for design is the understanding that time, change, contingency, emergence, innovation and creativity constitute important, even fundamental categories of metaphysical understanding. (Meyer, 2009, p. 6)

Kannengiesser's approach, while offering a systematic, design-oriented classification of methods, is regarded as limited in relation to this thesis project and the investigation of taxonomies of design research method. This is not only because of its underlying conceptualisation of method as artefact, but also because of its claimed generalisability as a system for classifying all design methods. Also, the function/behaviour/structure framework (FBS) is focussed on methods of designing rather than design research, that is methods are conceptualised as ways of solving design problems rather than as methods for conducting design inquiry. Secondly, it is framed by an engineering design approach that is primarily concerned with the design of physical artefacts and doesn't engage with the sorts of methods, proposed by theorists like Krippendorff, that are involved in the design of brands, services, systems, projects and discourses The distinction between design methods and design research methods has been discussed in Chapter Six.

The artefactual orientation of this approach is not restricted to the definition of the FBS model in terms of the teleology, attributes and components of design artefacts, but to a notion of design methods as process artefacts, and the designer as user of these artefacts.[96] This can also be seen as a notion of methods as tools. The analysis of a tool in terms of its function, structure and behaviour

[96] In the FBS system, as initially defined by Gero and Kannengiesser (2007), the function of an artefact is defined as its teleology, the behaviour of an artefact is defined as the attributes that are derived, or expected to be derived, from its structure, and the structure of an artefact is defined as its components and relationships. (Kannengiesser, 2008)

indicates an orientation to the instrumental that is based on another dualism – that between ends and means. Kannengiesser recognises that design methods require 'elaborating, combining and modifying these methods to fit with the individual design problem' (p. 263/9) and acknowledges that design methods as artefacts are more complex than domestic artefacts, which 'readily afford specific user behaviour without involving significant reasoning effort' (ibid.). He suggests that this process of adjusting methods may even be viewed as an act of re-designing, rather than of just using a method. However, the model itself provides a highly formalised way of supporting such adaptation. The FBS model, where all design methods are purportedly represented 'independently of the specific discipline, school of thought, or level of detail' (p. 263/12), is fundamental in approach, rather than discursive or interpretive.

The FBS model provides a systematic and prescriptive way of classifying methods. However, Kannengiesser (2008) does acknowledge there is a difference between a formal method and 'the actual course of design actions' (p. 263/9), while recognising the value of methods in 'providing useful guidance for meeting constraints that an individual designer may not be fully aware of' (ibid.). He suggests that prescriptiveness can be viewed as an aggregate construct that has four dimensions. These are: certainty, granularity, flexibility and authority. These dimensions support a consideration of the nature and some of the variations found across descriptions and applications of method. Certainty is described by Kannengiesser as the degree to which method, structure and behaviour are specified at the outset of method use (p. 263/10). Granularity is defined as the level of detail that is specified or made evident at the outset of method selection. Kannengiesser notes that the level of granularity is normally related to the level of difficulty associated with a design activity. Flexibility identifies variants in relation to possible or permissible methods. The more variants allowed, the more flexible the method. Finally, authority relates to the organisational or socio-cultural context of method use, which Kannengiesser suggests may be predefined or negotiated with stakeholders. The model raises some key issues in the understanding and categorisation of methods. It explains terminological issues based on 'different process perspectives that can be interpreted as different approaches to method structure' (p. 263/11). It also purports to address the issue of the prescriptiveness of method by using a four-dimensional construct that allows for the representation of variation, rather than implementing a binary 'prescriptive/descriptive' distinction.

Kannengiesser proposes this ontology as a language of representation that can provide formal representation of design methods for use in computational

systems to support design. Kannengiesser's ontology presents a detailed analysis of design method. However, in spite of claims that 'the underpinning ideas are applicable to any other design discipline' (p. 2), it presents a particular instrumental view of design method through an engineering framework, with an artefactual emphasis based on prescriptive notions of function, structure and behaviour. Vermaas and Dorst (2007) have argued that 'the uneasy relationship between description and prescription [of method] can be traced back to the very paradigms of design methodology themselves' (p. 134). They recognise two fundamental tendencies in the ways design methodologists have analysed designing (p. 152), based on different aims: to analyse or to improve design methods.

While recognising that these two distinct projects might be joined, for example by using studies of design cases to develop better methods, a normative evaluation of design, they suggest, will inevitably have to occur at some point. Vermaas and Dorst recognise that the history of design methodology did not 'follow a clean meta-methodological route through the different approaches' (p. 152). They identify 'a lack of interest in the theories aimed at understanding and explaining the how and why of the observed design activities and a rush from observation and description to prescriptive modelling and the construction of design tools' (p. 153). While Kannengiesser's model and Vermass and Dorst's analysis are focussed on design methods, they contribute to the broader discourse of design research methodology in focussing intently on the longstanding and still problematic issue of methodic specificity and generalisability in design.

Research approach	**Object of study**	**Output**	**Resulting in**	**Focus**
Empirical research	Actual design cases	Descriptive models	Capture of aspects of actual designing	Analysis
			Theories explaining designing	
Normative evaluation	Comparison between successful and less successful cases	Prescriptive methods and models	Tools to help compliance with these methods and models	Improvement

Table 13: Descriptive and prescriptive approaches to design methodology based on Vermaas and Dorst (2007)

The critique by Vermass and Dorst (2007), and the subsequent refinement of Kannengiesser's model from his earlier work with John Gero (Gero and Kannengiesser, 2004; Gero and Kannengiesser, 2007), has seen the introduction of more flexibility in this conceptualisation, and further consideration of the relationship between prescriptive and descriptive approaches. This contrasts sharply with earlier polarised debates between those for or against the prescriptive approaches of the Design Methods and the AI in Design movements and those of more descriptive, constructivist or human-centred approaches. In relation to the broader focus of this thesis on design research methodology, Kannengiesser's model and Vermaas and Dorst's critique are focused on design methods as methods of designing, rather than design research methods. Kannengiesser's approach, with its notions of structure, behaviour and function, is located in an instrumental paradigm with a focus on the design of artefacts and design methods as tools.[97]

Jonas and Chow (2008, 2010) have developed what they have described as an integrative 'methodological tool/medium for research through design', called the Matching Analysis Projection Synthesis Project or MAPS. They propose that 'research is a special mode of design' (p. 16), and are developing the MAPS system as a way of 'supporting practice oriented design, innovation and research processes' through an 'integrated knowledge and communication platform for research through design' (p. 9). Their system engages with both design and design research methodology.

Jonas and Chow identify a number of the 'unproductive dualisms' (p. 1) that have historically characterised design research methodology, including the ongoing tension between descriptive and prescriptive or normative approaches. Their MAPS model is proposed as a dynamic process model based on second-order cybernetic approaches, rather than a tool or problem-solving system. While recognising the limitations of generic process models within the Design Methods Movement as inflexible, normative standards, Jonas and Chow propose that both scientific methods and designerly approaches and their respective normative and descriptive methods have a place in design. These approaches, they suggest, can be integrated through flexible design process structures, based on second-order cybernetic perspectives. Second-order cybernetic systems incorporate feedback loops and can therefore respond and adapt to changes within a system and changes due to external factors. Jonas and Chow's approach aims to move beyond fixed taxonomies and static conceptual

[97] Instrumentalism is 'a system of pragmatic philosophy that considers ideas to be instruments that should guide our actions and their value is measured by their success' (*WordNet*).

relationships to enable dynamic models that can integrate both normative and descriptive methods. They describe this approach as conversational rather than focussed on control (p. 16). The approach taken in the MAPS project would seem to shift the focus from static taxonomies, based on a notion of design as artefact and methods as tools, to a notion of design method that is akin to Meyer's 'network of dynamic, processual relationships' (2009, p. 6), and which proposes a design methods system that is discursive, rather than prescriptive or oriented towards problem solving. Jonas and Chow claim that the MAPS system can help experienced design researchers locate references on design research processes, methods and tools, instruct researchers through step-by-step guides about research processes, methods and tools, promote the value and process to partners and clients, and support collaboration with partners and clients (p. 8).

The notion of process types developed in this model is distinct from Kannengeisser's function/behaviour/structure model. The FBS approach is based on an artefactual ontology of design, while the MAPS system draws from a notion of research through design, and is thus process oriented. Jonas and Chow define research for design as normative, aiming at pre-rationalisation. They identify research about design as descriptive, concerned with a post-rationalisation of existing processes. Research through design, they suggest, is conversational, and involves a circular play between pre- and post-rational processes (2008, pp. 15–16). This notion of practice as a discursive medium can be contrasted with Scrivener's artefact-oriented theory in which 'creative', practice-based research is associated with artefact creation, rather than knowledge creation, while 'problem-solving' approaches to design research use design practice to produce knowledge to be demonstrated through the resulting artefact. The notion of reflection in action in Scrivener's model is cerebral and individual rather than conversational. Jonas and Chow's interpretation of research through practice is discursive and dynamic, recognising a more radical potential for research through practice to engage, challenge or extend notions of design and its various pre- and post-rationalisations. This potential cannot be developed through a notion of practice that is defined by the production of mute artefacts or an approach to ontology development that is static. An approach activated in research through practice, as a discursive and generative process, underpins the development of this critical and dynamic medium for design research.

Conclusion

The categorisations of approach identified in the comparative analysis of design research theories in Chapter Six were compared with findings of a phenomenographical study of academic researchers' approaches to research by Akerlind (2008). The findings of this study identified four distinct conceptualisations of research that were not related to disciplinary frameworks or subject backgrounds of the research academics involved, but related to individual world views and values associated with the activity of researching. The correlation of these perspectives with the ways particular groups of design research theories were conceptualised, which were also unrelated to the paradigmatic frameworks underpinning the approaches of particular theorists or to the paradigms represented in particular theories, were very similar. This was seen as supporting the findings of the analysis of theories conducted in this research and confirming the potential usefulness of these categories as a method of linking with ways researchers might think about and approach research. This would support information hermeneutics if it was included in the structuring of an information resource about design research methodology. It was also recognised that certain key texts that have been pivotal to the articulation of specific positions in the development and theorisation of design research could be used as pivot points to locate different design research theories through the various ways they interpret these reference texts and incorporate or use them to support broader mappings of the field of design research.

Some paradigmatic typologies based in disciplinary notions of research from areas outside of design were also considered in this chapter. This was done to investigate whether they might provide another way of thinking about paradigms in design research, given the heterogeneity and lack of agreement on any such categorisation within the discipline of design. While ideas and research approaches from the social sciences have been influential in the development of design research, the limitations of attempting to use an epistemological framework from this area was evident when attempts were made to map a range of design research methodologies to such a model. It was clear that models from other disciplines cannot adequately represent the full range of design research approaches, and, while some approaches mapped easily, others sat across more than one category, while others could not be adequately represented in any of the social sciences frameworks presented in Mackenzie and Knipe's model of research paradigms in the social sciences. While issues such as terminological diversity and the widely different definitions and understandings of given terms are certainly part of this problem,

it is recognised that the answer does not lie in imposing standardised vocabularies or fixed definitions. Rather, these points of terminological overlap and conceptual diversity can be regarded as starting points for deeper inquiry into different theories and methodological understandings, and can be used to help researchers better locate their own epistemological orientations by engaging with this discursive field.

Finally, a consideration was made of typologies of method, both from outside and within the discipline of design. The approaches taken in models from the information and social sciences were both framed in terms of research oriented to data collection, analysis and theorisation, which were recognised as being limited in terms of the potential range of design research methodics. Further consideration was given to AI in Design models, an area in which most work on design methods typologies has taken place in the pursuit of problem solving or expert systems. While Kannengiesser's FBS framework is artefactually based and instrumentally oriented, it does recognise a level of relationality between functional, structural and behavioural attributes, which gives his most recent model some dynamic expression. Kannengiesser's model may offer a useful approach to analysing artefactually oriented, technological methods, but it cannot represent approaches outside this scientific domain, in spite of its claims to universality. The significance of Jonas and Chow's MAPS project is that it introduces a model of design research methodology that represents a range of different approaches; it was developed as a system rather than a static table or hierarchical taxonomy. The model is dynamic and the user of the system can move through a number of stages, each of which presents a range of options – as project dimensions, domains, constraints and types. This allows for the incorporation of contextual factors and recognition of the role of the designer and the role of stakeholders. It covers a broader perspective that recognises the technological and market-oriented aspects of design research and innovation, as well as social innovation processes (p. 14). This enables a fuller representation and engagement across the 'trans-discipline of design' (p. 16), and introduces a critical distinction of method as medium or agency, rather than instrument or tool. It re-emphasises the engagement of the designer in the design process and/or the researcher in the research process as a discursive, rather than a formalised process. The frameworks, typologies and systems considered in this chapter have informed the conceptual approaches for a series of experiments undertaken to explore the possible development of a system for representing and engaging with design research methodology, which is the focus of the next chapter.

Chapter Eight

An Information Framework for a Design Research Resource

Introduction

This chapter discusses the context, experimental development and evaluation of an information framework and system design for a design research resource. This design draws on the analysis and interpretation of design research theories and frameworks developed through this research and documented in the preceding chapters of this thesis. Inquiry into and experimentation with a particular delivery platform (Semantic Media Wiki) used to develop an information system to proof-of-concept stage is also discussed. This prototype system is analysed and evaluated, with recommendations made for the further refinement of the information structure. It should be noted that this early prototype, reproduced in screenshots in Appendix Five, was developed in 2008–09. Subsequent structural recommendations made in this chapter have not been translated into a practical application at this stage. The rationale behind the development of the prototype is that practical application can test the relevance of interpretation. The development, evaluation and conceptual refinement of a system design that can represent, relationally articulate and enable deeper engagement with design research methodology is presented as a way of testing the various theoretical perspectives and relationships identified through this inquiry and as an indication of the agency that could be introduced through such a resource and system. This approach recognises the need for more relational ways of accessing information to enable greater understanding of and engagement across the heterogeneous field of design research. Initially, within this chapter, system development is considered in relation to some critical issues from a broader discourse about information, knowledge, memory, technology and the semantic web. While the focus of this project is not on technical implementation, it is recognised that the technology through which a system is built will enable and limit the form and agency of a resource. Aspects of the

prototype resource are discussed in relation to these issues. Finally, recommendations for the further development of a resource, informed by this mnemotechne project research and parallel developments in technologies, design research theory and education, are discussed in the conclusion.

The question that underpinned this initial system design development was whether the interpretations and categorisations of design research theories identified through this research could be incorporated into the information architecture of a resource about design research methodology. A second question related to this development was whether these different frameworks could be systematically related to support a richer and more discursive engagement with the field of design research methodology. Such an approach, it was proposed, could offer opportunities for pathways to engagement more closely aligned with a researcher's particular understandings and motivations for doing research. This relational and hermeneutical approach would be quite distinct from more formalised and prescriptive models. While the development of a design research resource was originally seen as being the main focus and outcome of this thesis, the project changed as it was realised that the heterogeneity of the field and lack of relational analysis of design research theories made the development of any formally based ontological system to structure a more conventional resource difficult, if not impossible. This saw the project focus shift from an artefactual orientation to a critical process involving the analysis, interpretation and relational modelling of design research theories, with system design being seen as a way of further exploring, developing and testing the relational model. This shift, from a focus on the production of an artefact to an exploration of ways that the information categories identified in this research might be modelled, related and activated through an application, was a shift from a research approach that was outcome-focussed to one that was strategic or methodologically oriented. The investigation and identification of a technical approach that could support information hermeneutics, rather than formal search and retrieval hierarchies, is also considered as part of this process. In this context, one outcome of this research is a discursive engagement about and through a prototype system, rather than a designed artefact that embodies research knowledge in the form of a fully operational information system.

As discussed previously, according to Gadamer (1975) the validity of an interpretation can be gauged not only through the degree to which it gives rise to new insights and meanings, but also in terms of the way it stands up to the test of its practical application. Snodgrass and Coyne also recognise the value of application as a way of testing interpretation: 'The assessment of the validity of

a metaphor or model proceeds by an appeal to its potential deployability, arrived at by projective anticipations and not by objective logic or subjective intuition' (1992, p. 69). Experimentation with the development of a prototype system has been a way of testing validity through an exploration of the applicability of these findings. The original impetus behind this thesis project was to develop a mnemotechne – as a system for recording, identifying and recalling information about design research methodology through the development of an ontological structure. Through the process of the research this focus shifted away from the development of a formal ontology to the exploration of a model that might allow theories to be represented in relation to various points of intersection and commonality through the different frameworks identified in the inquiry. In spite of this profound conceptual and methodological shift, the notion of the mnemotechne has remained a valuable guiding metaphor.

Metaphors of Information Organisation and Retrieval

A consideration of the mnemotechne raises issues about the meaning and relationships between information, knowledge, structure, memory and technology. As identified in Chapter One of this thesis, mnemotechne literally means the art or craft of memory. The Greek word *techne* also forms the root for the terms technique and technology. Aristotle made a distinction between practical know-how or *techne*, and *episteme* or knowledge (Meyer, 2009, p. 4). The ancient mnemonic practices described by Frances Yates (1989) were not so much concerned with remembering information, as in rote learning, but in spatially locating what needs to be remembered and 'retrieving' it through a sort of mental navigation process – using the method of loci (place) or *ars memoriae*. The technologies that developed to support these techniques of recall evolved into physical memory devices such as memory theatres and *wunderkammer* or cabinets of curiosity.[98] These approaches associated different types of information or meaning with objects, structure, place and navigation to activate memory and knowledge. Stiegler (1988) has taken this notion further by proposing a concept of mnemotechnics (through writing and other media technologies) that moves from individual to collective human knowledge. Historians of computer science, such as John Sowa (2000) and Lev Manovich (2001), regard mnemonics as precursors of computational knowledge systems,

[98] In the twentieth century these approaches have been re-examined and extended through art historian and scholar Abby Warburg's unfinished Mnemosyne Atlas (1924–29) and more recently in the artist Gerhard Richter's Atlas (1961– present).

recognising earlier encyclopaedic and narrative forms of recording, systematising and recalling information and the use of spatial metaphors in human mnemonic systems as prescient to computational systems for the navigation and retrieval of information. Vannevar Bush's concept of the memmex is one example of this bridge between earlier card-based library retrieval systems and computers (Buckland, 1992; Landow, 1992). The term mnemotechne has been retained in this thesis title because it implies a history, as well as the ordering and location of information through techniques and/or technologies of memory and engagement. Importantly, it acknowledges both the human and the technological aspects of information systems.

The experimental development of a design research resource is recognised as a stage or movement towards a mnemotechne of design. This recognises the increasing potential of computer-based systems to support the development of networked, relational resources and associated discourse communities. There is also an acknowledgement of the different histories of design research and their various positions, framings and reinterpretations. Given the particular modes and specific qualities or framings of earlier mnemotechnologies, it was recognised that some further consideration should be given to the underlying conceptual basis and approaches to the design of computer-based information systems.

Structure and Knowledge

Structure is concerned with the nature, configuration and stability of patterns and relationships between entities. Structure defines the forms of interrelationships within a system. Structures can take many forms, including hierarchies, as sets of one-to-many relationships or networks featuring many-to-many relationships. In the field of information science, there are many approaches to structuring information – from informal lists to taxonomies to formal ontologies. Structures can be static, whereby relationships remain the same, or dynamic, where relationships can vary or change. The way information is structured affects what can be represented and how information can be accessed and used.

Research is concerned with the development of new knowledge. The term 'knowledge' can be used to describe expertise acquired through experience and education or the theoretical or practical understanding of a subject. Knowledge acquisition involves complex cognitive processes. Knowledge can be gained

from information, but knowledge and information are not precisely the same thing. This issue is complicated by different conceptualisations of information. *WordNet* lists six different meanings of information, including information as:

- Data, a collection of facts from which conclusions may be drawn
- A message received and understood
- Knowledge acquired through study or experience or instruction

The first two of these definitions present an objective notion of information as an entity that can be transmitted and received, 'that could be passed from one place to another much like physical artefacts can' (Boyarski et al., 1997, p. 45). Computer technologies and the methods developed to organise and retrieve information are based on such objective notions of information, which can be syntactically represented in systems that are based on rules of formal logic. Boyarski et al. suggest that the concept of information in relation to technology is 'at best ambiguous and at worst deviously misleading our understanding of why we are developing this technology' (1997, p. 45). The assumption here is that all information can be formalised into symbolic representations such as mathematical expressions, which can, in turn, be processed by computers. The third definition indicates a transitive relationship between information and knowledge, implying that knowledge comes from the interpretation and mediation of information by human beings through experiential, social or disciplinary perspectives. This culturally inscribed notion of information, which is about understanding information as a sort of knowing, rather than information as objective data, cannot be adequately represented using current information structures based on formal systems of representation (Veltman, 2004). Given the heterogeneity of design research theory and its terminology, and the ongoing disagreements about the ontological and epistemological foundations of design research, any extensive information framework would need to recognise and represent the cultural basis and historical context of particular design research theories.

Definitions of the term 'knowledge' also vary and, as Meyer (2009) notes, are matters for ongoing ontological debate. Meyer identifies two distinctions about knowledge that are significant for design research. These are between explicit or declarative knowledge and between implicit or procedural knowledge (Polyani, 1966). Notions of explicit or declarative knowledge and implicit, tacit or procedural knowledge, as conscious and communicable knowledge contrasted with unarticulated or intuitive knowledge, have been critical in the development of discourse about design research and knowledge formation

(Friedman, 2000; Rust, 2004). Discourse about the psychology of knowing also distinguishes between forms of declarative and procedural knowledge. Declarative knowledge, associated with *episteme*, can be described as 'knowing that', and it can be declared or represented in schemas as an ideational construct.[99] Procedural knowledge, associated with *techne*, can be described as 'knowing how', and is drawn from doing and actions that may not be easily expressible. Problem solving, making plans and developing arguments are examples of activities that require procedural knowledge. Forms of explicit and declarative knowledge can be articulated and thus formalised, while tacit and procedural knowledge, which involves 'know-how' is not so easily expressed. A key focus in design research has been on the articulation of implicit knowledge into explicit knowledge, for example through the description, analysis and theorisation of design processes.

Between the dualistic positioning of declarative and procedural knowledge is another hypothetical construct – structural knowledge. This has been proposed as a way of describing how the knowledge of concepts within a domain is interrelated, or how schemas interrelate with other schemas. Jonassen, Beissner and Yacci (1993) have suggested that structural knowledge can mediate the translation of declarative knowledge into procedural knowledge and might facilitate the application of procedural knowledge. Structural knowledge describes how declarative knowledge is interconnected and can provide a conceptual basis for understanding 'why'. Jonassen et al. recognise that: 'In order to know how you must know why' (p 5). The relationships between declarative, procedural and structural knowledge can also be related to classical notions of *episteme* (knowing that), *techne* (knowing how) and *phronesis* or practical wisdom (knowing why). These concepts can also be associated with Meyer's notions of the 'what', which is scientifically oriented, the 'how', which is methodologically oriented, and the why, which he suggests is politically oriented (2009, p. 5).

The notion of structural knowledge is based on schema theory (Rumelhart, 1980; Rumelhart and Ortony, 1977).[100] This is a cognitive model wherein knowledge is stored in packets or schemas that comprise mental constructs for ideas. A basic feature of schema theory is that, in it, human memory is organised

[99] A schema is an organisation of concepts and actions that form an internal representation of the world (*WordNet*).

[100] In computer science the term schema is used to describe 'structured, machine interpretable collections of information models consisting of structured relationships between data elements' (U'Ren, 2002).

semantically.[101] That is, memory is organised in relation to meaning as it is expressed and represented through language. Schemas are arranged in networks or schemata of interrelated schemas, known as semantic networks. Sowa defines semantic networks as 'graphic notations for representing knowledge in patterns of interconnected nodes and arcs' (1992, p. 1493). While computer implementations of semantic networks were first developed for artificial intelligence and machine translation, there were earlier parallels in disciplines such as philosophy, psychology and linguistics. There are many different types of semantic networks, but they are fundamentally all forms of declarative graphic representation that can be used either to represent structural relationships between knowledge concepts or to support automated systems for reasoning about knowledge. Such networks can range from informal to highly formalised systems based on logic. Logic, in this context, is the declarative and procedural representation language used in computer programming.

The notion of mnemotechne can be related to the idea that human memory is organised semantically and structurally. Concept mapping is considered to be method of representing structural knowledge. As discussed in Chapter Three, the meaning of a concept within a concept map depends on the relationships it has with other concepts. These relationships between concepts are specified by propositional terms.[102] Semantic networks are formed through the network of associations among related concepts. Semantic networks are sometimes described as concept maps, and have been defined by Jonassen (2004) as tools for spatially representing concepts and their interrelationships. Mapping, or semantic networking, is the process of identifying concepts, arranging those concepts spatially, identifying relationships among those concepts, and labelling the nature of the semantic relationship among those concepts. Novak and Cañas (2006) describe this process as forming propositions: 'Propositions contain two or more concepts, connected using linking words or phrases to form a meaningful statement. Sometimes these are called semantic units or units of meaning' (unpaged).

Concept mapping, semantic networks and structural knowledge are also described as cognitive structures. They have been linked to the patterns of relationships among concepts in memory (Preece, 1976). Shavelson describes them as hypothetical constructs 'referring to the organisation of the relationships of concepts in long-term memory, particularly semantic memory'

[101] Semantics is the study of meaning in language (*WordNet*).
[102] A concept being an abstract or general idea inferred or derived from specific instances (*WordNet*).

(1972, pp. 226 and 227). In cognitive science the notion of structural knowledge is central to both human understanding and machine information-processing and communication. It must be recognised here that while such cognitively based typologies of knowledge, theories of memory and associated forms of structuring have been productive in supporting the development of computerised information systems, this instrumentalist approach has significant limitations. A comparison of the schematisation of ideas evident in semantic networks with the rich and 'principled over-interpretation' that Garcia-Duttman (2002) recognises as characteristic of a form like the essay, highlights the divergent perspectives of philosophical and cognitive science approaches. The conceptual and representational formalism required in structurally based semantic systems stands in stark contrast to the openness and fluidity of ideas leading to understanding that is inherent in hermeneutical interpretation. However, the purpose and form of an essay as 'an analytic or interpretive literary composition' (*WordNet*) that explores a particular issue or subject and that of an information system that 'provides for data collection, storage and retrieval; facilitates the transformation of data into information and the management of both data and information' (Ni, undated) are quite distinct.

Information science, as the systematic study of the sources, development, collection, organisation, dissemination, evaluation, use and management of information (Reitz, 2003) has its own dual knowledge thesis. This is based on a distinction made between scientific notions of information as an object or thing, and constructivist notions of information as a subjective concept or sign. This is conceptually distinct from knowledge categories (such as declarative/explicit and procedural/tacit) in that both objective and subjective types of information can be declared and made explicit. One way of differentiating these conceptualisations is that one is framed empirically, claiming to identify 'real' things in the world, while the other is based in interpretation. Different disciplinary 'world views', and tensions between objective and subjective approaches to the theory and the technical methods of the reception and communication of knowledge, have contributed to these different concepts of information. The methodological approach taken in this thesis refuses this subject-object dualism, both as a basis for conceptualising design as a discipline and as a theory of information.

Information systems, whether they are manual or computerised, are concerned with organising bodies of information and making them accessible – by nature they are schematic. The notion of structural knowledge is central to human understanding, evident in the classical practices of mnemotechne, in earlier

analogue information resources such as the library and the encyclopaedia, as well as in machine information processing and communication. The development of information structures and the use of information systems involves interpretation. Semantic structures like C Maps introduce a way of working more closely with the interpretation and meaning of texts. Such granularity is not easily represented in more formalised 'top-down' structures like computer ontologies. In theory, semantic networks, based on natural-language structures or syntax can be refined, formalised and translated into symbolic representations such as mathematical expressions, which can, in turn, be related to other information structures and processed by computers. Experimentation with organisational strategies to develop an information system about design research methodology drew from various relationships identified between different types of information such as pivotal reference texts, specific project exemplars and case studies, the concepts and structures of individual C Maps from theories, the clusters and categories identified through a comparative analysis of groups of theories, and some broader framings of research paradigms, methodology and method related to theories of design research.

Information and Technology

Objective notions of information as data and message (discussed earlier in this chapter) are appropriate for certain areas of representation and types of engagement. Veltman (2004) recognises that 'the restricted sense of meaning evident in current information technologies is adequate for many areas of business and technical purpose, where machine to machine communication is concerned with current information or "today's world view"' (p. 39). Such systems are structured to support simple transactions. However, within cultural domains Veltman recognises that purpose and definition are much broader: 'History, context and the cumulative body of knowledge are significant, terms and conceptualisations are not always static, nor do they always have a single meaning' (ibid.). Such issues resonate with the problem of representing and communicating design knowledge that underpins this thesis inquiry.

As the original purpose of computers was the computation of numbers, the mathematical and logical basis of computing was, and is, fundamental to its development and modes of application. Veltman suggests there is a danger that 'the tools designed to help us become an end in themselves: merely providing solutions for the problems which they create' (p. 12). That is, the logical and

formal basis of computing becomes the framework through which all human knowledge and thinking must be structured and operationalised. Associated with this assumption is the notion that principles of logic are reflected in the functions of language through grammar or syntax.

Within the design domain, issues of design knowledge representation, first raised in the 1960s, have since been limited to areas of engineering design and architecture. Archer (1979) wrote of the potential that the development of information technologies offered for the organisation of information about design research and its potential for helping consolidate aspects of the discipline. He suggested that such developments would require better ways of structuring or organising design information to establish 'recognisable markers for centres of interest in design research' (p. 35). However, the issues of structuring and organising information about design research, and establishing agreements on such markers, have emerged as more complex and difficult than Archer initially envisaged. This is due not only to the diverse nature of design information, but due too to the ways that information is conceptualised and structured within information systems.

The pluralism of design discourse and lack of agreement about any overarching or unified design theory contradicts any singular or highly formalised notion of design information, and issues of definition and terminological inconsistency are regarded by some in the design research community to be a significant and ongoing problem (Love, 2000a, 2000b, 2001, 2002). Other design theorists argue against fixed or standard terminology in what is – and must be – a pluralistic cultural domain (Krippendorff, 2006). The formal logic and fixed definitions that are used in business and technical information systems cannot be imposed across the heterogeneous and culturally inscribed field of design. Liddament (1999) recognised that the computationalist paradigm offered a promising way of conceptualising design activity through 'a systematic treatment of a hitherto messy and rather disparate domain, a scientific approach with a correspondingly rigorous methodology' (p. 44), but he questioned a number of assumptions behind this approach. His concerns stemmed from the basis of computation being founded on the belief 'that human cognitive ability must be encodable in some specifiable set of explicit, unambiguous instructions of the type that could be produced in the form of a program to be run on a serial computer' (ibid.). The conceptualisation of a mechanical process as cognitive activity assumes that such activity can be reduced to specifiable sets, and overlooks distinctions between human and machine cognition.

Liddament understood that design processes cover a broad spectrum of skills and approaches, ranging from calculus through to the application of 'critical thinking' leading to insight, original design solutions and creativity in the development of possibilities. His criticism of the mechanical application of problem-solving processes, particularly to such high-level problem-solving skills as organisation, analysis, definition, development, refinement and evaluation, was that it led to a reductionism that robs design activity of its essential character. He identified a fundamental problem to be the conceptualisation of language within computing. This is based on the assumption that principles of logic are reflected in the functions of language through grammar or syntax. As a way of countering such reductionism, Liddament proposed a language-oriented approach based on Wittgenstein's conception of 'language-games' as a way of moving beyond the formal syntactical rules and static definitions that are defining features of information science approaches.[103] He suggested that a reconceptualisation of computational techniques through this alternative epistemological framework could assist the development of a new paradigm that would aid design research. However, at the time of Liddament's death in 1999 there were few computer-based alternatives to formal approaches. The notion of language-games underpins the relational nature of this project and the basis of the information system design.

Web-Based Developments

While computationally based information resources were initially organised in structured databases, the rise of the internet and, in particular, Web 2.0 (socially networked) and Web 3.0 (semantic web) technologies have introduced new approaches not only to the way information can be collected and organised, but to the way it can be accessed, shared and modified. The defining aspect of Web 2.0 has been the power of the internet to harness collective or social intelligence. This has challenged traditional systems of authorship and publication in relation to information gathering, discourse

[103] In his later work, and in a rejection of his earlier work on logic, Wittgenstein used the term 'language-game' to describe simple forms of language connected by family resemblance. The concept was intended to emphasise that the speaking of language is part of an activity where meanings are not separated from each other by sharp boundaries, but blend into one another. The analogy between a language and a game emphasises that words only have meaning in relation to human life and activities.

development and resource creation. It has also given rise to new commercial models, particularly in areas of software development, such as the open source movement, and in areas like online retailing. However, the term Web 2.0 does not refer to particular technological advancements, but rather to changes in the way the World Wide Web is used. In relation to this research project, certain features associated with Web 2.0 were recognised as having potential to help address the problem of developing and organising a resource about design research theory without using formal information structuring methods. These included:

- The process of users 'tagging' information for data recognition and retrieval rather than information being pre-organised into formal taxonomies. Ciastellardi, de Almedia and Kerckhove (2010) have recognised that such informal tagging systems can be used to develop vocabularies and indexing systems through user engagement rather than their being developed by technology experts and ontologists
- The development of participatory publishing or user-as-contributor strategies, for example blogs and open-content publications like Wikipedia, where users can initiate, comment on and/or supplement content
- The development of 'reputation' or relevance ratings, via reviews or usage statistics, which give feedback on usage and indicate possible relevance as well as helping establish trust
- The notion of the web as comprised of components, where sections or pieces of information can be hyper-linked and more complex information relationships developed and extended over time
- Granularity of content can also be built up and detail developed over time
- The use of a 'long tail' strategy that could include less well-known theories and methodological approaches, which may have relevance to more specialised areas or emerging contexts and applications[104]
- The right to remix, where a system is not static and allows users and participants to reinvent

[104] The 'long tail' (Anderson, 2006) is a statistical property that recognises that a larger share of population rests within the tail of a probability than observed under a normal or 'Gaussian' bell-shaped distribution. In online retailing it is used to describe a niche strategy of selling a number of items in relatively small quantities over a longer time or space.

- Where emergent user behaviour is not predicted, that is where there is flexibility in the ways a user might approach, access and respond to information

This analysis of potentials associated with Web 2.0 suggested the development of a website about design research, constructed as a wiki or blog that could develop over time through the engagement of the design research community. However, initial experiments with building a wiki led to the realisation that a more detailed approach to structuring was required if different information relationships between diverse design research theories and different research frameworks were to be adequately and dynamically represented. In addition, the basic wiki software was limited in terms of search and query functions. Web 3.0, or the semantic web approach, envisages the World Wide Web as a universal medium for data, information and knowledge exchange, to be achieved through the definition of the semantics of information and services on the web. Many aspects of the semantic web are theoretical possibilities, still to be implemented or realised. (Web 3.0 approaches were addressed previously in Chapter Two.)

Semantic Media Wiki technology, which combines aspects of Web 2.0 wiki technology with semantic web (Web 3.0) capability, was identified as a promising technology to explore in developing a design research resource.[105] This technology can incorporate social networks and collaborative content development as well as supporting the development of semantic structures to support computational agency. It was also recognised that C Maps can be automatically exported into OWL RDF, a semantic web language, so that the structural knowledge contained in C Maps could be incorporated into the structure of a semantic media wiki to provide relational information structures within the resource. However, it was also recognised that there remained a number of limitations with semantic web technology that would restrict the capability of such a resource. For example, there could be a disjunction between a semantic structure built across the information in a design research resource wiki that has a level of internal consistency in relation to the semantics of the content analysed, and broader, external meta-frameworks that could provide an overarching structure to link information across a range of web-based resources.

[105] Semantic Media Wiki (SMW) is a free extension of Media Wiki – the wiki-system powering Wikipedia – that helps to search, organise, tag, browse, evaluate and share the wiki's content. While traditional wikis contain only texts that computers can neither understand nor evaluate, SMW adds semantic annotations that make some of this information computer processable (Krötzch et al., 2005).

Another limitation would be associated with any future requirement to introduce greater formalism into such a resource should further knowledge discovery capabilities be desired or required. Veltman (2004) has recognised that, in spite of the aims and the optimism surrounding the development of the semantic web, its limitations are, indirectly, consequences of earlier, historical approaches to knowledge organisation and computing. While it is beyond the scope of this thesis to critique the historical development and limitations of computing, an overview and evaluation of the conceptual/technical approaches to knowledge representation in relation to semantic web developments is given here to provide some insight into these limitations. This overview also provides a framework for discussion of experiments for a design research resource that were conducted as part of this thesis research.

Knowledge Representation

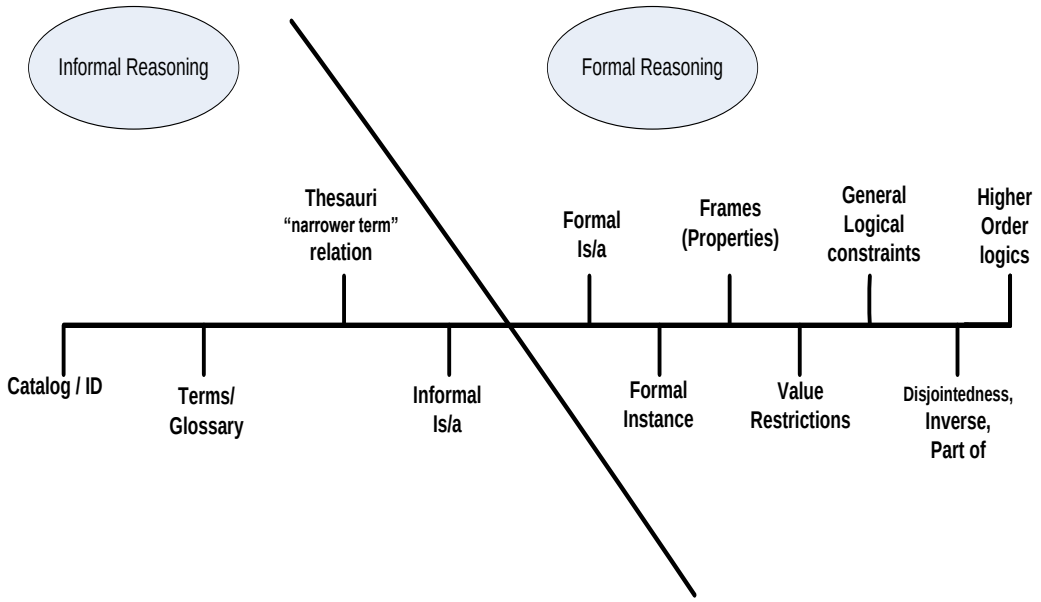

Figure 31: McGuiness's taxonomy of ontologies, from Legg (2007)

The main focus of knowledge engineering is to develop theories and systems for expressing structured knowledge and methods for accessing and engaging with it. Knowledge engineering has two aspects – one is the organisation of information, the other is the development of computational agency in the form of methods for search, selection, optimisation and prediction. The focus of this thesis research is concerned with knowledge representation, rather than with forms of computational reasoning. However, forms of structuring are closely related to the capability and forms of computational reasoning. McGuinness

(2003) has developed an overview or taxonomy of information technology approaches that are used to organise information (see Figure 31). The taxonomy presents a range of ontological approaches that show increasing logical expressivity. Logical expressivity in this context refers to the relationship between the formalism used to organise and represent information and the capability of a programming language to express the solution of a problem.

Ontological approach (McGuiness, 2003)	**Definition and examples (Legg, 2007)**
Catalogues	Finite lists of terms used as a controlled vocabulary, without defining terms
Glossaries	As lists of terms with meaning of a term stated in natural language
Thesauri	Identify some rudimentary semantic relationships in a glossary such as one of synonyms (example: a CD and compact disc mean the same thing)
Is/a relationships	Where there is membership of kind or class, often included in thesauri, but not expressed in a machine processable way
Formal is/a and formal instance	Formal classes with subclass relationships that can support formal reasoning
Frames	Involve subclass relations rendered transitive, providing an inheritance or subsumption hierarchy
Value restrictions	Assertions made about domain and range of ontological relationships (example: every named artist of a CD is a person)
General logical restraints	Inter-set relationships from classical set theory (example: union [the category of 70's music consists of music from 1971, and from 1972 and from 1976, etc) and intersections (example: the category of music recommended by group D consists of all songs that are on their iPods)
Disjointedness	Inter-set relationships based on distinction (example: no jazz CDs are heavy metal CDs). Sometimes has the complexity of some description languages (DL)
Higher-order logics	Includes first-order logic,[106] modal logic and context logic. Legg notes that the problems of inferential tractability[107] are

[106] First-order logic (FOL) or predicate logic is a formal deductive system that extends propositional logic by allowing quantification over individual objects in a given discourse domain. Unlike natural languages, FOL uses an unambiguous formal language – using mathematical structures. While propositional logic deals with simple declarative propositions, first-order logic additionally covers predicates and quantification.

	compounded here, due to the vast amount of information on the WWW and because little research has been done on such languages, in comparison to the work done on description languages (p. 428)

Table 14: Further definitions and examples to expand McGuiness's taxonomy, by Legg, (2007)

Legg (2007, pp. 426 and 427) has developed further definitions and examples to expand McGuiness's taxonomy, which are summarised below. Legg uses this framework to locate ontologies in the semantic web, and she identifies three distinct groupings based on levels of potential functionality in terms of computational processing. This framework confirms that the potential of computational processing is closely related to the sophistication of the ontological structure:

- Thesaurus ontologies (including the first four areas of the taxonomy – catalogues, glossaries, thesauri, is/a relationships)
- Ontologies with the expressivity of description logics (DL) (including formal is/a relationships, formal instances, frames and value restrictions)
- Ontologies with the expressivity of full or first-order logic (including general logical restraints, disjointedness and higher-order logics)
- Within this classification, OWL RDF, which is regarded as the cornerstone language of the semantic web, is located in the middle category of ontologies with description logic expressivity (Legg, pp .432–34). While natural languages reflect human experience in the world, and are both expressive and reflexive, there are significant limitations to what can be said using formal languages, as they are based on an idealised notion of pure identity, and, strictly speaking, do not express anything other than themselves. Formal languages require meta-languages, as they are not reflexive and cannot speak about themselves

The discussion in this section about knowledge representation in information systems and the status and levels of logic-based expressivity in ontological

[107] Inferential tractability relates to the ability of an application to decide whether a query is answerable within a reasonable time frame. This requires the ability to reason over information retrieved to identify the best heuristics to decide on a case by case basis (Legg, 2007).

forms of representation provides a background to considerations that were made in exploring possible approaches to take in designing a design research resource that might begin to represent and enable relationships between the diversity of design research theories and methodologies. Understanding these features and limitations led to the recognition that traditional knowledge organisation approaches, such as a formal ontology, were not flexible enough to represent the important historical dimensions and the complex relationships that exist between the terminology, approaches and different theoretical perspectives that exist across the heterogeneous fields of design research. The recognition of these limitations led to further consideration of the problems and potential of semantic web approaches.

The Semantic Web

While semantics, in the context of linguistics, engages with meaning through language, in computer science semantics reflects the meaning of programs or functions as an application of mathematical logic. A computer program is a language that can be considered in terms of its syntax or grammatical structure and its semantics or meaning. Technically, meaning lies at the intersection of grammatical and semantic structures, where semantics refers to the associative levels of a structure or its conceptual fields of association. The aim of the semantic web is for the meaning of information on the web to be better represented to enable data, information and knowledge exchange by humans and by computers.

The Web Ontology Language called OWL is actually a family of knowledge representation languages, based on two approaches to semantics that are largely, but not completely, compatible: OWL DL and OWL Lite semantics are based on description logics that have well-understood computational properties, while OWL Full uses a novel semantic model intended to provide compatibility with RDF (Resource Description Framework) schema. While OWL is recognised as one of the primary technologies underpinning the semantic web, Legg (2007) notes that it has some problems including its 'verbosity' of expression (p. 434). This means that coding in RDF is complex and difficult to read, and that much more memory is required for parsing an OWL/RDF document than is required to hold the actual ontology in memory. These programming complexities, along with the researcher's technical limitations, meant that any experimental development would require some technical support, and also, given the exploratory nature of this part of the project, the use

of a platform that was accessible, flexible and did not require a high level of technical expertise.

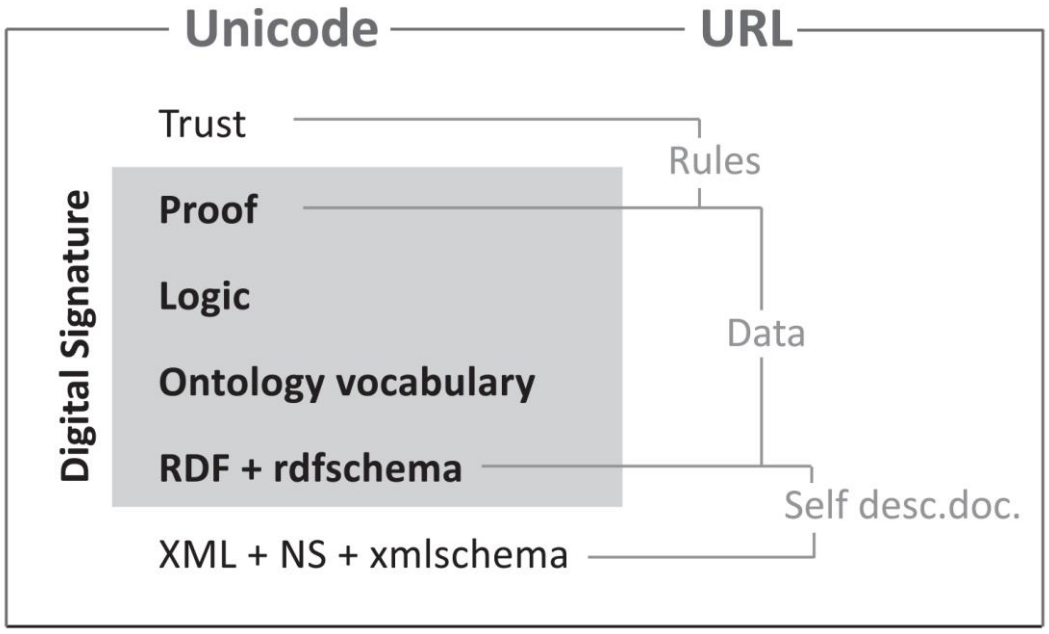

Figure 32: Diagram of the semantic web 'wedding cake' model based on the diagram used by the World Wide Web Consortium (W3C) to explain the structure of the semantic web: http://www.w3.org/2001/09/06-ecdl/slide17-0.html

While the focus of the W3C is on the development of technologies that work across the WWW, developments like Semantic Media Wiki (SMW) are examples of specific web-based applications. SMW enables the addition of semantic annotations to make information in the wiki computer-processable. By accessing these semantic annotations, Semantic Media Wiki generates machine-readable documents in OWL/RDF format that can be accessed via Special Export RDF. There is also a maintenance script for automatically generating complete exports of all semantic data. This means that semantic changes to the wiki are automatically noted and updated. Krötzsch and Vrandečić (2005) have identified five areas of added functionality through SMW. These include improvements in areas of: list generation, information searching and the inflationary use of categories, inter-language consistency and external reuse.

There have been criticisms that the 'new dimension of meaning' (Veltman, 2004, p. 3) promised by the semantic web has not yet been delivered. It is recognised that this has been caused by both conceptual and technical limitations. The technical limitations of the semantic web are not the focus of this thesis. However, the conceptual limitations of these technologies, as identified by

Veltman, are relevant to the design and evaluation of a design research resource using this type of platform. Veltman recognises five issues that challenge the restricted aspects of current semantic web technologies. These include: changing world views, the inclusion of different types of definition, distinctions between words and concepts, the creation of new links between classes of relations and dynamic meaning.

In experimenting with the development of a design research resource, these issues, identified by Veltman, were used as a set of criteria and a way of highlighting some of its features. In addition, some of the capabilities of the SMW identified by Krötzsch and Vrandečić (2005) were also used as a framework to evaluate experimental development. It should be noted that two of the capabilities listed by Krötzsch and Vrandečić – inter-language consistency and external reuse – were not used in this evaluation. This is because the experimental work was all conducted in one language (English). And secondly, while recognising that there is potential for further extension of the framework developed from this analysis of design research theories, the process of external reuse was seen as being beyond the scope of this thesis. This project aimed to develop a relational analysis and explore the potential for developing information structures to better represent design research methodology, testing them through an experimental system, rather than developing a more generalisable meta-theoretical structure to be used across a number of resources.

Representing Changing World Views

Michel Foucault (1969) recognised that an understanding of the history of ways of knowing gives insight into current systems. Kim Veltman's analysis of information systems also recognises the significance of historical understandings and related technological developments to limitations in the way current technologies determine the way we organise, use and understand information (2004). Veltman has traced shifts in human thinking about knowledge from oral to written to digital, multimodal forms of media. He also suggests that the study and understanding of the philosophy and history of knowledge can help shape new advances in knowledge organisation (p. 9). Current approaches to knowledge organisation via information technologies are underpinned by the *episteme* of western science, based on ideals of universal ordering, logic and the assumption of fixed definitions. Veltman suggests there is a need for new approaches that help trace the cumulative development of

bodies of knowledge while identifying 'key moments when a new explanation brings a disjuncture in how these facts are seen as relating to each other' (p. 51).

The content of the prototype design research resource was based on the selection of theoretical texts that address and span a critical period in the emergence and development of design research. The notion of developing a timeline tracing the emergence of design research and identifying 'critical moments' was initially considered as one way of structuring a design research resource, but was set aside because, as Jonas has recognised (2000), many of the key ideas associated with design research emerge, recycle and re-emerge in different areas at different times. For example, the emergence of design science in the 1960s was related to the development of artificial intelligence. However, while both the Design Methods Movement and the AI in Design Movement faltered, design science still holds considerable sway in areas of engineering design, and has more recently been embraced in areas of software design.

In addition, some ideas go on to merge and contribute to the formulation of new approaches. An example is Margolin's 2002 positioning of design research approaches (described as design methods, design studies and project-oriented research) in relation to his earlier and more rigid definitions of design studies, and to his emergent notion of sustainable design. Margolin's more recent writing gives greater emphasis to sustainability. Such conceptual shifts that are happening in 'real time' are difficult to show in a fixed, linear format. However, SMW supports the automatic generation of lists, which automatically include any new material added into the media wiki and a sequential timeline of all publications and cited references from the texts analysed. Thus a timeline can be generated 'on the fly' and updated as more reference texts are added to the resource. The capability to generate lists is an added function of SMW, as standard media wiki software requires lists to be manually generated and maintained by editors or participants. The use of this automatic list-generation feature could offer a way of mapping the rise and impact of different design research approaches, as a larger body of texts about design research are modelled and added into the wiki, enabling clusters of publication dates and key concepts within texts to be correlated. This feature could be further enhanced by linking to a citation index, which would help identify how a theory was taken up or critiqued by other researchers and theorists. The emergence, development and influence of particular ideas and approaches could then be more clearly identified and traced over a period of time.

Definitions, Words and Concepts

Veltman suggests that a greater understanding of meaning or semantics comes from the examination of sources of meaning in definitions and relations (p. 15). He notes that conceptualisations of definition and the methods used to develop definitions have changed across classical, medieval and enlightenment periods. Within classical thought, principles of definition were based in logic, during the Middle Ages a definition triangle of *vox* (word), *res* (object) and *conceptus* (concept) was developed, and in the eighteenth century attempts to create comprehensive dictionaries and thesauri began to contextualise and relativise the meanings of terms. Veltman recognises that the limited results gained through these efforts led to new areas of exploration in the twentieth century, including semiotics and linguistics, and in terminology and concept relations. While functional or syntax relations can be used to address meaning in whole sentences, they can't identify meaning of words at an individual level. Meaning occurs at different levels and 'needs a multileveled approach' (p. 23). He suggests that a further distinction also needs to be made between concepts and words: 'Concepts are carefully gathered clusters of words that define their relationships'(p. 23). Recognising the growth in specialist, professional, regional and colloquial dictionaries, and the dynamic nature and richness of language, Veltman suggests that the solution isn't in fixed or singular definitions, but in creating bridges, mappings, walkways and other metadata systems between levels of definitions, dialects and languages. Rather than standardising and homogenising language, these approaches recognise and support the particular historical and cultural dimensions of language. New ways of visualising such terminological and definitional differences also need to be developed.

In experiments to develop a design research resource-prototype two approaches to terminological definition were explored. One was graphical (using *Hypergraph* software) and visually located a particular term in relation to other associated terms.[108] These terms and relationships were drawn directly from concepts and relational terms in C Maps developed from the analysis of each text, and from C Maps that record relationships between groups of texts that were identified and mapped during subsequent analysis. While the current version of *Hypergraph* is not always easy to read when representing multiple topic relationships, this method does suggests a way of visually locating a term/concept in relation to a textual context, which has some correspondence with Veltman's suggestion of finding visual ways of addressing definitional

[108] Hypergraph is open-source topic-mapping software that visualises topics and topic relationships. See http://hypergraph.sourceforge.net/example_tm.html

problems, and begins to create bridges between terms, concepts and levels of definitions.

Another approach to terminology and definition was through a glossary page that lists particular terms with links to all the different texts and C Maps that use this term. These links are provided as a list of defining concepts, identifying the term and the text/author reference where it is located. It is also presented as a hypergraph linking the term to the different authors and texts that use the same term. By clicking on a term in the 'defining concepts' list one is linked to a hypergraph of the term in the context of the specific text represented in the original C Map. Where available, the exact definition of the term in the words of the author is provided. (One limitation here is that authors don't always define terms they use in a text.) In addition, a commentary can be added, discussing some of the different definitions and implications of such definitional differences. The approach taken to the development of the glossary recognises that particular terms can be used by different authors to mean different things. It provides a method for the resource user to be able to identify different uses and definitions from source material, and to access commentary discussing some of the issues and implications of this terminological differentiation. The purpose of such commentary is not to smooth or homogenise terminological difference but to recognise and help navigate this diversity.

New Links between Classes of Relations

Veltman discusses several different approaches to the definition of relationships and the classification of types of relations in information science. These include the identification of relationships in classical logic, and later in computer science, as one of five 'semantic primitives', which include existence, co-reference, conjunction, negation and relation (p. 6). As discussed in Chapter Three, C Maps involve the linking of concepts by relational terms, and, while the initial mappings of theories involved the use of language from each particular text, some more generalised relational terms were developed to help identify particular relational frameworks as these were recognised through the analysis. The selection of some standardised propositional terms was an interpretive act on the part of the researcher, used to indicate types of relationships between concepts and particular framings across groups of theories. It is acknowledged that he introduction of standardised relational terms begins to shift the focus of the inquiry away from the analysis and modelling of texts towards more formal information relationships. However, to

be fully implemented this would require the standardisation of all terms and the definition of all possible levels of relationships indicated by different terms in subsumption hierarchies, thus moving away from the particular language and nuance of each author and text.[109] Computational agency requires such syntactical prescription, which allows for machine reading, as such relationships can ultimately be stated mathematically. However, while subsumption relationships can be defined in terms of relationships between categories of things, they are not so obvious in defining relationships between more abstract ideas that are often expressed in different terms. One approach to this dilemma would be to create lists of synonyms or nested terms that would allow the original terminology of authors to be accessed to indicate ideational relationships within specific texts while also linking sets of such terms from different texts to more generalised syntactical terms defined by the wiki author. While this would privilege the semantic or associative designation of the analysis, it would also give access to particular terms and concept relationships identified in a particular theory. The underlying difficulty here is the range of language used, for example to identify or indicate methods – researchers can use methods, they can employ methods, they can conduct research through methods; as authors can list methods, identify methods and associate methods. While the meanings of these terms are similar, they are not the same.

Query Development

Some further issues raised by Veltman indicate the potential value of being able to more precisely specify syntactical relationships to assist in the development of queries. 'Function relationships', identified when two concepts are put together in a syntactical relationship, can be used to formulate questions. Veltman demonstrates a number of question types that can be formed using different grammatical combinations. He also draws from work by Dahlberg (1995, cited in Veltman, 2004, pp. 10–18) on function relationships (see Table 13) and early precedents in the automation of questions posed by Raymond Lull in his *Ars Magna* of 1274 to identify different types of questions and fundamental ontological categories that can be associated with them.[110]

[109] Subsumption hierarchies define relationships between classes of information. They are based on *is/a* relationships, for example a cat is a subtype of animal (Mineau, 2000).

[110] Sowa writes: 'The main trunk supports a version of the *tree of Porphyry*, which illustrates Aristotle's categories. The ten leaves on the right represent ten types of questions, and the ten leaves on the left are keyed to a system of rotating disks for generating answers. Such diagrams and disks comprise Lull's *Ars Magna* (2000, http://www.jfsowa.com/krbook/). Raymond Lull (1235–1311) was a Majorcan philosopher, poet and missionary. His *Ars Magna*, published in

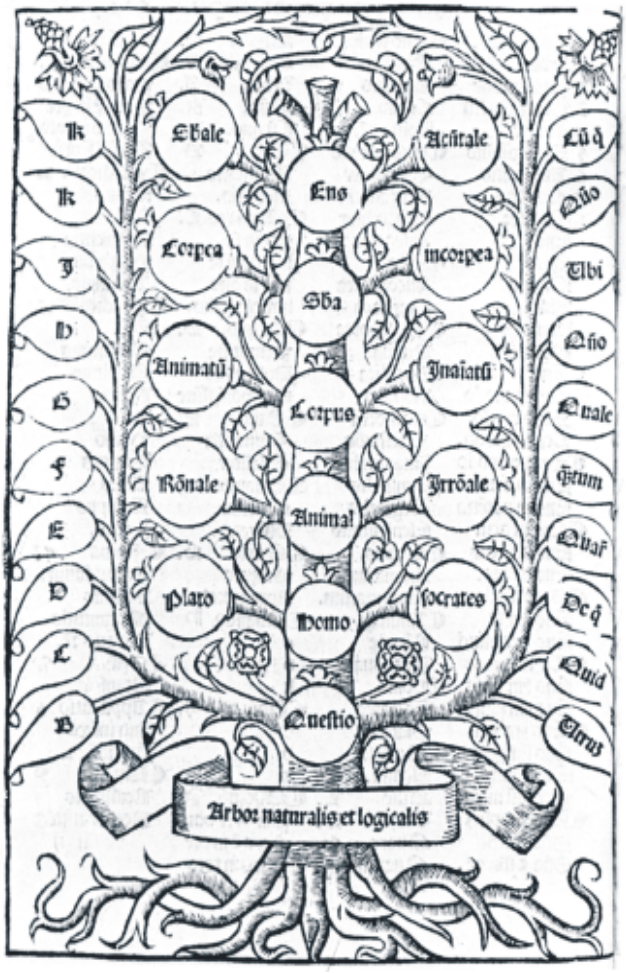

Figure 33: The tree of nature and logic from Raymond Lull's *Ars Magna*, image from Sowa (2000)

Veltman notes that while Lull's notion of the mechanisation of such questions has been linked to the development of the calculating machines of Leibniz in the seventeenth century, to Babbage in the nineteenth century and to subsequent twentieth century-developments in computing, his notion of systematic questioning has yet to be fully implemented. While recognising that library categories support access to authors (Who?) and titles (What?), and that some libraries also provide chronological access (When?) and publication location (Where?), he suggests that more systematic access using a wider range of question types would greatly expand the scope and precision of searching (p. 23).

1305, attempted to develop mechanical aids to reasoning. It inspired the pioneering work of Gottfried Leibniz in symbolic logic.

Question	Category	Latin questions
What if?	possibility	Utrum?
What?	nature, essence	Quid?
From what?	material stuff, essence	De quo?
Why?	causality, reason	Quare?
How big?	quantity, size	Quantum?
When? Since when?	time	Quando?
Where? From where?	place	Ubi?
How? In which way?	modality	
By which means?	instrumentality	
By what?	potentiality, capacity	
How generated?	genesis	
By whom?	originator, producer	
With whom?	accompanied by, together with	
For what purpose?	finality	
How occurring?	occurrence	
Under which conditions?	condition	

Table 15: Dahlberg's list of seventeen questions related to categories, and Latin questions found in Lull's *Ars Magna*, from Veltman (2004), pp. 70–92

These types of syntactical relationships and the use of such relationships to support the use of such questions for searching, were considered in relation to the question-based approach to design research that was identified in a number of the design research theories analysed and modelled in this thesis research (see Chapter Six). The question forms identified by Poggenpohl (2000) can also be correlated, to some extent, with Dahlberg's schema. While this query-form approach may appear somewhat formal and limited in terms of searching specific design research theories, it suggests a way of being able to interrogatively engage users with a resource. The issue of question forms in design research has not been taken up by many theorists to date, and could introduce an engagement and way of searching a resource if, for example, related archives of case studies, theses, research papers and journal articles were linked to the resource. In these particular formats, specific research questions are articulated in relation to particular projects and could thus be easily classified in terms of these fundamental categories of question types. The value

and types of associations that could be made through such query categorisation in design research, however, would need further investigation.[111]

Veltman also recognises a history of 'encyclopaedic efforts' concerned with answers 'which potentially entailed a range of questions to include: who? what? where? when? how? and why? as well as their systematic combinations' (p. 42). He suggests that an expanded question-oriented approach could be an important opportunity for future knowledge organisation strategies. The work being done by the developers of the SMW platform is also focussed on improving information searching through the development of semantic structures that can support queries rather than word or simple Boolean searches.

Initial experiments conducted on developing query-based searches in the prototype design research resource were limited, because no layers of computational intelligence were added into the basic software system. A series of test questions were posed and an analysis of search results using various terms was conducted. These provided an initial investigation into the inherent capability of the system to assist with queries that go beyond simple word searches. While these initial tests give better results than simple word searches, a more formal system of syntactical relationships would need to be implemented across a resource before this approach could be more effectively utilised or supported by computational intelligence. It is recognised that this aspect of the project offers considerable future potential, and that query-based searches could be enhanced incrementally by the refinement of query categories over time. For example, currently information about authors of the analysed texts is provided through links to existing online biographies. If this information was included in a template of categories associated with each author (year of birth, sex, professional background, nationality, institutional affiliations, cultural affiliations, research areas, etc.), a number of different types of questions about these texts could be supported. For example: Which authors of texts in the resource are women? Are there any authors with backgrounds in industrial design? Are any authors Australian? This capability would be useful to support the analysis of the body of literature in terms of the representation of particular professional, cultural or institutional perspectives, particularly if the body of theory texts in the resource was increased substantially, to form more extensive corpora.

[111] Jonas and Chow's MAPS project interface uses questions as a way of getting researchers to think about and identify possible methods. To date this has been the only design resource identified as using questions to engage users and navigate the system.

It is recognised that there is an inflationary use of categories in collaboratively built informal systems like Wikipedia. Examples given by Krötzsch and Vrandečić (2005) include categories taken from Wikipedia that include: Rivers in Buckinghamshire, Asteroids Named for People and 1620s Deaths. This profusion of highly localised categories is the downside of community-initiated taxonomic initiatives. While recognising this may be helpful in specific instances, Krötzsch and Vrandečić suggest that many such categories could be removed and reorganised to enable better query results using more logical systems based on more general categories and the specification of properties. They suggest that annotations such as Category: Rivers, Property: located in; Category: Asteroids; Category: People, Property: named after; and Property: date of death, would be enough to create thousands of similar listings on the fly and remove such highly specified categories as identified above. This process of identifying more general categories and specifications of relationships that are also more flexible and useful for search and query, requires both a familiarity with the information being represented and with ways of thinking about information structures and relationships. This is one of the critical issues facing 'grass-roots' content building initiatives, as well as 'top-down' information scientists.

Information layer	**Existing features**	**Potential development**
Texts (theories analysed)	Authors/titles of texts/dates	Synopsis or abstract/link to online references
Models (interpretations of design research theories)	Dates/ synopsis/C maps, key concepts and propositions/ associated references and case studies	Narratives of cases and C maps of key references – link to Cite Seer[112]
Authors (of theories)	Link to specific theory/to online biography/other publications/ citations in other theories, texts and cases in DRR	Link to Cite Seer
Dates (of texts)	Associated with authors	Graphical representation as timeline
Concepts (from models,	Defined from theory – included in glossary/linked to	Links to relevant references develop related concept

[112] Cite seer identifies other academic texts which reference a given book, paper or article.

from theories)	propositions/associated with interpretive frameworks	clusters
Propositions (relational properties)	Associated with concepts in C Maps/some associated with particular interpretive frameworks	Thesaurus development/ synonymic links to support additional model building by design research community and to support search and information retrieval
Glossary	Terminological relationships/terms defined in relation to specific theories, cases/also definitions on *WordNet*	Further terminological analysis to develop synonymic groupings and clusters of terms (Niedderer and Roworth-Stokes)
References	Pivot points – related to different theories – included as authors/ dates/theories	Can be C Mapped and linked to other relevant resources/journals etc.
Cases and exemplars	Related to theories/ frameworks/methods/glossary	Synopses or links to cases and examples/ask authors to provide exemplars/design researchers to provide relevant cases
Paradigms	Related to concepts in theories	Richer definitions/associated reference texts
Strategic frameworks	Methodological – related to concepts in theories	Links to related methods/relevant reference
Thematic frameworks	Related to concepts in theories	Links to relevant references/cases etc.
Inquiry-based frameworks	Related to concepts in theories	Further research into relationships between query forms and research themes, outcomes and methods to support query interface
Outcome-based frameworks	Related to concepts in theories	Links to relevant references/cases etc.
Methods	Related to concepts in theories/definitions	Link to cases/link to other resources
Dates	Associated with texts, authors	Graphical representation
Texts	By authors/titles of texts , full citation	Link to online references

Table 16: Table listing information layers, features and linkages and potential areas of development in the design research resource

Within the investigation for a prototype design research resource, informal categories were developed from an analysis of the design research texts and models of design research theories, moving from an analysis of the particular towards the development of shared and potentially more generalisable categories. Some fourteen layers have been introduced – for example, identifying the theory texts as a category distinct from interpretations of theories, which are described as models to differentiate interpretations of theories from the theories as texts. This differentiation would allow for the addition of other interpretations of the same theories if the system was opened up to include other contributors.

Through the analysis of the prototype outlined in this chapter, the information frameworks relating to design research were further refined. In conceptualising the design research resource these information categories are considered as flexible layers, with numerous associations and linkages made between and across these layers. The following table (Figure 53) identifies fourteen information layers, summarises some features and linkages from each layer and identifies some areas of potential development. The linear sequence of these layers in this representation is the result of using a table format; within the system these categories sit in a rhizomic relationship with one another, rather than in an hierarchical or linear relationship.

Dynamic Meaning

Veltman points out that universals are seen to be eternal and static while particulars are spatio-temporal and dynamic (p. 25). He introduces the notion of a space-time horizon as a theoretical framework where universals, being above the line, are outside time/space, whereas particulars, sitting below the line, are in space-time. However, he recognises that such a framework will itself change with time as understanding of universals and particulars changes, meaning that all knowledge is in space and time. This means that knowledge systems need to be able to reflect the cultural and historical dimensions of knowledge, as well as recent developments and changes in our understandings of this knowledge. Veltman recognises a need 'for bridging and mapping devices' (p. 28) that will allow a dynamic engagement with different levels of language, chronologies and policies. He writes: 'such dynamic insights will allow us to trace changes of interpretation over time, have new insights and help discover new patterns in knowledge' (p. 28).

His commentary recognises temporal change, but assumes a level of consensus about 'current' knowledge and knowledge frameworks. In an undisciplined domain like design, where such consensus is difficult to find, bridging and mapping devices also need to be developed to span different but concurrent frameworks and understandings. In extending the design of a design research resource, one significant issue is the development of an interface to allow resource users to approach information through their own particular understandings or orientations to research. This could be through historical perspectives, for example based on the work of Archer and the Design Methods Movement or on Gasparski's approach to design science. Or it could be a perspective related to a researcher's own phenomenological orientation to research, such as research themes or question types. These frameworks were identified within the prototype versions of the resource produced during this research, but would need to be pushed in terms of both visual and interactive capability. Standard Semantic Media Wiki software has very limited inbuilt graphical capability, and would require specialist customisation to develop a more flexible interface. Such agency would introduce greater dynamic capability to the system.

An obvious potential for the design research resource is the use of wiki technology for collaborative content development. It has already been noted that the design research resource has been built up from a basis of selected design research theory texts that in themselves cover a period of time during which theories, understandings and practices of design research have emerged, been promoted, been questioned and/or changed. The addition of analyses of more recent theoretical texts as well as other material about design research, such as case studies, method descriptions, theses, conference papers, images or multimedia files, would enrich the capacity to identify and trace these historical shifts. An earlier plan for this project was to ask other participants to contribute their own analytical models (as C maps). These could be models of some of the selected texts, providing other interpretations of the same texts, or models of other design research theories. However, as the focus of this research project shifted into the analysis, interpretation, mapping and correlating of a number of selected texts, the logistics of realising any such collaborative content development in the project was not feasible within the project timeframe. This content development capability is evident in most wiki systems and it would certainly provide a way of representing greater diversity of interpretation and ensuring a more dynamic system provided the system itself was properly designed to support such engagement. In addition, over the course of this

project a number of online design-related projects and systems have emerged. The potential to link with some of these initiatives to form a richer and more layered resource is another avenue to be pursued.

Conclusion

Underpinning the aim to design a design research methodology resource, different theories of design research were analysed, and the findings of this analysis were used as the basis for the development of an information structure and system design that could more adequately represent different understandings and theories about the domain of design research and the relationships between different theories and conceptualisations. It is recognised that systems can represent diverse viewpoints, whereas entities can evolve their meanings and reflect important cultural dimensions that can be activated by less formal information structures. From this basis, more formal or meta-level structures might be developed, built up from the content of the resource and information relationships and patterns identified through the interpretation and subsequent structural analysis of material, or from patterns of engagement and associations made by resource users, rather than being imposed, a priori, as a general or universal knowledge structure. This approach offers a way of developing ontological structures that are hermeneutically oriented rather than logic-based, which are more relevant in a discipline like design that is concerned with innovation rather than scientific veracity and where pluralism is recognised as an implicit strength.

Features identified by Veltman in his discussion of the potential of semantic web technologies in the representation of cultural rather than scientific information have been considered and discussed in relation to the development and evaluation of an early prototype for a design research resource using Semantic Media Wiki software, along with some criteria proposed by Krötzsch and Vrandečić. Further consideration was given to the refinement and future development of this design for a design research resource. The system at this early stage indicates both a feasible methodological approach and a capable technological platform that can begin to represent some of the theoretical complexity of the field. In terms of the project methodology this provided a metaphor and a practical approach for thinking through and exploring interpretations of theories and representing different perspectives. It presents a strategy for developing information categories relevant to the domain, built up from theories and concepts within the field, rather than through the external

imposition of universal categories. But it also attempts to link with broader approaches to research and other disciplinary domains and methodologies relevant to design research, as these are both part of the history and the ongoing and vital trans-disciplinary engagement of the domain. This approach also introduces ways that terminological differences and specificities can be acknowledged yet related – by defining and linking terms to their original textual context and listing them in a glossary, while also developing tables of synonyms so they can be linked to more general terms and used productively as a way of enriching the search processes.

The inclusion of C Maps and hypergraphs as visualisations of different information relationships provided a static (C Map) and a somewhat more dynamic (hypergraph) visual representation within the resource. While these are both rudimentary forms, which could be improved by the development of greater visual articulation , the principal of using visualisation technologies to enable interaction and help communicate complex informational relationships is recognised, and is another feature that can be taken further in future resource development. The inclusion of more visual references such as photographs and video links, as well as creating richer references in the form of case studies and exemplars, would also be important developments in taking the prototype further. It is recognised that due to the analytical and interpretive focus of this research, the collaborative content development function of the wiki software has not been explored in the prototype. This capability exists and would also be explored in future research, introducing a greater richness of interpretation.

Gadamer (1989) recognised that 'application is neither a subsequent nor merely an occasional part of the phenomenon of understanding, but co-determines it as a whole from the beginning' (p. 324). Thus the process of analysing and interpreting design research theories, and their exploration for the design of a design research resource, should not be regarded as separate theoretical and applied approaches, but as part of a single hermeneutical 'practice'. In this respect, the prototype design research resource, for all its limitations, is recognised as a way of extending, testing and reflecting on this ongoing hermeneutical process.

Conclusion

Mnemotechne of Design

Implications–Explications

Summary of the Project

Mnemotechne, throughout this thesis, has referred to a concern with how we collect, recollect, devise and organise the already seen, the already said, in general, the already known. Memory and technology together present the conjunction of the organic and the inorganic, the past and the future. This thesis title suggests a fundamental concern with a mnemotechne of design, which recognises the subjective and the objective encounter of knowledge of design through technology. The project engages with a questioning of how design and its research may be framed, assayed, understood and interpreted by mnemotechnics, by techniques of recovery, synthesis, analysis and containment. Equally, or perhaps more critically, the thesis recognises that design is itself fundamentally and primordially a mnemotechne, that the human world is mediated and understood through design. The thesis thus encounters, on the one hand, the design of mnemotechnics, as structures for keeping and recalling what can be known, and, on the other hand, the mnemotechne of design as a disclosure of design as that which, in the heterogeneity of its categories, recognises the differences of what is understood. Design research methodologies have, over the past fifty years, oscillated between design science ontologies tasked with the project of a technics of memory or a science of the artificial, and an artistic design process or discourse that lodges its concern in forgetting trace structures. This thesis project has aimed to choose neither one nor the other in an absolutist sense, but rather has aimed to reveal something of the primordial dependence and potential repositioning of each in terms of the other, recognising the possibility of multiple, relational perspectives.

This inquiry has engaged with the discipline of design from the perspective of the emergence of design research over the past half century, with particular focus on the development of design research theories. The research has recognised that the discipline of design is heterogeneous, with diverse paradigmatic claims as to its epistemological ground and a concomitant range of ontological implications for what is considered to be within the disciplinary domain of design, and with associated methodological implications for its research. The project set out to address three topics: firstly, how different ways of reflecting about design research might be understood in relation to one another; secondly, whether the results of such understanding could be used to inform the organisation of information about design research methodology; and, thirdly, whether new computational systems and technologies could be used to support relational models of design theories. The second and third of these topics emerged as the research process unfolded and shifted – from what was initially envisaged as a project that would result in the development of a formal, ontological structure to overcome the underlying problem of the heterogeneity of design and its theories of research – to become, in fact, a deeper and more critically focussed engagement with issues of interpretation and relationality.

While a hermeneutical approach was first adopted as a way of understanding different theories, the fundamental significance of hermeneutics to the inquiry became evident during the research process. This extended to inform a wider methodological framework that revealed deeper conceptual linkages between different aspects of the project. In undertaking this research two competing understandings of 'ontology' were engaged, one opening to ontology as a questioning of the grounding or meaning of the being of entities categorised as design, the other emerging from knowledge engineering and computational science, which comprehends ontology in the formal and syntactical sense of categorisation and hierarcherisation. With a critical hermeneutics of design theories, the former understanding of ontology is foregrounded; with respect to engaging with information hermeneutics and semantic web capabilities for information relationality and retrieval, the latter framework is recognised, based on the understanding that information is interpreted, rather than existing as an objective 'thing'.

Through a series of hermeneutical engagements, the thesis deals with comparative analyses of twenty key design research theories that have emerged over the past half-century. A second hermeneutical employment elicited a series of deeper structural relations that work across these theories, an approach that

eschewed meta-theoretical unification. Correlations were then sought with literature, for the broader understanding of theories of research as well as information hermeneutics. These frameworks grounded the development of a design for an information system based on interpretation and relationality, rather than formalism.

The research confirmed that design's ontological underpinnings could not be limited or adequately represented through its various 'disciplinary' frameworks, such as the fundamental dualism that has tended to define the heterogeneity of the field, dividing it between design science and design aesthetic, with the former more easily engaged in defining formal design research theories, and the latter more easily engaged with a theoretical emphasis on individual expression and intuition. The thesis adopts a critical hermeneutics in order to approach analyses of design research theories, with an aim to maintain heterogeneity in the field while yet recognising a series of primordial structures that construe relationality across diverse frameworks. The history of design and its research is grounded in its many different discourses, understandings and approaches, and, given the changing focus of design's subject matter and its fundamental concern with the development of alternative resolutions and possibilities, rather than claiming truths or singular solutions, this heterogeneity is recognised as a defining feature of design, rather than a problem to be solved through a singular, unified theory. This pluralism was also recognised as being vital to design's role as an inter-discipline that engages with complex contemporary problems and draws on multidisciplinary teams of experts and stakeholders with diverse perspectives. Such engagement – be it through research, discourse and/or practice – also requires an interpretive disposition.

This recognition also led to an engagement with systems thinking, or second-order cybernetics, as a dynamic framework through which traditional approaches to the structuring and syntax of expert systems was critiqued, and as a way of exploring the possible use of Web 2.0 and Web 3.0 technologies to support the development of a more flexible approach to the design and agency of an information system that supported engagement and insight rather than problem solving. The development of this prototype system was recognised as a practical way to test the relevance of the interpretations of theories and to initiate the development of a resource about design research methodology. The design for the prototype sought to address two further topics: whether the interpretations and categorisations of design research theories identified through the research could be incorporated into a relational architecture to

support the development of a resource about design research methodology, and whether these different frameworks could be systematically and dynamically related to support a richer and more discursive engagement with the field of design research methodology. A critical consideration was made of the implications of formal approaches to information design using computational ontologies that are characterised by canonicalisation and the new opportunities offered by semantic web technologies, which are based on decentralisation and webs of information. The mnemotechne project took an a posteriori approach to knowledge organisation, drawing from conceptualisations developed from the analysis of design research theories, rather than abstract categorisations drawn from outside the field of design. This approach resulted in a multilayered and interrelated framework that presented a number of different ways that design research is theorised, and some key nodes and pathways through which different perspectives can be compared, associated or related. The potential for this system, based on Semantic Media Wiki technology, to be expanded to include additional perspectives, information layers and linkages was also recognised.

The system explores the possibility of multiple pathways through which researchers, teachers and students might engage with design research theory. It provides a basis for approaches through:

- Specific theories, authors, dates
- Interpretations (models) of theories
- Key concepts from a theory
- Relationships between a particular concept and other concepts in the same theory and/or related concepts in other theories
- A series of deeper structural frameworks (identified through this research) that work across these theories; more general categories of research, such as paradigms related to aspects of certain design research theories; and methods as articulated in particular theories
- Case studies and exemplars related to particular concepts
- Reference texts cited in particular theories, which, if cited in a number of theories, become pivotal points for accessing references to theories that present different understandings and interpretations of critical ideas that have informed, affected and often continue to affect design research discourse

Relationality, rather than formalism, is also supported by the inclusion of a glossary (rather than a standard vocabulary), which allows for groupings of

synonymous terms and for the identification, definitions and referencing of polysemous terms, where different authors use the same term to mean different things. Terms are referenced to and defined through their source texts. This approach uses terminological difference to reveal discursive nodes where different epistemological positions intersect. Such nodes present different interpretative perspectives and require the user of such a resource to make their own interpretation, rather than merely accept an authoritative prescription. At the very least (should a user of the resource resist such interpretive engagement) it will introduce awareness that design research is multivalent, that any particular methodological perspective is a theory, and, with its associated actions, is related to a position rather than a truth. This approach to designing an information system for a design research methodology resource is based on multiplicity that requires interpretive engagement, rather than definitive answers to methodological problems. This approach echoes the nature of design, which seeks to develop alternative approaches and possible worlds, rather than truths or generalisable solutions.

Research Findings and Contribution to Knowledge

The contribution made though this research lies primarily in the relational analysis of design research theories, which has given rise to some new insights into certain theoretical positions, and some further insights into different theoretical perspectives through comparative analysis. This analysis and interpretation of design research theories engages with and recognises different perspectives, and challenges fundamental ontological dualisms based on binary models that have historically influenced understandings of the field of design research. While there is a growing discourse about design research, some theorists aim to develop new perspectives based on individual orientations that are independent of past positions. Others have sought to develop theories that map the field, identifying different areas and expressing them as categories of research. However, despite a recognised need, there are few comparative analyses of theories about design research, particularly involving numbers of different theories, as was undertaken in this inquiry.

Some novel insights have been developed through the identification of a series of deeper structural relations that work across these theories. These findings present four different ways that design research theories have been conceptualised. They help to explain, in part, why comparing and correlating different theories is a difficult process, given the different levels of abstraction

and the particular orientations of these approaches, which are associated with types of research strategies, research themes, research questions and research outcomes.

This mnemotechne project engages with the relational mapping of different theories, including positions that were part of design research history. It recognises and extends from Jonas's observation of design's dynamic history, where theories emerge, flourish, are reacted against, fade and often re-emerge as parts of newer forms, rather than undergoing a linear, futuristic process of progressive radical change. This research confirms that it is important to understand the history of design's research theories in order to be able to recognise and utilise present methodological options, and to more clearly identify limitations and also future directions that can give rise to new methodological approaches. The design for a resource about design research methodology is a prototype for a system to support such understanding.

Another contribution has been made in terms of the development of a novel methodology. While hermeneutics is well recognised as an approach for interpreting texts, and has been recognised by Coyne and Snodgrass as a way of conceptualising the process of design, the contribution lies in the way the methodological approach has been extended and combined to include technologies that enable other registers of hermeneutical engagement. Thus the extension from textual interpretation and comparison into a concept-mapping process results in models that can not only be produced visually, and compared structurally, but can also be exported into the semantic web language OWL RDF. The hermeneutical underpinnings of the project are further extended into a relational structure developed as a design for an information resource about design research methodology. This initiative is not proposed as a research outcome or designed artefact, but as a way of testing the interpretive models, and the flexibility and openness of the system design, to enable information hermeneutics. This hermeneutical iteration cycles through and brings together the different aspects of the project into the prototype design of an information system.

Project Limitations and Future Directions

There were a number of difficulties faced in realising this project, including the inherent complexity of understanding and relating different theoretical positions. While twenty texts were analysed, it is acknowledged that there are

many other theories and positions that were not analysed or modelled due to time restraints. However, the methodology and systems established in this project are flexible and allow further analyses to be undertaken in the future. It is recognised that the analysis of more theories could also lead to the development of new conceptualisations that would also have to be included in the model. However, the system model and the technology used anticipates the possibility of such an extension of the project in the future. In fact such responsiveness and flexibility is fundamental both to the systems-thinking approach and to open-source, socially networked software like Semantic Media Wiki.

As the inquiry uses a hermeneutical approach, it is understood that the models of theories produced by the researcher are interpretations. The potential of including models of these theories made by the authors of the theories, or by other researchers, would add other interpretive layers to the resource. While one unsuccessful attempt was made to engage an author in this process early on in the research, the task at hand, that is the analysis of theories by the researcher, limited this possibility of authorial engagement as the project developed. However, this is a future possibility, and would offer an interesting way of critiquing, extending and publishing further interpretations as models of theories.

Of the four conceptualisation approaches identified through this analysis, it is recognised that the 'strategic' perspective is an area that would bear further scrutiny, which may lead to more considered forms of sub-categorisation or to new conceptualisations. In the 'strategic' category, the thesis includes a wide range of forms of theorisation: from those which use broader, paradigmatic categories to those that identify more specific methodological approaches, and from those that use more generally recognised terms and conceptualisations of design research theory to those that use original terms and conceptualisations or terms and ideas drawn from disciplines outside design.

There were also a number of technical restraints that limited the extent of the project. These were largely due to the researcher's background and lack of technical expertise. While this limitation was addressed in part by involving technical developers, to help build initial prototype Semantic Media Wikis, this engagement occurred during a specific phase of the project, over six months in mid-2008, and did not allow for further developments or revisions of the prototype. However, the focus of this project was on the relational analysis and modelling of conceptualisations of design research theories, and the

development of this prototype system was seen as a way of testing the model through application, rather than developing a fully resolved information system. In analysing the model during the writing up of this thesis, further refinements have been identified and described as part of the evaluation.

Perhaps the greatest difficulty in completing this project has been working across areas of design discourse and information science. While the historical basis of this juncture led to the emergence of the field of design research, the subsequent schisms that emerged between design science approaches and more culturally or discursively oriented approaches are still evident in the field today. While critics like Liddament suggested strategies, such as language-games, that might address this impasse, there are few design researchers currently working in this area, outside of those engaged with highly systematised, engineering approaches. In this regard the significance of the work of practical theorists like Chow and Jonas in developing a system which introduces discursive, computer-based engagement with design research methodology, is acknowledged. The difficulty of working in this field, which engages design research theory and computing, is exacerbated by the complexities of each area: engaging with the heterogeneity of design research discourse and its various philosophical antecedents requires considerable focus, and, as has been acknowledged in the literature, is in need of more relational analysis and explication. And the field of information science brings its own technical and conceptual complexities, which, in terms of this project, required understanding across a number of different areas ranging from logic-based systems and computational ontologies to the aims and limitations of the semantic web. This complexity and range is the reason why some areas of this thesis are less well developed, or are reliant on the acknowledged work and ideas of other researchers. However, this span of inquiry was necessary in order to begin to understand and engage with this process of analysing theories and testing this analysis through practical application.

While the development of intermediate conceptual results is recognised as being important in developing information structures from content within the field of information hermeneutics, there is little work in this area within the design research field. This has meant that, with one or two exceptions, there was little prior research to draw on and few precedents to follow. It is hoped that the insights gained and articulated in this thesis will help inform future work in developing greater relational understandings and opportunities for productive interplay between different design research theories and practices. It is also hoped that the technical side of the project can be extended into a beta version

system, and that links can be made with other design research information systems and theorists to activate ways of extending and connecting across projects.

Implications

As forms of mnemotechne shifted from analogue to digital media, logic-based systems from the domain of computer and information science have come to dominate the way information is defined, organised and accessed. In domains like science, engineering and business, where knowledge organisation is highly systematic and information is grounded in objectivity and empiricism, these systems of formal organisation and computational agency are highly effective. Within the humanities, including art history and design history, the development of extensive metadata schema for organising corpora and media archives have also been developed, based as they are on the description and cataloguing of artefacts. However, within a trans-disciplinary domain like design, which engages with science, technology, social sciences, business, humanities and the creative arts, as well as its own forms of 'designerly thinking', disciplinary knowledge is heterogeneous and difficult to organise. There are few examples of design knowledge resources or methodological tools that extend beyond those developed from a design science perspective.

This mnemotechne project has begun to address these issues through an engagement with both interpretive and technological approaches, underpinned by critical hermeneutics and information hermeneutics. This approach has been supported by recent developments in web-based technologies, which are beginning to enable information to be organised by users rather than by information experts, and which support the development of more layered and relational webs of meaning, rather than formalised information structures. This approach, it is suggested, may offer more fruitful ways of mapping multivalent domains without having to pre-designate types of information in fixed hierarchies, allowing users to engage with alternative perspectives, discovering through interpretive engagement, rather than through automated solution-oriented systems. This approach does not exclude the potential for automated processes like optimisation, which allow systems to 'learn' through user engagement and selection, but it recognises that such approaches require a high level of information formalism on which to operate. This area of computational agency – which sits at the ontology/logic/proof levels of the semantic web layer cake, reproduced in Figure 32 of Chapter Eight – remains a significant problem

for computer scientists working with the development of the semantic web, and has not been addressed in this project. The organisation of broader, cross-domain design research knowledge resources cannot be achieved through traditional, systems-science approaches, which require consensual hierarchical information structures. New approaches to information organisation and systems-thinking strategies that enable discursivity and interpretation must be developed to support the presentation of alternative theories and encourage awareness of methodological positioning and possibilities among design researchers.

Mnemotechne is an old name, an archaic term for what is the most substantial of notions: how memory and thought have a fundamental relation with the inorganic through the world's materiality. As such, it may well be the oldest name for design. This thesis has aimed to bring into relation how we can think ontology, memory and technology such that design's future opens to the pluralism and heterogeneity of our potential to be, rather than entering into the definition of a supposed certainty of what has been.

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Appendix One

Full List of Categories for the Description of a Work of Art (CDWA) produced by the Art Information Task Force (AITF) 1992

J. Paul Getty Trust and The College Art Association
Revised 9 June 2009 by Patricia Harpring
Murtha Baca and Patricia Harpring, Editors. From
http://www.getty.edu/research/conducting_research/standards/cdwa/categories.html

1. OBJECT/WORK Core	23. OWNERSHIP/COLLECTING HISTORY
1.1. Catalog Level Core	23.1. Provenance Description
1.2. Object/Work Type Core	23.2. Transfer Mode
1.3. Object/Work Type Date	23.3. Cost or Value
1.3.1. Earliest Date	23.4. Legal Status
1.3.2. Latest Date	23.5. Owner/Agent
1.4. Components/Parts	23.5.1. Owner/Agent Role
1.4.1 Components Quantity	23.6. Ownership Place
1.4.2 Components Type	23.7. Ownership Date
1.5. Remarks	23.7.1. Earliest Date
1.6. Citations	23.7.2. Latest Date
1.6.1. Page	23.8. Owner's Numbers
2. CLASSIFICATION Core	23.8.1. Number Type
2.1. Classification Term Core	23.9. Owner's Credit Line
2.2. Remarks	23.10. Remarks
2.3. Citations	23.11. Citations
2.3.1. Page	23.11.1. Page
3. TITLES OR NAMES Core	24. EXHIBITION/LOAN HISTORY
3.1. Title Text Core	24.1. Exhibition/Loan Description
3.2. Title Type	24.2. Exhibition Title or Name
3.3. Preference	24.3. Exhibition Type
3.4. Title Language	24.4. Exhibition Curator
3.5. Title Date	24.5. Exhibition Organizer
3.5.1. Earliest Date	24.6. Exhibition Sponsor
3.5.2. Latest Date	24.7. Exhibition Venue
3.6. Remarks	24.7.1. Venue Name/Place
3.7. Citations	24.7.2. Venue Date
3.7.1. Page	24.7.2.1. Earliest Date
4. CREATION Core	24.7.2.2. Latest Date
4.1. Creator Description Core	24.8. Exhibition Object Number
4.1.1. Creator Extent	24.8.1. Number Type
4.1.2. Qualifier	

4.1.3. Creator Identity Core
4.1.4. Creator Role Core
4.1.5. Creator Statement
4.2. Creation Date Core
4.2.1. Earliest Date Core
4.2.2. Latest Date Core
4.2.3. Date Qualifier
4.3. Creation Place/Original Location
4.3.1. Place Qualifier
4.4. Object/Work Culture
4.5. Commissioner
4.5.1. Commissioner Role
4.5.2. Commission Date
4.5.2.1. Earliest Date
4.5.2.2. Latest Date
4.5.3. Commission Place
4.5.4. Commission Cost
4.6. Creation Numbers
4.6.1. Number Type
4.7. Remarks
4.8. Citations
4.8.1. Page
5. STYLES/PERIODS/GROUPS/ MOVEMENTS
5.1. Styles/Periods Description
5.2. Styles/Periods Indexing Terms
5.2.1. Term Qualifier
5.3. Remarks
5.4. Citations
5.4.1. Page
6. MEASUREMENTS Core
6.1. Dimensions Description Core
6.2. Dimensions Type
6.3. Dimensions Value
6.4. Dimensions Unit
6.5. Dimensions Extent
6.6. Scale Type
6.7. Dimensions Qualifier
6.8. Dimensions Date
6.8.1. Earliest Date
6.8.2. Latest Date
6.9. Shape
6.10. Format/Size

24.9. Exhibition Object/Work Label/Identification
24.10. Remarks
24.11. Citations
24.11.1. Page
25. CATALOGING HISTORY
25.1. Cataloging Institution
25.2. Cataloger Name
25.3. Cataloger Action
25.4. Area of Record Affected
25.5. Cataloging Date
25.5.1. Earliest Date
25.5.2. Latest Date
25.6. Remarks
25.7. Object/Work Record ID
26. RELATED VISUAL DOCUMENTATION
[references to Object/Work]
26.1. Image References
26.1.1. Image to Work Relationship Type
[Image Authority information]
26.2. Image Label/Identification
26.2.1. Image Catalog Level
26.2.2. Image Type
26.2.3. Image Title/Name
26.2.3.1 Image Title Type
26.2.4. Image Measurements
26.2.4.1. Dimensions Type
26.2.4.2. Dimensions Value
26.2.4.3. Dimensions Unit
26.2.5. Image Format
26.2.6. Image Date
26.2.6.1. Earliest Date
26.2.6.2. Latest Date
26.2.7. Image Color
26.2.8. Works Depicted
26.2.9. Image View Description
26.2.9.1. View Type
26.2.9.2. View Subject
26.2.9.2.1. View Subject Indexing Terms
26.2.9.3. View Date

6.11. Remarks
6.12. Citations
6.12.1. Page
7. MATERIALS/TECHNIQUES Core
7.1. Materials/Techniques Description Core
7.2. Materials/Techniques Flag
7.3. Materials/Techniques Extent
7.4. Materials/Techniques Role
7.5. Materials/Techniques Name
7.6. Material Color
7.7. Material Source Place
7.8. Watermarks
7.8.1. Watermark Identification
7.8.2. Watermark Date
7.8.2.1. Earliest Date
7.8.2.2. Latest Date
7.9. Performance Actions
7.10. Remarks
7.11. Citations
7.11.1. Page
8. INSCRIPTIONS/MARKS
8.1. Inscription Transcription or Description
8.2. Inscription Type
8.3. Inscription Author
8.4. Inscription Location
8.5. Inscription Language
8.6. Typeface/ Letterform
8.7. Mark Identification
8.8. Inscription Date
8.8.1. Earliest Date
8.8.2. Latest Date
8.9. Remarks
8.10. Citations
8.10.1. Page
9. STATE
9.1. State Description
9.2. State Identification
9.3. Known States
9.4. Remarks
9.5. Citations
9.5.1. Page
26.2.9.3.1. Earliest Date
26.2.9.3.2. Latest Date
26.2.10. Image Maker/Agent
26.2.10.1. Image Maker Role
26.2.10.2. Image Maker Extent
26.2.11. Image Repository
26.2.11.1. Image Repository Numbers
26.2.11.1.1. Number Type
26.2.12. Image Copyright/Restrictions
26.2.12.1. Image Copyright Holder
26.2.12.1.1. Image Copyright Holder's Numbers
26.2.12.1.1.1. Number Type
26.2.12.2. Image Copyright Date
26.2.12.2.1. Earliest Date
26.2.12.2.2. Latest Date
26.2.13. Image Source
26.2.13.1. Image Source Number
26.2.13.1.1. Number Type
26.2.14. Related Image
26.2.14.1. Image Relationship Type
26.2.14.2. Image Relationship Number
26.2.14.3. Image Relationship Date
26.2.14.3.1. Earliest Date
26.2.14.3.2. Latest Date
26.2.15. Image Broader Context
26.2.16. Remarks
26.2.17. Citations
26.2.17.1. Page
26.2.18. Image Authority Record ID
27. RELATED TEXTUAL REFERENCES Core
27.1. Citations for Sources
27.1.1. Page
27.1.2. Work Cited or Illustrated
27.1.3. Cited Object/Work Number
27.1.3.1. Number Type
[Citations Authority information]
27.2. Source Brief Citation Core
27.2.1. Source Type
27.2.2. Source Full Citation Core
27.2.2.1. Source Title
27.2.2.2. Source Broader Title

10. EDITION
10.1. Edition Description
10.2. Edition Number or Name
10.3. Impression Number
10.4. Edition Size
10.5. Remarks
10.6. Citations
10.6.1. Page
11. FACTURE
11.1. Facture Description
11.2. Remarks
11.3. Citations
11.3.1. Page
12. ORIENTATION/ARRANGEMENT
12.1. Orientation/Arrangement Description
12.2. Orientation Indexing Terms
12.3. Remarks
12.4. Citations
12.4.1. Page
13. PHYSICAL DESCRIPTION
13.1. Physical Appearance
13.2. Physical Description Indexing Terms
13.3. Remarks
13.4. Citations
13.4.1. Page
14. CONDITION/EXAMINATION HISTORY
14.1. Condition/Examination Description
14.2. Examination Type
14.3. Examination Agent
14.4. Examination Date
14.4.1. Earliest Date
14.4.2. Latest Date
14.5. Examination Place
14.6. Remarks
14.7. Citations
14.7.1. Page
15. CONSERVATION/TREATMENT HISTORY

27.2.2.3. Source Author
27.2.2.4. Source Editor/Compiler
27.2.2.5. Source Publication Place
27.2.2.6. Source Publisher
27.2.2.7. Source Publication Year
27.2.2.8. Source Edition Statement
27.2.3. Remarks
27.2.4. Citations Authority Record ID
28. PERSON/CORPORATE BODY AUTHORITY Core
28.1. Person Authority Record Type
28.2. Person/Corporate Body Name Core
28.2.1. Preference
28.2.2. Name Type
28.2.3. Name Qualifier
28.2.4. Name Language
28.2.5. Historical Flag
28.2.6. Display Name Flag
28.2.7. Other Name Flags
28.2.8. Name Source Core
28.2.8.1. Page
28.2.9. Name Date
28.2.9.1. Earliest Date
28.2.9.2. Latest Date
28.3. Display Biography Core
28.4. Birth Date Core
28.5. Death Date Core
28.6. Birth Place
28.7. Death Place
28.8. Person Nationality/Culture/Race Core
28.8.1. Preference
28.8.2. Nationality/Culture Type
28.9. Gender
28.10. Life Roles Core
28.10.1. Preference
28.10.2. Role Date
28.10.2.1. Earliest Date
28.10.2.2. Latest Date
28.11. Person/Corporate Body Event
28.11.1. Event Date
28.11.1.1. Earliest Date

15.1. Conservation/Treatment Description
15.2. Treatment Type
15.3. Treatment Agent
15.4. Treatment Date
15.4.1. Earliest Date
15.4.2. Latest Date
15.5. Treatment Place
15.6. Remarks
15.7. Citations
15.7.1. Page
16. SUBJECT MATTER Core
16.1. Subject Display
16.2. Subject Indexing Terms Core
16.2.1. Subject Indexing Type
16.2.2. Subject Extent
16.3. Subject Interpretive History
16.4. Remarks
16.5. Citations
16.5.1. Page
17. CONTEXT
17.1. Historical/Cultural Events
17.1.1. Event Type
17.1.2. Event Identification
17.1.3. Event Date
17.1.3.1. Earliest Date
17.1.3.2. Latest Date
17.1.4. Event Place
17.1.5. Event Agent
17.1.5.1. Agent Role
17.1.6. Contextual Cost or Value
17.2. Architectural Context
17.2.1. Building/Site Context
17.2.2. Part/Placement Context
17.2.3. Architectural Context Date
17.2.3.1. Earliest Date
17.2.3.2. Latest Date
17.3. Archeological Context
17.3.1. Discovery/Excavation Place
17.3.2. Excavation Site Sector
17.3.3. Excavator
17.3.4. Discovery/Excavation Date
17.3.4.1. Earliest Date
28.11.1.2. Latest Date
28.11.2. Event Place
28.12. Related Person/Corporate Body
28.12.1. Person Relationship Type
28.12.2. Person Relationship Date
28.12.2.1. Earliest Date
28.12.2.2. Latest Date
28.13. Person/Corporate Body Broader Context
28.13.1. Broader Context Date
28.13.1.1. Earliest Date
28.13.1.2. Latest Date
28.14. Person/Corporate Body Label/Identification
28.15. Person/Corporate Body Descriptive Note
28.15.1. Note Source
28.15.1.1. Page
28.16. Remarks
28.17. Citations
28.17.1. Page
28.18. Person Authority Record ID
29. PLACE/LOCATION AUTHORITY Core
29.1. Place/Location Authority Record Type
29.2. Place Name Core
29.2.1. Preference
29.2.2. Name Type
29.2.3. Name Qualifier
29.2.4. Name Language
29.2.5. Historical Flag
29.2.6. Display Name Flag
29.2.7. Other Name Flags
29.2.8. Name Source Core
29.2.8.1. Page
29.2.9. Name Date
29.2.9.1. Earliest Date
29.2.9.2. Latest Date
29.3. Geographic Coordinates
29.4. Place Types Core
29.4.1. Preference
29.4.2. Place Type Date

17.3.4.2. Latest Date
17.4. Historical Location Context
17.4.1. Historical Location Place
17.4.2. Historial Location Date
17.4.2.1. Earliest Date
17.4.2.2. Latest Date
17.5. Remarks
17.6. Citations
17.6.1. Page
18. DESCRIPTIVE NOTE
18.1. Descriptive Note Text
18.2. Remarks
18.3. Citations
18.3.1. Page
19. CRITICAL RESPONSES
19.1. Critical Comment
19.2. Comment Document Type
19.3. Comment Author
19.4. Comment Date
19.4.1. Earliest Date
19.4.2. Latest Date
19.5. Comment Circumstances
19.6. Remarks
19.7. Citations
19.7.1. Page
20. RELATED WORKS
20.1. Related Work Label/Identification
20.1.1. Work Relationship Type
20.1.2. Work Relationship Date
20.1.2.1. Earliest Date
20.1.2.2. Latest Date
20.2. Work Broader Context
20.2.1. Historical Flag
20.2.2. Broader Context Date
20.2.2.1. Earliest Date
20.2.2.2. Latest Date
20.3. Relationship Number
20.4. Remarks
20.5. Citations
20.5.1. Page
21. CURRENT LOCATION Core
21.1. Current Location Description
29.4.2.1. Earliest Date
29.4.2.2. Latest Date
29.5. Related Places
29.5.1. Place Relationship Type
29.5.2. Place Relationship Date
29.5.2.1. Earliest Date
29.5.2.2. Latest Date
29.6. Place Broader Context Core
29.6.1. Broader Context Date
29.6.1.1. Earliest Date
29.6.1.2. Latest Date
29.7. Place/Location Label/Identification
29.8. Place/Location Descriptive Note
29.8.1. Note Source
29.8.1.1. Page
29.9. Remarks
29.10. Citations
29.10.1. Page
29.11. Place Authority Record ID
30. GENERIC CONCEPT AUTHORITY Core
30.1. Concept Authority Record Type
30.2. Concept Term Core
30.2.1. Term Qualifier
30.2.2. Preference
30.2.3.Concept Language
30.2.4. Historical Flag
30.2.5. Term Source Core
30.2.5.1. Page
30.2.6. Term Type
30.2.7. Term Date
30.2.7.1. Earliest Date
30.2.7.2. Latest Date
30.3. Related Generic Concepts
30.3.1. Concept Relationship Type
30.3.2. Concept Relationship Date
30.3.2.1. Earliest Date
30.3.2.2. Latest Date
30.4. Concept Broader Context Core
30.4.1. Broader Context Date
30.4.1.1. Earliest Date
30.4.1.2. Latest Date

21.2. Current Repository /Geographic Location Core
21.3. Current Repository Numbers Core
21.3.1. Number Type
21.4. Gallery/Shelf Location
21.5. Current Credit Line
21.6. Object/Work Label/Identification
21.7. Remarks
21.8. Citations
21.8.1. Page
22. COPYRIGHT/RESTRICTIONS
22.1. Copyright Statement
22.2. Copyright Holder Name
22.3. Copyright Place
22.4. Copyright Date
22.4.1. Earliest Date
22.4.2. Latest Date
22.5. Remarks
22.6. Citations
22.6.1. Page

30.5. Generic Concept Label/Identification
30.6. Concept Scope Note Core
30.6.1. Note Source Core
30.6.1.1. Page
30.7. Remarks
30.8. Citations
30.8.1. Page
30.9. Concept Authority Record ID
31. SUBJECT AUTHORITY Core
31.1. Subject Authority Record Type
31.2. Subject Name Core
31.2.1. Preference
31.2.2. Name Type
31.2.3. Name Qualifier
31.2.4. Name Language
31.2.5. Historical Flag
31.2.6. Display Name Flag
31.2.7. Other Name Flags
31.2.8. Name Source Core
31.2.8.1. Page
31.2.9. Name Date
31.2.9.1. Earliest Date
31.2.9.2. Latest Date
31.3. Subject Date
31.3.1. Earliest Date
31.3.2. Latest Date
31.4. Subject Roles/Attributes
31.4.1. Preference
31.4.2. Role Date
31.4.2.1. Earliest Date
31.4.2.2. Latest Date
31.5. Related Subject
31.5.1. Subject Relationship Type
31.5.2. Subject Relationship Date
31.5.2.1. Earliest Date
31.5.2.2. Latest Date
31.6. Subject Broader Context Core
31.6.1. Broader Context Date
31.6.1.1. Earliest Date
31.6.1.2. Latest Date
31.7. Related Place/Location
31.7.1. Place Relationship Type

	31.8. Related Person/Corporate Body 31.8.1. Person Relationship Type 31.9. Related Generic Concept 31.9.1. Concept Relationship Type 31.10. Subject Label/Identification 31.11. Subject Descriptive Note 31.11.1. Note Source 31.11.1.1. Page 31.12. Remarks 31.13. Citations 31.13.1. Page 31.14. Subject Authority Record ID

Appendix Two

List of initial 112 design theory texts reviewed with texts selected for analysis starred

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Appendix Three

Quote from text by Buchanan (2007, pp. 57–58) that informs the discussion of the development of C Maps in Chapter Three, pp. 9097

The first strategy is to explain design and the products of design within a larger whole or system. It begins with contradictions and conflicts in everyday experience – for example the conflicts of user requirements or the values of designers and their clients – and seeks unifying ideas and a larger context within which differences may be overcome in theory and practice, often with specific methods of participation, analysis, synthesis and creative thinking. It emphasises the social and cultural context of design, and typically draws attention to the limitations of the individual designer seeking sustainable solutions to problems. This is the strategy of Dialectic, whether in an idealist, materialist or sceptical variation. In each variation, technical issues are assimilated into a broader context, and the perspectives or opinions of individuals are as much part of understanding design as any technical analysis. (p. 57)

The second strategy is to explain design and the products of design by seeking the basic elements that underlie the complexities of the material world and the workings of the mind. It emphasises analysis of the processes and mechanisms by which those basic elements, once they are identified and analysed, are then combined and synthesised to yield the world of experience and the cognitive processes of designing and decision making. This is the strategy of Design Science, whether in the form of cognitive science, psychology and computer simulation, or in related variations of the study of consumer and user behaviour. In this strategy, Design Science is often complemented by knowledge gained from other sciences, but the perspective of individuals is strictly limited, since the proper method of analysis is objective and independent of opinion and personal perspective.

The third strategy lies between Dialectic and Design Science. Instead of seeking to understand design and the products of design by reference to something else – the context of a holistic system or the basic elements that underlie the complexity of experience – the third strategy seeks an explanation in the experience of designers and those who use products, without recourse to the theoretical abstractions of Dialectic or Design Science. On the one hand it may emphasise the inventive and creative power of the designer and his or her ability to effect social change through argument and

communication – whether in words or products. On the other it may emphasise the discipline of designing, based on analysis of the essential elements of products and the creative synthesis of these elements in the various branches of design with appropriate regard for how products are produced and distributed as well as for how products evolve in human use within a community. This is the strategy of design inquiry, unfolding in two closely related but distinct lines of investigation […] One line focuses on communication and the imaginative power of the designer, while the other focuses on the discipline of making, within the framework of products and their use. One is a strategy of Rhetorical Inquiry; the other is a strategy of Productive Science or Poetics – from poesis, the ancient Greek word for all activities of human making and from Aristotle's specific use of the term for the science of made-things or the artificial. (p. 58)

Appendix Four

Detailed Working C Maps of the 20 selected theories. Includes C Map images, and versions as C Map texts and OWL format. See CD ROM

Appendix Five

Outline and Screen Shots from Proof-of-Concept Design for an Information Structure of a Design Research Resource. See CD ROM