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Design Research and Domain Representation

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Abstract:

While diverse theories about the nature of design research have been proposed, they are rarely considered in relation to one another across the broader disciplinary field. Discussions of design research paradigms have tended to use overarching binary models for understanding differing knowledge frameworks. This paper focuses on an analysis of theories of design research and the use of Web 3 and open content systems to explore the potential of building more relational modes of conceptual representation.

The nature of this project is synthetic, building upon the work of other design theorists and researchers. A number of theoretical frameworks will be discussed and examples of the analysis and modelling of key concepts and information relationships, using concept mapping software, collaborative ontology building systems and semantic wiki technologies will be presented. The potential of building information structures from content relationships that are identified by domain specialists rather than the imposition of formal, top-down, information hierarchies developed by information scientists, will be considered. In particular the opportunity for users to engage with resources through their own knowledge frameworks, rather than through logically rigorous but largely incomprehensible ontological systems, will be explored in relation to building resources for emerging design researchers.

The motivation behind this endeavour is not to create a totalising meta-theory or impose order on the 'ill structured' and 'undisciplined', domain of design. Nor is it to use machine intelligence to 'solve design problems'. It seeks to create dynamic systems that might help researchers explore design research theories and their various relationships with one another. It is hoped such tools could help novice researchers to better locate their own projects, find reference material, identify knowledge gaps and make new linkages between bodies of knowledge by enabling forms of data-poesis - the freeing of data for different trajectories.

Keywords

Design research; Design theory; Methodology; Knowledge systems; Semantic web technologies.

The discipline of Design, as a distinct knowledge domain with its own subject matter, philosophical and methodological procedures, has drawn from, and contributed to, the development of a number of different knowledge frameworks or paradigms. A consideration of Design as an integrative discipline has helped articulate the relationships between design and other disciplines (Archer, 1979; Buchanan, 1996; Friedman 2000). Within the domain of Design, however, the contradictions and tensions that exist between

various theories, practices and cultures of Design, and the lack of any widely agreed to formal knowledge framework suggest that it is an ill-structured and undisciplined domain.

This discord has been productive, particularly for the growth and richness of design discourse. The plurality within the discipline is recognized as a challenging but positive potential of Design, particularly if diverse perspectives can somehow be brought into relationship with one another. '...the complexity of problems related to nature and humanity requires several viewpoints, elicited from new tendencies and theories.' (Navarez & Feher, 2000. p.37).

However, it is difficult, particularly for novice researchers, to gain an overview, yet alone a deeper understanding of the complex, emergent field of Design. The understanding of postgraduate students and the potential development of design research projects are often limited by the particular frameworks and approaches promulgated by supervisors or institutions. Margolin has acknowledged the restriction of such conceptual and methodological specialisation. '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.' (2002. p.246). Such disciplinary segmentation may work against innovative thinking and the development of more relational ways of researching and designing that are needed to address complex and critical issues of sustainability, social and economic wellbeing and the role of technology.

As the discipline of Design has developed the discourse and knowledge across its various fields has grown. The problem of organizing and accessing such a complex body of knowledge is of concern for designers, educators and researchers. Even within traditional information systems like libraries, Design lacks proper representation, with material being dispersed across other typologies (Chayutsahakij, 2002). While a number of projects aiming to create total systems through which design knowledge could be comprehensively organized, have been proposed (Hubka & Eder 1996; Love, 2000, 2002; Garbacz, 2006), there is a fundamental contradiction between Design's dynamic complexity and the aspiration for a formalized and unified body of knowledge.

This paper discusses work in progress which is exploring the potential of open content and semantic web technologies to build more relational modes of conceptual representation to assist the development of design research resources. It describes a research process and presents some speculations and findings rather than conclusions. The nature of the project is synthetic and is built upon the work of other design theorists, information scientists and researchers. The project is still ongoing. It is hoped that the resource and system will be opened up and linked to resources developed by other members of the design research community.

Project Focus

The motivation behind the project discussed in this paper is to create dynamic models and systems that might begin to more adequately represent different

design research theories, research practices and methodologies and their various relationships with one another. It is not an attempt to impose some impossible, hierarchical, order on the rich but 'ill structured' domain of design. It is not an attempt to homogenize difference. Nor does it seek to use machine intelligence to solve design problems.

The refinement of more searchable and useful information systems requires the development of strategies that can enable resources to be accessed and interpreted more fully by search engines and other (human and computer) agents. Such processes, if they are to move beyond mere word searches, need access to higher order information structures that 'mark up' resources with detailed descriptions of their content and information relationships. Such structures must be relevant to different types of information across a body of knowledge (that is they need to have some consistency and formality) if they are to be machine readable. However they also need to be intuitively accessible to the people who want to develop and use such resources. Given the diversity of fields and the history of knowledge representation in design, this is no easy task.

This issue is explored through the review of literature, the development of a knowledge base or resource; the construction of a flexible, relational, information scaffold; and the development of a set of computational tools to help novice researchers search and question this information base; to better locate their projects and help illuminate the often unquestioned paradigmatic frameworks that underpin them. It is hoped that this system will help researchers contextualise and further consider their own projects, identify knowledge gaps and make new linkages between separate bodies of knowledge, enabling forms of data-poesis - the freeing of data for different trajectories (Dietz, 1999).

The project was initiated through a literature review focussing on four areas;

- models of design (models of design as a discipline, to identify paradigmatic approaches)
- theories of design research (specific design research models and meta-theories, as models of theories of design research);
- artificial intelligence in design (the context of historically predominant approaches to ontology building, computational agency and knowledge systems development in design)
- knowledge systems (the methods, limitations and potential of formal and informal approaches to knowledge system development)

This review has informed a consideration of disciplinary models; an analysis of theories and meta-theories of design research; and an exploration of the problem of representing the undisciplined domain of design in formal and informal information structures. A concept mapping process, using CMap tools software, was used as a way of analysing and modelling theories as informal knowledge structures. This process of analysing and mapping design research theories and of relating and identifying shared and unique abstractions across different theoretical models will be discussed. The extension of this method for building and comparing knowledge structures and for a shared development of ontologies (using the Collaborative Ontology Environment (COE) which

supports the automatic extraction of OWL/RDF schema from C maps) will be considered. OWL/RDF is a semantic web mark up language. Web 3 or Semantic web technologies are being used for the development of semi-structured data systems that will support new levels of data integration, operability and access to information via the internet.

Finally the paper will briefly outline the process of developing an open information base about design research (using Media wiki software) and the development of semantic web mark up (using Semantic wiki software) to enable a semantically rich, responsive, information system. A dynamic and participatory approach, supported by Web 3 technologies, that allows domain specialists and users of the resource to build information scaffolds up from content relationships, rather than a traditional approach of information scientists developing formal ontological theories and applying them to structure bodies of information, underpins this project.

Design Knowledge and Organisation

The difficulty with any ontological endeavour which attempt to represent or classify knowledge within the domain of Design is the complexity of design itself. There is a lack of agreement about the nature and scope of the field: `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 ephemeral.' (Poggenhol, 2004. p. 579)

Methods of organizing and making accessible information from across this growing body of knowledge are still limited. As a formalized knowledge domain, even within traditional information systems like libraries, design is invisible, dispersed within other typologies: `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)

Recognition of how the understanding and organisation of knowledge has changed and evolved historically is critical to the representation of cultural domains like Design. The grand but flawed project of design science; to create a totalized system of logically related knowledge which would 'contain and organize the complete knowledge about and for designing' (Hubka & Eder, 1996. Section 4.2.) has fuelled a level of scepticism within the design research community towards ontological endeavours. Design science sought to build a comprehensive knowledge base with `fixed terminology, classes (taxonomy), relationships (including inputs, throughputs and outputs), determination of measures, laws, theories and hypotheses' (ibid) which would serve as the basis for 'consciously guided design activity'. This approach to systematising design knowledge was seen as a first step in developing guidance, or even design decision making, through machine intelligence, an ambition that became the project of the Artificial Intelligence in Design Movement (Brown,1997; Gero, 2007).

Terence Love's `meta-theoretical structure for design' (2000; 2000b, 2001; 2002) sought to underpin the development of a `unified body of knowledge,' (Love, 2002, p.345) an ambition that may have clouded the response to what is potentially a very rich and useful model. Like all models, however, it can only ever be a partial representation (Snodgrass and Coyne, 1992).

The epistemology and ontology of design and design research have been the subject and focus of much theoretical inquiry. Buchanan (2007, p.56) recognizes the value of this diversity: `The pluralism of design and design research is one of the fundamental characteristics of the field. It is a characteristic that we may ignore at the peril of gross misunderstanding of the complexity and richness of the field.... 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.'

However the difficulties created by such diversity (such as the barriers developed between sub-disciplinary specialisations or design genres) can limit the utilization of the richness of the field, and must also be acknowledged. Michel recognises the need for greater systematic understanding: 'At the core of most, if not all, concepts of design research is the realisation that, in a age of increasingly complex conditions for practicing and studying design, there are almost no systematic bases for the continued development of design as an academic discipline.' (Michel, 2007. p. 15)

There is a growing recognition that the limitation of formalized knowledge structures (such as ontologies and taxonomies) lies in their inevitable assumption of a single world view:

> *'Every thing 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.)*

The potential of an information system which can be approached through an individual's particular knowledge framework and then expanded out by linking to other frameworks or approaches may offer a flexible way to map and model the complexity of the emergent and undisciplined field of design: 'While traditional media were limited to recording factual dimensions of collective memory, digital systems have the potential to help us explore theories, ways of perceiving, ways of knowing; to enter into other mindsets and world views and thus to attain novel insights.' (Veltman, 2004. p.2)

The lack of consistency of design terminology is another issue that has been the focus of much debate. There is no agreement on key terms and their meaning (Poggenhol, 2004). Issues of inconsistency of terminology are – 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, p, 354-355.

However the specified vocabularies which are fundamental to traditional computer based knowledge systems, 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 importance of the contextualisation of terms and the impossibility of developing universal terminology for design. These concerns have also been recognised in discussions about culture and the semantic web:

> *'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.' (Veltman, 2004. p.7)*

The information science approach, where formal ontological theories are developed by information specialists working to develop universal structures with limited domain understanding, is problematic in a number of respects. For example while such knowledge structures may be semantically correct they can be difficult for 'domain experts' to use because formal logic and specified vocabularies are often very different from the dynamic, culturally inflected ways such experts 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.

Models of Design

The notion of Design as a new and distinctive knowledge domain or discipline that constitutes a particular intellectual approach developed over the second half of the twentieth century. Theories and models of Design as a discipline foreground theories and conceptualisations of design research. While an investigation of different theories of design as a discipline is not the main focus of this project, the paradigmatic assumptions on which such models are based also underpin theories of design research. For example the relationship between Science, the Humanities and Design (referred to by Coyne and Snodgrass (1991) as Design's 'dual knowledge thesis'), has underpinned the development of many theories about design research. Huron (1999) suggestion that 'the most pronounced methodological differences can be observed in the broad contrast between sciences and the humanities.' (p.3) hints at some of the confusion novice researchers face in trying to understand the domain of Design, which draws from both traditions.

Archer (1979), recognised Design as being quite distinct from science or the humanities, 'as the area of human experience, skill and understanding that reflects man's concern with the appreciation and adaptation of his

surroundings in light of his material and spiritual needs.' (p.17) Archer represented Design in a triangular configuration (see figure 1.) in which the established oppositional positioning of the sciences and humanities is challenged by a third domain, that of Design, which is simultaneously defined through its relationship with these other disciplines.

Buchanan (1996) has described Design as 'new liberal art of technological culture,' (p.3) a notion that can be considered in relation to Archer's diagram where Design is positioned in proximity to both the liberal arts (painting, dance, theatre etc) and to technology and science.

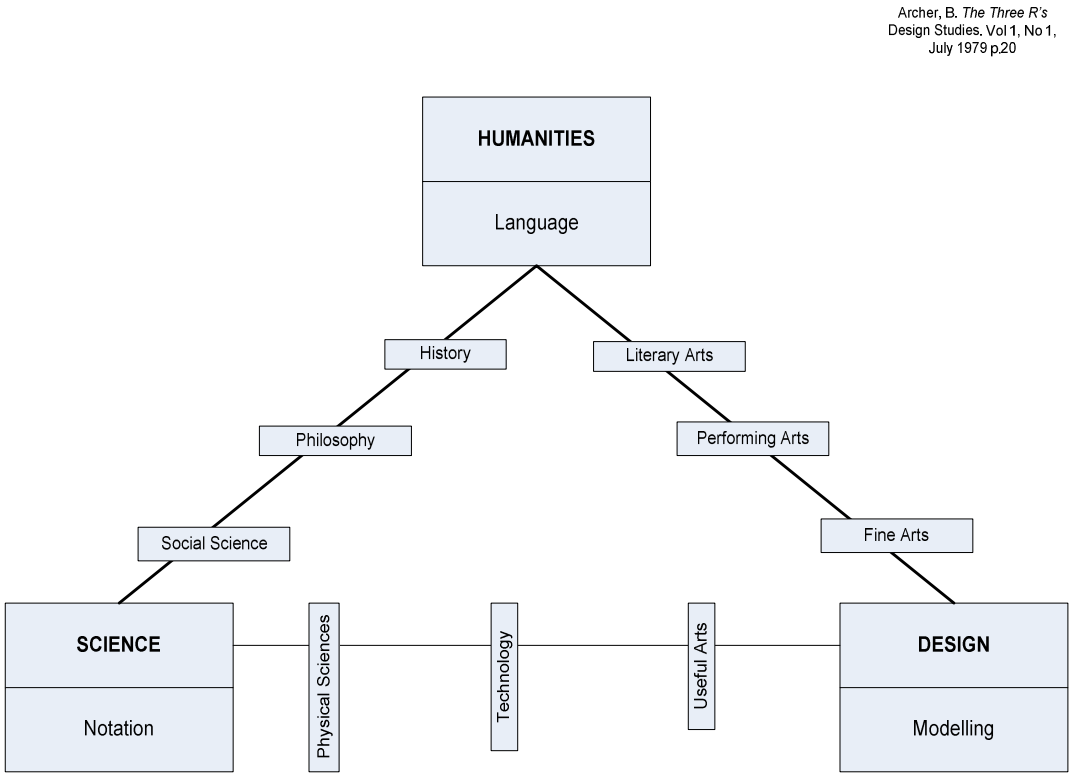

Figure1. After Archer, 1979: Model of Design as a Discipline

Bonsiepe (1991) proposes a model of the domain of Design based on distinct fields of design activity, rather than in terms of Design's relationship with other disciplines. His model describes with 6 fields (design research; design education; design practice; design discourse; design management; design policy). Reymen (2001, p.3) suggests a simpler taxonomy of three fields: design practice, design education and design research. In identifying key relationships between these fields she suggests that the significance of design research in relation to the domain is expressed as the development of theories and support for design practice and design education. However the value and potential of research about and for the development of design research, to support the disciplinary development and agency of Design, is overlooked in this model.

Models of Design Research

A clear distinction also needs to be made between theories of design research (as a field within the discipline of Design) and theories of design as a process or activity (designing). The process of designing is fundamental to professional practice and is also central to practice-led research and as part of design education curricula. There have been many different models of design practice developed through design research. These have focussed on understanding the act of designing and how such processes can be studied, improved upon, communicated to others or even supported or replicated by computers. Dorst (2007) notes: 'The overwhelming majority of … work in design research focuses on the design process to the exclusion of everything else' (p. 2). While such models of designing are used by educators to teach students how to design, and are the focus of much research, they appear to be less influential on the practices of professional designers.

Within my own project to date some twenty models of design research, taken from writings produced between 1983 and 2008 have been reviewed. These have been selected from across the spectrum of writing about design research, drawn from books, journals, conference papers and theses. While broadly based models were sought, these are not so numerous, and models of more specific positions and methodological approaches were also included in the study. This sample of writings cannot be considered definitive, but was selected to give a wide representation and variety of approach. In particular the level of granularity of a model, and the relationships (e.g. commonalities, differences, similarities, distinctions, types of orientation) between different models were important to the selection of theories.

During this process of analysis a number of clusters or classes of models have been identified. These typologies are built up from an analysis of the different approaches taken in developing and structuring particular theories. Subsequently groups of theories, based on similarity of approach, have been identified e.g. models of design research defined by output types or models of design research using paradigmatic framing, or by types of research questions asked. This categorization has developed from the content and focus of the models analysed rather than from information theories developed extrinsically to the phenomenology of design research.

This approach differs from a more formal ontological approach, whereby categories are based on generalized philosophical distinctions. For example the categories proposed by Love (2000) are drawn from Popper's ' three world' model (1976). This approach is based on a separation of concepts from; the physical and material world; the subjective world of mind and contents; and the objective world of theories, knowledge and problems (Love, 2000, p.301). The purpose behind Love's rational approach is to enable clarity by creating distinct categorizations to 'minimize the conflation of concepts that inevitably will occur across incommensurate worlds.'

The purpose of my own project is quite different: to identify commonalities and differences; to consider shifts of meaning and understanding; to trace linkages; 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 which need to be smoothed over or unified. The process allows for information scaffolding (as a portable, reconfigurable structure) to be built around and between theories rather than a formal structure to be concretised into which theories must be fitted.

Some groupings of models include:

- Theme based models where research themes or subjects are defined as distinct, recurring, and unifying ideas e.g. Models by Fraying, 1993; and Archer 1995; Cross 1984; supplemented by Love, 2000; Love, 2000b; and Cross, 2006.
- Output based models, where the model is based on types of research output (defined as the type of intellectual or creative production) e.g. models by March & Smith,1995; Jarvinen 2004; Reymenen, 2001.
- Inquiry oriented models based on types of research question e.g. Roth, 1999; Jarvinen 2000.
- Paradigmatic models based on philosophical approaches to research e.g. Buchanan, 1996; Cross, 2001; Cross, 2006; Krippendorff, 2006; Margolin, 2002; Scrivener, 2000.
- Meta-theoretical models, as design research models that engage with and seek to link design research theories across different levels of conceptualization e.g. Jarvinen 2004; Jonas, 2007; 2008; It should be noted that in this context a meta-theory is not used in the sense of a classification system or theory for creating a unified body of knowledge.

The model proposed by both Frayling (1993) and Archer (1995) was one of the first design research models articulated and was defined in terms of the relationship of research to design. According to Frayling and to Archer, research can be `About practice,' where design is the subject of the research. This approach includes studies about design history, about design in relation to society, about design methodology etc. 'For practice', where the research will assist design and is purpose oriented, contributing to other practitioner activity. Or `Through practice' where the research is conducted through designing `where the best or only way to shed light on a proposition, a principle, a material, or a function, is to attempt to enact something, calculated to explore, embody or test it.' (p.11). This Frayling/ Archer model is defined within my project as a theory, that is it uses abstractions that sit at a level of epistemological consistency. This `trinity' model can be related in part to a number of newer theories of design research.

Jonas (2008) in an ongoing project to identify `paradigmatic clusters in design research' has expanded Frayling's model and proposed a more detailed schema. Jonas's model is meta-theoretical in that it attempts to relate a number of design theories which are based on different levels of abstraction (or different epistemological conceptualisations), and is thus a theory about theories. He re-interprets Frayling's three categories and associates each with questions and a number of `paradigmatic' processes (e.g. cognitive knowledge solving process; semantic process). Each process is analysed in terms of its epistemological assumptions; underlying theories; basic assumptions; methods; examples and references. This work-in-progress is

significant in attempting to analyse and articulate relationships between different design research 'processes' across the design research domain.

Another meta-theoretical model of design research approaches has been developed by Järvinen (2000). Working from an Information Science perspective, Järvinen's classification follows a 'top down' principle where the top category is first divided into two classes and one or both are then divided again into two sub-classes etc. Järvinen first distinguishes 'approaches studying reality' from 'mathematical' approaches, recognising formal languages like algebra as 'symbol systems which don't have direct reference to objects in reality.' (p.125). The emphasis on design research, within Järvinen's schema, is focused onto 'approaches studying reality,' as mathematical approaches are oriented towards programming and logic. He distinguishes between approaches 'that stress what is reality' and those that 'stress the utility of artefacts.' Each of these categories is further divided and refined. Järvinen also associates each category with questions (e.g. the category 'utility of artefacts' which includes 'building artefact approaches' and 'evaluating artefact approaches.' Categories are related respectively to the questions 'is it possible to build a certain artefact?' and 'how effective is this artefact?'). He also identifies methodological approaches, related methods and types of research outputs in relation to each category or research approach.

Like the discipline of design itself, the nature of design research (its scope, methodology and the validity and/or success of the different frameworks or paradigms used by design researchers) is still widely debated and contested. Such debate is important within an emerging discipline. Friedman (2000) notes 'the fact that design is young poses challenges to the development of a rich theoretical framework. In order to develop this framework a community of researchers must identify them selves and enter dialogue… The exchange of opinions and even disputes concerning the nature and limits of a field help to construct identity and thus become bases for social cohesion.' (p.16)

Within this context the development of open, networked resources, flexible and dynamic information structures and knowledge discovery tools could help novice researchers through processes of identification and interaction. This could assist in developing an understanding of knowledge theories underpinning design research as well as methodological approaches. Veltman (2004, P.2) suggests that while traditional media were limited to 'recording factual dimensions of collective memory', digital systems have the potential to help us 'explore theories, ways of perceiving, ways of knowing; to enter into other mindsets and world views and thus to attain novel insights.'

Methodological Issues

The philosophical and practical issues raised in this paper have also been explored and articulated through particular technologies which have supported different forms or methods of representation. The selected design research theories were analysed in conjunction with a process of concept mapping, using CMap tools software. Concept mapping should be distinguished from 'mind mapping', 'brainstorming' and other generalised ideas mapping techniques. Concept maps are based on the work of Novak and Gowin (1984) into human learning and knowledge construction. Concept

maps are recognised as an effective method for representing and communicating knowledge (Cañas, Hill, et al. 2004), but can also be used as part of an analytical methodology. 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.

CMap Tools comes as a client-server based software kit which enables users to graphically express their understanding of a domain of knowledge (Cañas, Hill, Carff et al, 2004). This makes it an interesting medium for a visualisation of ideas and relationships between ideas, and for identifying the underlying structure and argument of a text. The software also supports the collaboration and sharing of CMaps through a constructivist online learning environment. In order to check relationships, CMaps can be compared and common concepts or concept relationships identified. Most of the images presented in this paper have been developed using CMap tools and exporting as image files. CMaps can also be exported in a range of other formats including the semantic web mark up language, OWL/RDF.

There are however limitations to the use of this software in that comparison of 'concepts' is just a comparison of words. The different terms used by authors, or, perhaps more significantly, the different definitions, meanings or levels of granularity associated with common terms by different authors, limit the use of this sort of machine supported comparison. For example the term 'Design Science' is proposed as a distinctive paradigm in a number of models of design research surveyed. However the generic category of design science, positioned in some theories as being opposite to creative or practice based modes (e.g. Scrivener 2000), is hard to reconcile through simple word recognition with the more nuanced model proposed by Cross (2001) and extended by Krippendorff (2006) which identifies four distinct approaches within the field of design science, which all contain the terms design and science in their titles. (See figure 2.)

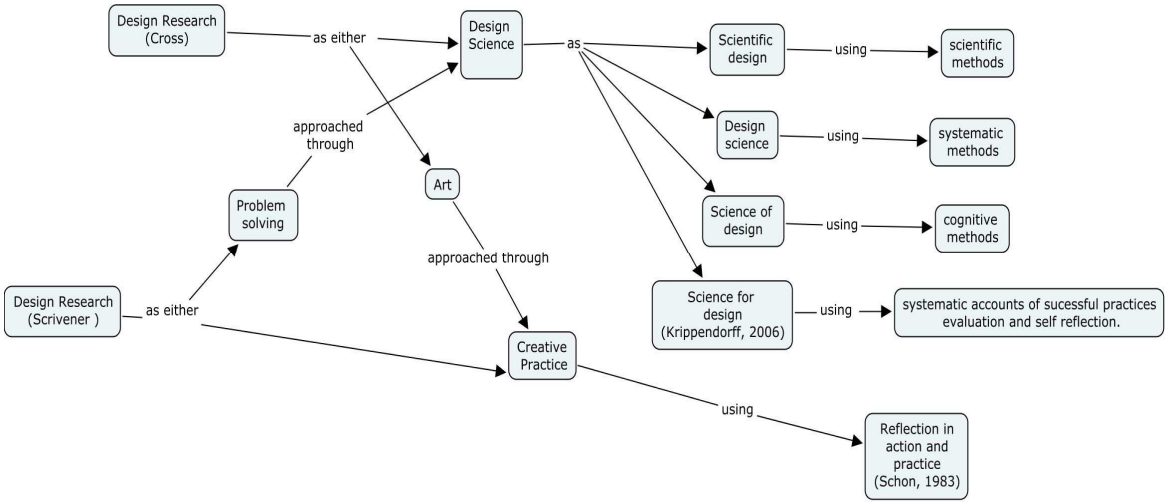

Figure 2: Development of concept map relating some paradigmatically based design research models from Scrivener 2001, Cross, 2001 and Krippendorff, 2006

Larger composite concept maps were built to try and relate different design research models. The difficulty with this process is that these models are based on different sorts of abstractions. Issues such as the level of model detail and the heterogeneity of terminology make the synthesis of different theories into a cohesive meta-theory or unified structure impossible. Above all, the particularity of each position reflected through these various models would be eroded by this sort of subsumption.

However the process of attempting to relate different theoretical models in CMaps led to the identification of different types of design research models which will be used to provide different conceptual pathways into the design research resource (see Figure 3). Huron notes while we might expect 'that the positions we hold regarding the philosophy of knowledge would inform and shape the concrete procedures we use in our day to day research methods. However the information flows in both directions.' (1999, p.3)

Concept maps are knowledge models, but their 'semantic expressivity' which makes them so easily used and understood by humans, means that they 'cannot easily be interpreted and made actionable by computers' (Eskridge, Hayes et al. 2006. p.1) CMap Tools is linked to COE, a collaborative ontology environment, which is an RDF/OWL ontology viewing/composing/editing tool. OWL/RDF is a standard for the representation of data on the Semantic web.

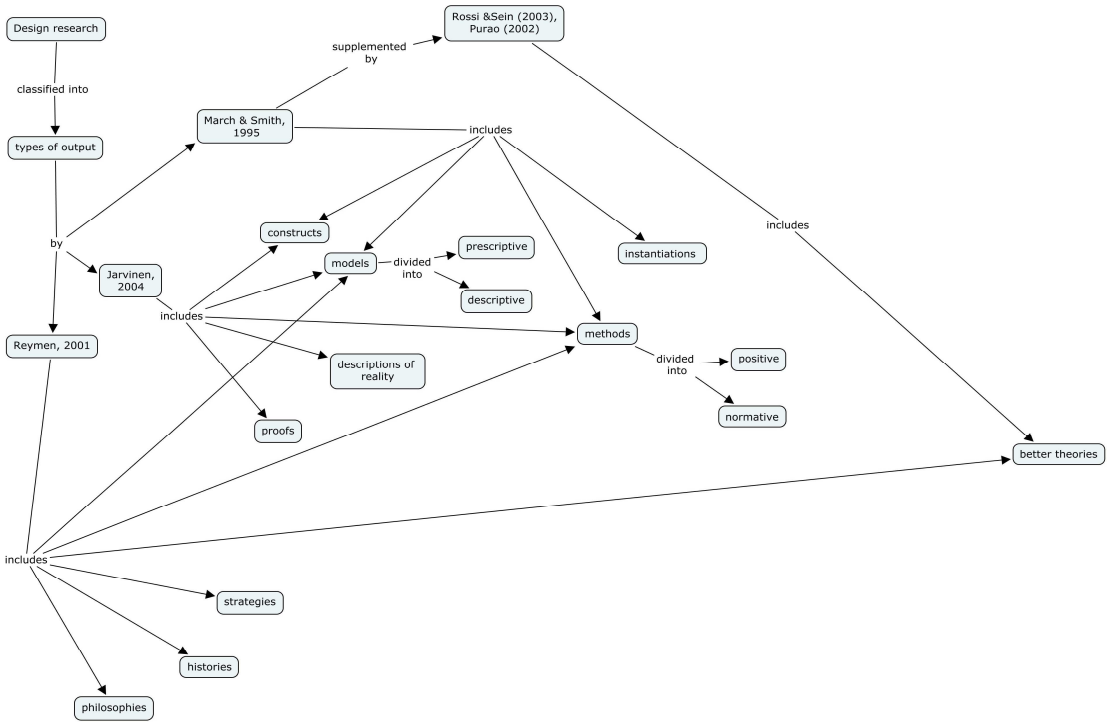

Figure 3: Detail from CMap exploring relationships between output based models by March & Smith,1995; Jarvinen, 2004; Reymenen, 2001

Semantically Enabled Knowledge Technologies

The notion of the Semantic Web, or Web 3, is associated with the development of a layer of machine readable data to support more sophisticated search engines, automated and intelligent agents to support

the sharing and better use of information. It is based on the 'Web Way', the same philosophy that underpinned the development of the internet as a scalable, adaptable, extendable, system. The Web Way, characterised as being without a central authority, has led to the development of participatory networked developments and systems like open source and open content movements. The Semantic Web project is being enhanced by a number of tools, systems and applications being developed to enable non-specialists to access and more easily use these powerful specification languages.

The development of wiki as web based tools for communities to collect and share knowledge has been a significant development in so called Web 2 technologies that promote social networking and collaborative knowledge building. Wikipedia is and example of this sort of open content development system. A problem with Wikipedia is that its search system is relatively primitive, with users relying on full text search, article names, links or lists of links for finding information. (Krötzch, Vrandečić & Völkel, 2005. p.1). A number of Semantic Web applications have been developed in relation to wiki software. For example Semantic Wiki, built as an extension to Media Wiki (the platform on which Wikipedia is built) enables RDF/Owl output. It has been developed as 'an extremely simple, low tech way of augmenting Wikipedia with machine readable information that allows one to (internally or externally) implement all kinds of query answering systems.' (Krötzch, Vrandečić & Völkel, 2005 p.2). Additionally, the availability of machine readable descriptions is prompting the development of a multitude of new tools and applications which include the ability to visualise content relationships (Krötzch et al, p.12) and the linking of semantic wiki data with data on other websites.

My project involves building a design research wiki which will include semantic mark up. The individual concept maps and synthesised maps developed during the analysis of design research theories is being exported in RDF/OWL to form a semantic scaffolding for the wiki, which will be enhanced by correlation with tags built up from other content developed for the wiki and other relevant marked up web based content (e.g. other papers on design research available on the internet which have, or are open to being developed with, semantic mark up) .

I am also involving research students and staff in developing concept maps as part of their project development process. The potential of using such maps to identifying points of commonality or relevance to particular theories or frameworks identified within the resource is also being explored. Creating visual or spatial interfaces that allow resource users to approach information through their own terms or frameworks and lead them out to other concepts and models, or to identify knowledge gaps, is critical.

The resource can also be made publicly available to be developed further as an open content resource for the design research community. This system offers the potential of a semantically rich, flexible but adequately formalised data structure. It can be developed without advanced information systems expertise and expanded through participatory processes.

Different theories of design research have been discussed in relation to the development of an information system that might more adequately represent

different understandings and theories about the domain of design research. The need for systems that can represent diverse viewpoints and where entities can evolve meaning are important cultural dimensions which can be enhanced and activated by less formal information scaffolds and the flexibility of Semantic Web technologies.

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