Learning from the Design-Science Paradox: New Foundations for a Field of Design

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The Problem and Paradox

The development of sound foundations for a coherent body of design theories and a unified discipline of Design has so far eluded design researchers. Professor Wolfgang Jonas has argued the foundations of the field of Design are swampy and paradoxical due to the complex interdependent relationship between the discipline of 'Design' and scientific disciplines (Jonas, 1999, 2000). On one hand, theory making in the natural sciences depends on the activity of designing as the underlying creative mechanism. On the other hand, the main role of the natural sciences is to produce theories of use in designing. This gives rise to paradoxical 'swampy' problems of how to build and justify scientific theories about Design. The paradoxical implication of the interrelationship between these scientific and design approaches is that it is impossible to build scientific theories about Design because there is no firm foundation on which to build them. Such design theories are epistemologically ungrounded because building Science depends on Design as a precursor. This Design-Science paradox implies the problem is unsolvable, and the two worlds are intrinsically incommensurate.

Addressing and resolving this paradox and problem is significant because of the social and economic importance of Design and Science to human development.

Exploring the Design-Science paradox with Klein

Klein and others have described how logical reasoning is dependent on other factors (see, for example, Klein, 1996, pp. 101-106; Rosen, 1980). Klein drew attention to the paradoxical way that 'logical rigour, which frames the scientific structure, should cease to function at the moment of its construction' (p. 105).

Klein described the epistemological origins of 'paradox' as the combination of *para* meaning adjacent, out of phase, difference, or singularity, and *doxa* meaning opinions regarded as self-evident and natural in a given society or situation. That is, a paradox is something that conflicts with those things 'taken for granted', 'beyond question', or 'common sense'. He identified several common forms of paradox:

- Those involving self-referentiality in which a system refers to itself in ways that lead to a logical dead-end, e.g. 'it is forbidden to forbid'.
- Logical paradoxes such as Godel's 'undecidability' theorem in which arithmetic must logically contain at least one undecidable proposition, which in turn makes the whole of the arithmetic system undecidable.

- Antimonies in which two lines of analysis from the same origin lead to opposite conclusions.
- Simple paradoxes that expose flaws in reasoning (Klein gives the example of a small boy who argues ‘I am very glad I don't like spinach because if I did I would eat lots of it, which would be a problem because I can't stand spinach’)
- Paradoxes drawing on the concepts of infinity and zero, such as Zeno's ‘hare and tortoise’ puzzle.
- Paradoxes in which the conclusion contradicts ‘common sense’.

The Design-Science paradox contains elements of several of these common paradox forms.

Klein suggested that all paradoxes could be characterised as combinations of three idealised types:

1. Paradoxes that indicate discord between concurrent theories, or theory and experiment.
2. Paradoxes in which the conclusion contradicts common sense.
3. Paradoxes that result from a contradiction or internal inconsistency in a theory.

Klein argued that addressing, understanding and resolving a significant paradox builds better theory, and moves a discipline onward by revising inadequate concepts, preventing the establishment of dogma, and avoiding cultural fixation (pp. 16, 31-35). Klein (pp. 16-22) concluded that resolving a paradox:

- Rarely incurs in terms of the elements of its proposition (it requires reviewing the situation from an epistemologically different tack)
- Is frequently contrary to surest subjective intuitions or 'common sense'
- Often demonstrates the inadequacy of familiar constructs
- Frequently forces the revision of earlier well established concepts and theories

Of the above factors, Klein emphasised the problems of ‘common sense’ arguing it is ‘suspect number one in any case of paradox and guilty almost every time’. Klein is strongly critical of ‘common sense’, because of its limitations as a form of knowledge and the problems it causes in research, theory making and knowledge creation (pp. 37-43). He noted that good theory usually emerges from paradox by contradicting common sense. For design researchers, theory makers and designers, Klein’s ‘common sense’ includes all those concepts, theories and terminology that are taken for granted as the essence and immutable foundations of the field of Design.

Exploring the Design-Science paradox

The analyses and principles presented by Klein offer the basis addressing the Design-Science paradox. The ‘common sense’ aspects of Design seem a good place to start.

There are several aspects of 'taken-for-granted', 'common sense' concepts, theories and terminology that are already subject to criticism from within design research as epistemologically unhelpful, inconsistent or plain wrong. These include:

- Defining theories of designing on the physical attributes of design problems, design solutions of the relationships between them (the 'Dilnot paradox' (Dilnot, 1982)).
- Lack of attention to defining terms and concepts research (see, for example, Hubka & Eder, 1996; Ullman, 1992), especially relating to sensible epistemological definitions of words involving the root, 'design' (Love, 2001b; O'Doherty, 1964)
- Problems in unifying design theories across the sub-disciplines in which designing is undertaken (Sargent, 1994)
- Lack of correlation between design theories and theories from other disciplines, especially those that relate directly to human behaviour such as anthropology (Margolin, 2000)
- Weakness in the inclusion of social, environmental and ethical factors alongside technical factors in design theories (Love, 1998b)
- Inadequate explanation of the relationships between properties of designed objects, human internal processes of designing, communication between designers, the aesthetic appreciation of users and purchasers.

Klein's conclusions distil into the following four approaches to addressing a paradox in design theory:

- To look beyond the elements of existing theory propositions. In other words, the resolution of problems of design theory does not lie in those areas currently addressed by design theories.
- To critically review the 'common sense' theoretical paradigms of design theory making, designing, designs and Design to identify weaknesses.
- To identify the inadequacies of familiar and well established concepts in the field of Design.
- To forcibly revise well established concepts and theories of the field of Design to resolve paradoxes and epistemological inadequacies.

In short, by raising this Design-Science paradox, Professor Jonas has emphatically pointed to the need for a complete overhaul of the theoretical foundations, theories, concepts and terminological definitions of the field of Design. This may involve going against and redefining many, if not most or all, existing commonly held concepts about 'Design' to resolve the valid problems raised by the Design-Science paradox, and address problematic issues in design theory raised by design researchers over the last three decades.

A New Program of Design Research and Design Theory

The above analyses indicate that many problems of design theories and the foundations of design research cannot be adequately addressed by the traditional approaches to design research that focus on activities, situations and processes outside humans, and on the properties of designed objects. The author's previous research into developing improved theoretical, epistemological and onto logical foundations for design research suggests four areas need to be addressed:

- The implications of viewing designing as a human activity
- Developing epistemologically useful definitions of key terms on the basis of theoretically useful boundaries for the concept of designing
- Identifying the appropriate scope for a discipline associated with theory making about designing and designs

These provide the basis of an alternative research program to deconstruct the concept of designing with the aim of identifying its core elements. This critical epistemological approach starts by stripping away all those aspects of the activity of designing that are already identified as part and parcel of other domains and disciplines. It continues by probing deeper into individual cognition than is usually undertaken in design research so as to analyse those areas of human functioning that precede conscious or rational thought.

It is at this level of human functioning it is possible to start building coherent theories of design that take into account the psycho-neuro-biological aspects of human agency and action that underpin human creativity. It is at this level that it is possible to start building coherent and well-justified design theories that addresses issues such as; codesigning, the social construction of design cognition, creative thought and action, the role of affect in designing, the impact of social, environmental and ethical factors on designing. In short, the whole gamut of factors that most design researchers regard as essential aspects of designing but which cannot be adequately addressed through superficial epistemological approaches that focus on the properties of designed objects, or the characteristics of external design processes.

Using the above research program, many of the apparent theoretical conflicts and paradoxes disappear. A new picture emerges with designing as a micro-creative act within a matrix of other activities. 'Design processes' then consist of these micro-creative design acts supporting conscious rational thinking and decision making that in turn support routine activities such as data gathering, writing, drawing etc.

The outcome of this sort of deeper analysis is a move towards a definition of designing as a primary human activity that is conceptualised at a similar epistemological and physical level as thinking and feeling. This programmatically alternative research approach points to a clearer focus for Design as a field.

Design Theory grounded in research into human psycho-neuro-physiological processes

- Cognitively related somato-sensory and physiological changes, feelings and affects play key roles in designing and in theorising about designing and designs. There are several reasons for going down this path:
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- Many designers and researchers insist on the importance of 'feelings', intuition and human values in designing (see, for example, Akin & Akin, 1996; Cross, 1990; Davies & Talbot, 1987; Galle & Kovács, 1996; Glegg, 1971; Kolodner & Wills, 1996; Lawson, 1990, 1993, 1994; Lera, 1983; Liu, 1996; Love, 1996, 1998a, 2001b; Tovey, 1997).
- Feelings and the neurology of affect in designing have been relatively neglected. Computational cognitive design theories have mainly focused on *emotions*, especially 'emotions as physiological expression of cognition' rather than exploring the underlying neurological phenomena and its relationship to information models of brain activities (see, for example, topic areas in ISRE, 2001; Picard, 1997; Sloman, 2001).
- Cognition-related somato-sensory processes, feelings, and to a much lesser extent, emotions and moods, underpin the moment to moment interplay of human *closure* processes crucial to undertaking, communicating and understanding designing and designs. Explaining closure requires going beyond theories based on information transformations and analysis (see, for example, Bastick, 1982; Dewey, 1959; Hamlyn, 1990; Rosen, 1980) (Fleckenstein, 1992; Ryle, 1990).
- Increasing neurological evidence points to affect, as physiologically based somato-sensory processes, being an important element of all human functioning (see, for example, Fleckenstein, 1992; Kiehl, Liddle, & Hopfinger, 2000).
- Understanding human somato-sensory processes is significant to creating computational models of creative design cognition because it offers a more sophisticated working model for how designers create concepts (and scientific theories) and identify optimal solutions error checked against complex criteria (Davis, 2000, 2001; Love, 2000).
- Affect is the basis for the distribution of requisite variety in cybernetic analyses of systems models of designing (Love, 2001a).

This approach differs significantly from the way that affect is commonly conceived in the literatures of affective computing and cognition. It emphasises the active and often initiatory partnership that human somato-sensory processes have with brain activities in the process of human cognition (Davis, 2001; Fleckenstein, 1992). It contradicts the trend over the 1990s for viewing affects almost exclusively in terms of 'emotions' with their properties regarded as 'James-Lange' by-products of informatically based cognition. By focusing on the neurobiological representation of somato-sensory 'feelings' it moves the emphasis away from remote and abstracted cognitive conceptual constructs used in the discourse of emotion and cognition.

Social, Environmental and Ethical factors

Anthropology, Psychology and other Social Sciences appear to be important in creating better design theory, and establishing firmer foundations for design research, design

education, and design as a discipline. Designing is fundamentally an activity that is socially, environmentally and ethically situated.

- Social - because designing is a human activity, undertaken by humans and for humans.
- Environmental - because the primary purpose of all designs is to change human environments (designing also may result in unintended environmental side-effects)
- Ethical - because planning to change human environments and societies is essentially an ethical process

All designing is intended to have social and environmental effects to change society in some way. In many ways, these situational issues are more important aspects of designing than the physical characteristics of the designed objects, and therefore issues of technology and form would be expected to be theoretically secondary and contingent.

The human activity of designing underpins most action and agency. This also includes extensive amount of designing that occurs in areas that 'design professionals' might regard as outside the profession of 'design'. Currently, there is little epistemologically well-reasoned design theory that relates to the roles of design in these areas.

Taken together, these also point to potential contributions from design research to the creation of new insights in Philosophy.

My experience has been that satisfactorily including social, environmental and ethical factors in design theory is not easy, and presents many terminological, conceptual and epistemological challenges - not least to do with theoretical perspectives and the vast range of skills contributing to designing that competently addresses social, environmental and ethical issues. Some of the conclusions from this research indicate it is not epistemologically satisfactory to use the properties of designed objects as a basis for design theories that include social, environmental and ethical factors.

New Definitions of Key Terms that define boundaries for the concept of designing

In the different fields associated with designing, theoretical discourse has been terminologically and conceptually problematic since the inception of modern design research (see, for example, French, 1985; Hollins, 1994; Hubka & Eder, 1988; Hubka & Eder, 1996; Jones, 1970; Lewis, 1964; O'Doherty, 1964; Reich, 1994a, 1994b; Ullman, 1992; Wray, 1992). This issue is widely regarded as peripheral to design theory. The reality is, however, that it reaches deep to the heart of design research and theory making. It challenges the validity of the existing and future bodies of design literature, and is one of the key factors blocking a unified discipline of design.
Reviewing the research literature about designing and designs (human and AI) indicates that in most texts, key concepts such as 'designing', 'designs', 'design process', 'creativity', and 'cognition' have not been defined in sufficient detail (Love, 1998b). Unlike Engineering and Physics, there are no widely accepted definitions of core

concepts, and, across the myriad sub-fields involved in designing, even small variations in definition frequently result in significant differences in meaning (Cross, 1993; Hubka & Eder, 1988; Hubka & Eder, 1996; Love, 1998b).

This widespread lack of definition of concepts results in different meanings being confused and conflated by researchers and in problems of conceptual indeterminacy that reach deep into theory making about designing and designs. In many cases, contradictions in the differing ways that the core concepts are used reduce the validity and usefulness of theories and research findings. These problems of terminology are at root problems of epistemological neglect.

It is necessary that definitions of key terms should fulfil several requirements. They should:

- Align with common usage as defined in major dictionaries
- Reduce the multiplicity of meanings attributed to concepts by excluding meanings that are epistemologically problematic
- Locate design theories and the field of Design in a unique space not occupied by other disciplines
- Integrate the outcomes of research and theory making about designing and designs with theories and findings of a wide range of other disciplines
- Provide a single theoretical core across the several hundred sub-disciplines that involve designing and designs.

The following definitions satisfy the above requirements:

- 'Design' - a noun referring to a *specification* for making a particular artefact or for undertaking a particular activity. A *design* is different from an artefact - the design is the basis for making the artefact, and this distinguishes designing from Craft and Art.
- 'Designing' - non-routine human internal activity leading to the production of a *design*.
- 'Designer' - someone who is, has been, or will be *designing*. Someone who creates *designs*
- 'Design process' - *any* process or activity that includes at least one act of 'designing' alongside other activities (e.g., calculating, drawing, information collection), which may be routine or automated.

Significant problems arise, however, with other meanings of 'design' that give it agency or intrinsic value. These problems are found, for example in statements such as:

'Design operates . . .'
'This is good *design'*.
‘The last few years have seen improvements to *design’*

These epistemologically problematic meanings of the term 'design' appear to have come into existence because it is terminologically and linguistically more difficult to use only epistemologically straightforward meanings. An example of a short two step pathway leading to one problematic meaning of ‘design’ becoming established as ‘common sense’ starts from the unproblematic idea of designing as an activity (e.g. ‘the individual _*designed*_ the solution’). It moves on, however, to the epistemologically unjustified us of 'design' as an attribute (e.g. ‘this solution is 'designed'’) through a subtle shift from the passive verb form (‘the solution has been designed’ is unproblematic) to the adjectival form. The adjectival form now indicates the ‘solution’ has some pseudo-physical property of 'design'. This may be followed by a short but equally unjustified step to the idea of a 'design solution' as something done by ‘Design’. Lo! There is now a pseudo agent, ‘Design’ that apparently exists and goes around doing things. As far as I can ascertain, the design literature does not contain any adequate justification for the validity of using 'design' as 'something that does activities all by itself' or ‘a property that an artefact possesses or doesn't’ in spite of its widespread use.

There are several structural reasons that encourage the use of ‘design’ in this manner:

- It offers significant reductions in word count in writing about designing.
- The English language emphasises simple ‘subject-verb-object’ and ‘object-has-property’ structures. Hence, it makes structural but not epistemological sense to say, e.g. ‘Design improves solutions’ or ‘This solution has more Design’.
- Designers and design researchers mainly work with objects and the properties of objects. This leads to a predilection to reconceptualise the activity of designing and other human issues as an object, Design, or in object terms.
- It takes significant care, effort and additional work to avoid this convenient but epistemologically faulty linguistic shortcut.

In many situations, the epistemological inconsistencies are more than offset by benefits in brevity, readability and accessibility, particularly in documents aimed at a general readership or in informal discourse.

In formal theoretical discourse, the careless use of ‘design’ results in an epistemological morass that is a significant factor in the creation of the conceptually swampy milieu in which is situated the Design-Science paradox.

Structural bounds of design theories and design research

Many design theories sit in the gaps between theories of other disciplines tying them together to explain the hows, whys and wherefores of humans creating designs. Design theories are the glue that holds other theories together into a larger whole. This is unique space in the realm of theory not occupied by other fields, and offers the basis for axiom 1.

Axiom 1: Design *theories* (theories about humans creating designs) are *interdisciplinary*.

This specifically implies that design theories are NOT cross-disciplinary or multi-disciplinary.

Design research presents a different picture. It is not possible to analyse the phenomena involved in and associated with designing by only taking into account design theories. It is necessary to look to theories from other disciplines. This is not to say that the field of design contains all other disciplines, e.g. there are many aspects of (say) engineering or communication theory that a designer might draw on in creating a design but these are not 'core business' for research into designing. Design researchers cross into other disciplines and draw on their theories, but this does not imply that the theories of other disciplines are subsumed under design research. This leads to axiom 2.

Axiom 2: Design *research* is *cross-disciplinary.*

This specifically implies that design research is NOT inter-disciplinary or multi-disciplinary.

When researching designing, design researchers draw on knowledge and research findings from other disciplines. They require the skills to:

- Understand the relevant knowledge available in other disciplines
- Identify the boundaries of knowledge in these other disciplines as well as design research

These skills are essential for identifying new research topics that make a contribution to knowledge, what problems need to be addressed, and to be able to undertake the research. Understand the research from other disciplines and crossing disciplinary boundaries requires a multiplicity of disciplinary skill sets because research and knowledge in different disciplines is different. This gives axiom 3.

Axiom 3: Design *researchers* require *multidisciplinary skills*

Design researchers cannot get by with the skills of a discipline that sits between disciplines. The ability to cross discipline boundaries requires researchers to have the necessary skills for each discipline that they cross into in order to understand and use the knowledge from that discipline as well as the skill of 'crossing boundaries'.

The above focuses on 'research into creating designs': the skills and activities of designing. Another picture relates to 'research into designs'. This is not so straightforward because it is unclear why many aspects of the study of designs' should be regarded as part of a discipline of Design rather than as topics of existing traditional disciplines. The historical analysis of designs, for example, falls naturally as a subset of History. There are several reasons:

- History provides the theoretical and research tools
- The knowledge created lies fully in the boundaries of History research

- Design researchers drawing on historical knowledge about designs are also likely to require the fullness of historical understanding about socio-economic and cultural conditions - rather than that specifically bounded by the history of the designs themselves.

Similar arguments apply to other aspects of research into designs - in contrast to research into designing.

Taken together, the above factors suggest a discipline of Design founded on research into designing is likely to be unproblematic provided that researchers are able to create disciplinary specific theories that are interdisciplinary and lie outside the main territories claimed by other disciplines.

In contrast, a discipline of Design founded on research into designs is likely to suffer ongoing difficulties because of its cross-disciplinary contradictions.

Summary

To summarise, exploring the swampiness of the Design-Science paradox points to the need to re-envisioning the foundations, theories, concepts and terminology of the field of Design to address epistemological problems. It suggests it is more satisfactory to ground the discipline of Design in research into the human activity of designing rather than the properties of designs.

This approach represents a new programmatic basis for researching and developing grand theory with respect to the discipline of Design (Bryne, 2000) offering substantial benefits over other approaches. It allows the formation of coherent design theory that includes contemporary research about human psycho-neuro-physiological functioning. It enables the field to move beyond the conceptual and terminological confusion that has occurred as a result of a neglect of the underlying epistemological foundations of research and theory making. It allows design research to better integrate conceptually with other disciplines - especially its natural partner, Futures Studies. Finally, it enables social, environmental and ethical factors that relate to designing to be included in design theories in a well-justified manner.

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Brief bio

Dr. Terry Love was born in Manchester, UK. Trained as a designer form an early age. Studied design theories of John Chris Jones and Nigel Cross via John Woollatt in the late 1960s. Has a BA (Hons) in Engineering from a design-based degree at Lancaster University (1975). Spent 20 years based in Lancaster as a consultant/ designer/ contractor working on commercial and community projects in the UK, France and Spain. Moved to Western Australia in 1991 and undertook a PhD exploring how designers can include social, environmental and ethical factors alongside technical and aesthetic factors and what kinds of theory is needed to describe it. Since then, has undertaken research and design work across a range of topics including: coherent foundations for design theories, the future of Australia to 2015, youth service provision and education, relationships between criminal justice agencies and community organisations, public open space management, information warfare, brain neurology and models of cognition, forces and factors impacting on the future of the PhD and other doctorates, e-business systems and models, portfolio-based assessment, computer-based techniques in knowledge management, a lung transplant database system, and affective cognition. Currently involved in the We-B Research Centre at the School of Management Information Systems, Edith Cowan University, is an Adjunct Research Fellow Curtin University, and is proprietor of Love Design and Research and Praxis Education.