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Abstract: Design Thinking is frequently argued to be unlike scientific thinking. Existing literature questions the validity of this differentiation with regards to: the characterisation of scientific thinking in design research; the notion that designers are more effective than scientists at generating empathy with users; the idea that scientific problems are not wicked. Such research posits commonalities between the way designers and scientists think. In further investigating the relationship between design and scientific thinking, this paper explores the issue of inductive reasoning. Frequently, research suggests that designers do not rely on inductive reasoning. This paper revisits Rowe's (1987) study which observes designers to commonly employ it. Rowe's work provides further evidence of a link between design and scientific thinking. This paper calls for additional research into such links in order to optimise design's potential. In also suggests that highlighting commonalities between design and scientific thinking may support access to government funding, and thus the future prosperity of design in UK universities.

Keywords: Design Thinking and scientific thinking; Inductive Reasoning; Wicked Problems; STEM funding; Empathy

1. Introduction

Research on Design Thinking concerns the cognitive behaviour of designers both in terms of:

> "individual cognitive activity during the process of design […and…] thinking 'projected' into the world in the form of talk and discussion". (Open University, n.d., unpaged)

Design Thinking research has established a body of knowledge on both the analysis of empirical data and the formation of philosophical principles (e.g. Stempfle and Badke-Schaub, 2002; Cross, 2011; Dorst, 2011; Oxman, 2002). Commonly, Design Thinking research suggests that designers' cognitive behaviour differs from that of professionals in other fields (Owen, 2007). The concept of Design Thinking has become increasingly "ubiquitous"

(Kimbell, 2011, p.287) in design research. Indeed, it is argued to be “part of the collective consciousness of design researchers” (Dorst, 2011, p.521).

Beyond its significance in design, Design Thinking has become influential in research in a wide range of disciplines (Dorst, 2011). This is because non-designers can also become versed in it (Manzini, 2011; Burns et al, 2006). When competent in Design Thinking, individuals from disciplines as diverse as “engineering, medicine, business, the humanities, and education” can collaborate to “solve large-scale problems in a human centered way” (Meinel and Leifer, 2011, p. xiii). Because of its effectiveness, ultimately the process is argued to aid humans “address the challenges of global, systemic issues” (Sanders and Strappers, 2008, p.14). Because of its claimed importance to design and society, Design Thinking has become integral to education in leading institutions. Stanford University offers a non-assessed short course in Design Thinking (Stanford University, n.d.). The Open University (n.d.) runs an undergraduate module in Design Thinking. At Loughborough University, Design Thinking is intrinsic to the diets of the Design Ergonomics (Loughborough University A, n.d.) and Industrial Design & Technology (Loughborough University B, n.d.) undergraduate programmes. For students wishing to explore further, Plymouth University (n.d., unpaged) offers a postgraduate qualification in Design Thinking.

A central premise of Design Thinking is the notion that it is significantly different to scientific thinking (e.g. Owen, 2007; Löwgren and Stolterman, 2004; Cross, 2011). There however exists a small body of research which questions the validity of the differentiation between Design Thinking and scientific thinking. Such research:

- Criticises the characterisation of scientific thinking which is common in much design research (New and Kimbell, 2013);
- Questions the view that designers are more effective than scientists at generating empathy with users (New and Kimbell, 2013);
- Problematizes the idea that scientific problems are not wicked in nature (Farrell and Hooker, 2013).

In putting forward their criticisms, the above researchers (New and Kimbell, 2013; Farrell and Hooker, 2013) argue for the presence of commonalities between Design Thinking and scientific thinking. In contributing to this small but important body of knowledge, this paper discusses the issue of *inductive reasoning*—a form of cognition common in science. Influential research suggests that designers do not rely on inductive reasoning (Dorst, 2011). Rowe (1987) however observes designers to commonly employ it. Rowe’s (1987) study has been cited as “seminal” (Hassi and Laakso, 2011, p. 3) and his position on inductive reasoning has never been criticised. In revisiting Rowe’s (1987) study, this paper argues that his position provides further evidence linking design and scientific thinking. This paper calls for more emphasis on investigating the connection between Design Thinking and scientific thinking to optimise the design process.

As well as potentially being flawed, the premise that Design Thinking is significantly different to scientific thinking may also be detrimental to sustaining the future prosperity of design pedagogy and research in UK universities. This is due to changes in the prioritisation of central funding. Recently, design pedagogy and research have become less of a priority for the UK government. In preparing its strategy for the 2014 Research Excellence Framework (REF) review, the government concentrated on funding what are termed 'STEM' subjects in higher education (Morgan, 2010). STEM is an acronym for disciplines associated with the areas of Science, Technology, Engineering and Mathematics (Morgan, 2010). This strategy included the removal of all funding to universities which do not teach STEM subjects (Prince, 2010). Post REF 2014, the government announced that it would no longer follow the policy of protecting STEM funding (Higher Education Funding Council for England, n.d.). Despite this move, it has allocated a "teaching capital fund" of £200million in the 2015-16 academic year to universities to further promote teaching and research in STEM subjects (Higher Education Funding Council for England, 2015, unpaged). The Education Secretary Nicky Morgan argues the rationale for supporting STEM subjects is clear:

> "the subjects that keep young people's options open and unlock the door to all sorts of careers are the Stem subjects". (Morgan, cited in Paton, 2014)

In contrast to the positive effects of studying a STEM discipline, Morgan argues that future prospects for those studying arts subjects may be quite limited. Morgan suggests that the decision to study arts disciplines may hold people back for the rest of their lives (Paton, 2014). The effect of the government's prioritisation of STEM subjects over arts disciplines has already been felt in universities. For example, in 2015 Central Saint Martins announced it will be cutting over 500 places for foundation students (Young-Powell and Gil, 2015). This move led to well-publicised student demonstrations (Young-Powell and Gil, 2015). Rather than being a STEM discipline, the government considers 'Design' to be an arts subject. Conceivably, given the UK government's promotion of STEM programmes, the long term fiscal viability of design education and research are less certain than scholarly activities related to STEM subjects.

Given the government's position, this paper argues that highlighting commonalities between design and scientific thinking may be of vital importance to accessing central funding—and thus to facilitating the future prosperity of design at UK universities. Conceivably, Design Thinking's common characterisation as a process which is unlike scientific thinking may contribute to preventing design subjects from accessing STEM-related support in the future. This research begins by exploring important steps which have informed the oft-cited position that designers and scientists make use of different forms of cognition.

2. Design Thinking: A Journey From 'Like' to 'Unlike' scientific Thinking

In the 1960s the *Design Methods* movement proposed that design practice should be viewed in terms of rationalistic, scientific principles (de Vries et al., 1993). The industrial designer

Chris Jones (1970) was a leading figure in propagating this line of thinking. Believing that design problems had become too complex for humans to solve using traditional craft methods, Jones (1970) identified what he believed to be a better approach, a model containing the following distinct and sequentially occurring elements: *divergence*, *transformation* and *convergence*. For Jones, this characterisation of a linear, chronological order to the design process meant practitioners no longer had to rely on their intuition to solve design problems. In the 1960s, Design Methods processes were "widely accepted" (Downton, 2003, p.41) with figures such as the Nobel laureate philosopher and mathematician Herbert Simon attempting to determine empirical formulae to describe elements of design activity (Cross, 2001).

In the 1970s the Design Methods movement lost momentum as some of its early pioneers rejected the idea that all problems could be reduced to solvable formulae (Jones, 1977; Cross, 2001). Design research instead was to become influenced by Horst Rittel and Melvin Webber's (1973) notion of *Wicked Problems*. Rittel and Webber (1973) compared problems tackled in the natural sciences with those undertaken by city planners. Problems in the former could be characterised as being "definable and separable" (Rittel and Webber, 1973, p.160). Accordingly, their solutions may be "findable" (Rittel and Webber, 1973, p.160). The following illustrates examples of these *tame* problems:

> "consider a problem of mathematics, such as solving an equation; or the task of an organic chemist in analyzing the structure of some unknown compound; or that of the chessplayer attempting to accomplish checkmate in five moves. For each the mission is clear. It is clear, in turn, whether or not the problems have been solved". (Rittel and Webber, 1973, p.160)

In contrast to the above characterisation, planning problems do not have "clarifying traits" (Rittel and Webber, 1973, p.160). Planning problems therefore do not have a solution, "in the sense of definitive and objective answers" (Rittel and Webber, 1973, p.155). The notion of wicked problems has heavily influenced design philosophy. Researchers argue that the characteristic of wicked problems relates not just to the area of city planning but instead to a broad range of design disciplines (Downton, 2003; Cross, 2001).

In the 1970s, the idea of Wicked Problems influenced the *Second Generation Design Methods* movement (de Vries et al., 1993). Rather than focusing on locating optimal solutions, associated theorists moved "towards recognition of satisfactory or appropriate solutions" (de Vries et al., 1993, p.17). The new-found belief in the value of constructivist (as opposed to rationalistic) ways of tackling issues led leading researchers to call for exploration into an epistemology of design. Bruce Archer (1979, p.18) for example claimed the existence of a legitimate "designerly way of thinking" which differs from the cerebral processes of scientists. Similarly, Cross (1982) called for further investigation into *Designerly Ways of Knowing* which are separate to and as credible as those of the scientific community.

At the time, neither Archer (1979) nor Cross (1982) could express how designers' cognition may be characterised. Donald Schon (1983) however did make an important contribution in this area (Koskinen et al., 2011; Cross, 2011). Schon (1983) rejected positivistic design philosophy (Meng, 2009). Echoing Rittel and Webber's (1973) research, Schon (1983) argued that each design problem is unique. Schon (1983, pp. 39) suggests that in design practice "problems do not present themselves […] as givens". They instead need to be constructed during the design process. Accordingly their nature is often "puzzling, troubling, and uncertain" (Schön, 1983, pp. 40). Schon (1983, p.21) criticises theorists for applying "scientific theory and technique" in attempting to describe design activity. Instead, Schon (1983, p.49) suggests that researchers should acknowledge the value of the "intuitive processes" of designers.

Koskinen et al. (2011) argue that Schon's contribution created a perceptible *turn* in the way design philosophy would come to be understood, for he:

> "…did more than anyone in teaching researchers that design is a reflective dialog between designers and their materials. His perspective, building on pragmatism, was historically important in turning design research to post-Cartesian thinking…" (Koskinen et al., 2011, p.159)

In illuminating the capabilities of designers, Schon paved the way for the development of a form of research into design philosophy which Cross (2001, p. 53, Original Emphasis) terms "'design thinking research'". Design Thinking research is argued to have begun in the 1990s with the commencement of the Design Thinking Research Symposia (DTRS) (Cross, 2001; Lloyd et al., 2007). Pertinent to the discussion to be presented in this paper, the following points have become widely accepted in the Design Thinking research community:

- Design problems are fundamentally different in nature to problems faced by scientists (Löwgren and Stolterman, 2004)
- Designers tackle problems in ways that differ from the way that scientists tackle problems (Cross, 2011).

There exists a small body of research which questions the presence of a discrete form of cognition practiced by designers. Norman (2009, unpaged) for example, labels Design Thinking a "myth". Norman however moves on to commend its use in "spread[ing] the word that designers can add value to almost any problem" (Norman, 2009, unpaged). Other researchers are more critical of the evidence presented within the academic community. Kimbell (2011) argues that research has yet to produce:

> "a definitive or historically informed account of design thinking, nor any explanation for why [designers] might have a particular cognitive style." (Kimbell, 2011, p.292)

Similarly, Johansson-Sköldberg, et al. (2013, p.121) claim that within the academic literature there exists "no sustained development of the concept" termed Design Thinking. Pertinent to this paper, a small but important body of research questions the notion that Design Thinking is unlike scientific thinking. This research highlights 3 points of critique, namely:

- The characterisation of scientific thinking in design research (New and Kimbell, 2013);

- The commonly held view that designers are more effective at empathising with users than are scientists (New and Kimbell, 2013);
- The notion that science problems are not wicked in nature (Farrell and Hooker, 2013).

A discussion of these criticisms is presented below.

3. Existing Criticism of the Characterisation of Design Thinking with Respect to Scientific Thinking

New and Kimbell (2013) do not support the oft-stated argument that Design Thinking is unlike scientific thinking. In evidencing their position, New and Kimbell argue that Design Thinking research does not present a *true* representation of scientific approaches to problem-solving. Rather, design research presents what might be termed a *straw man* characterisation of scientific thinking. In such research, New and Kimbell suggest that Design Thinking is:

> "repeatedly characterized in opposition to a caricature of rationalist, analytical 'orthodox' approaches" (New and Kimbell, 2013, p.139; Original Emphases)

New and Kimbell (2013) move on to support their argument by discussing claims associated with the issue of *empathy*. Commonly, Design Thinking research posits that the process differs significantly from rationalist, analytical cognitive behaviour through its ability to help practitioners generate empathy with users (Zimmerman et al., 2007). New and Kimbell (2013) criticise this position. As a vehicle for their critique, New and Kimbell (2013) illustrate how designers may claim to generate empathy with wheelchair users:

> "…design practice would perhaps involve the designer themselves using a wheelchair, or collecting data on the *overall* travel experience, and look [*sic*] for interactions with the wider process." (New and Kimbell, 2013, p.144; original emphases)

New and Kimbell (2013) argue that the above form of empathy has parallels with that developed though an analytical approach to problem solving:

> "This type of empathy, however, might still only be 'cognitive'. For 'affective' empathy to be involved the process of seeing through others' eyes requires a deeper engagement: this requires sharing the emotional response of the other. In the wheelchair example, it would require the designer to share, perhaps, the level of anxiety that a user might experience in the situation, or anger […] It is not that one can rationally appreciate the fact of another's emotions, *but that one has the emotions oneself*." (New and Kimbell, 2013, p.145; original emphases)

The issue of empathy therefore highlights how designers share cognitive attributes with rationalistic processes undertaken by scientists (New and Kimbell, 2013).

The notion of *wicked problems* provides a further instance of the connection between design and science. Design research characterises design problems as being wicked (Buchanan, 1992; Lowgren and Stolterman, 2004). Furthermore, much influential design research makes use of the notion of wicked problems to differentiate design problems from those faced by scientists. Farrell and Hooker (2013) summarise the stance taken in a swathe of design research. It is usual for design researchers to claim that:

> "design is characteristically faced with wicked problems whereas science is not".
> (Farrell and Hooker, 2013, p.681)

Going beyond New and Kimbell's (2011) argument that Design Thinking literature caricatures rationalistic analytical processes, Farrell and Hooker (2013, p.683) argue that influential work on Design Thinking is "fundamentally flawed" in its depiction of science. Farrell and Hooker (2013) claim that design theorists construct an erroneous dichotomy between design and science which serves to propagate a myth that scientific problems are not wicked in nature. Farrell and Hooker (2013) argue that, contrary to the beliefs of design researchers, scientific problems are indeed wicked. In addition Farrell and Hooker (2013, p.701) suggest the existence of an intrinsic relationship between the way designers and scientists think, for both are the "product of a common core cognitive process". In criticising academic design inquiry, Farrell and Hooker (2013, p.701) claim their argument may aid design researchers become more critical and "widen their outlook and reflect on their practices".

This paper moves on to contribute to the body of Design Thinking research presented in this section through exploring the issue of inductive reasoning—a form of cognition common in scientific disciplines. It does this through comparing and contrasting Peter Rowe's (1987) description of Design Thinking with more contemporary characterisations.

4. Design and Inductive Reasoning: an overview of more contemporary Design Thinking Research

In analytical professions, problems tend to present themselves at the beginning of a project (Cross, 2011). Problem-solving is thus based on the processes of "deducti[ve]" and "inducti[ve]" reasoning (Dorst, 2010, p.133). Scientific disciplines exist as examples of areas in which practitioners rely on analytical, inductive reasoning.

Influential research suggests that design is not an analytical profession (Cross, 2011). Accordingly, problems do not present themselves at the beginning of a project (Cross, 2011). Rather, design problems are argued to emerge during the course of attempting design tasks (Cross, 2011). Design professions are therefore "fundamentally differently" from disciplines in which problems tend to be formed at the beginning of a project (Dorst, 2010, p.133). Hence, the type of thinking required to be a designer differs from that necessary in areas which focus on analysis of fixed problems (Cross, 2011).

Prominent research suggests that designers do not over-analyse during the early stage of a project for fear of stifling creativity:

> "[Designers] know that bringing the full force of evaluation to bear upon a fledgling idea is a very effective way of killing it, blocking any further exploration and stifling any progress in the project". (Dorst, 2010, p.133)

In not engaging in inhibitive over-analysis, designers are prepared to take chances in following uncertain ideas and directions:

> "…designers tend to be good at suspending judgment, and allow themselves to pursue pretty risky lines of thought…" (Dorst, 2010, p.133)

The above traits are argued to help designers effectively tackle a range of complex problems and are fundamental to the characterisation of Design Thinking (Dorst, 2011).

Peter Rowe's (1987) position on Design Thinking differs from the above characterisations. In his investigation, Rowe coined the term *'Design Thinking'* (Dorst, 2010; Blizzard et al., 2015). As such, contrary to the notion that Design Thinking research begun in the 1990s with the commencement of the DTRS (Cross, 2001; Lloyd et al., 2007), it is possible to claim that such research may have been initiated by Rowe in the late 1980s.

5. Design and Inductive Reasoning: Rowe's Design Thinking

Through examining four case studies of architects undertaking large projects, Rowe (1987, p. 1) creates "a generalized portrait of design thinking", applicable to a broad range of design disciplines. Rowe's (1987) suggestion that practitioners across design disciplines may share a style of thinking echoes arguments made both by prominent predecessors (Jones 1970; Simon, 1996; Schon, 1983) and successors (Dorst, 2010; Cross, 2011).

The inclusion of quotes from Rowe's (1987) analysis provides an opportunity to compare his research concerning the way designers think with more contemporary characterisations. Rowe (1987, p.2) identifies "three different styles of design thinking". Of importance to this paper is Rowe's suggestion that one of these styles revolves around a process of *inductive reasoning*. Rowe presents the following description of induction:

> "…the expression 'If conditions Z are encountered, then problem X becomes defined' can be seen to lend itself to an inductive reasoning process, where one moves from the particularities of a situation to a more comprehensive conclusion." (Rowe, 1987, p. 101, Original Emphasis)

Rowe applies this description to his observation of architects at work:

> "During architectural design [the above characterisation] is often the case, as when the observation of particular user needs precipitates formulation of a more general problem and the actions that stem from it." (Rowe, 1987, p. 101)

Rowe continues by providing a specific example of when inductive reasoning becomes important in design activity:

> "…a designer at the outset of tackling a problem in housing may decide to make use of a particular type of configuration. Furthermore, that type becomes the model through which the problem is essentially understood and construed." (Rowe, 1987, p. 102)

Of significance is Rowe's suggestion that architects do not make use of inductive reasoning in isolated instances. Rather at times, Design Thinking is:

> "almost totally dominated by the a priori use of a particular building type as a model for resolving the problem at hand." (Rowe, 1987, p. 2)

Rowe's (1987) observation that designers habitually use inductive reasoning makes his description of the way practitioners think at odds with more contemporary descriptions of Design Thinking (e.g. characterisations presented by Dorst, 2010; Cross, 2011; Oxman, 2002). Indeed, Rowe's (1987) position on inductive reasoning appears to support Farrell and Hooker's (2013) aforementioned argument regarding the existence of a commonality between the way designers and scientists think.

To further contextualise Rowe's (1987) exploration it is important to present an overview of instances in which this work has been referenced in existing Design Thinking research. Interestingly, "Rowe is rarely cited in more recent" Design Thinking research (Kimbell, 2011, p. 291). Dorst (2010) and Blizzard et al., (2015) note that Rowe (1987) coined the term 'Design Thinking' but neither provide further discussion on Rowe's work. Hassi and Laakso (2011, p. 3) describe Rowe's (1987) contribution as "seminal" in their exploration of the roots of Design Thinking research. Hassi and Laakso (2011) however do not elaborate further on Rowe's (1987) characterisations of the way designers think. Kimbell (2011, p.291) notes Rowe's (1987) suggestion that designers may rely on their "hunches and presuppositions" in their practice. Ho (2000) supports Rowe's description of how designers create compartmentalised solutions before synthesising overarching solutions. Cross (2004, p.438) notes Rowe's (1987) observation that designers may tend to proceed with initial concepts to the detriment of exploring others. For Cross (2004. p.439; original emphasis), Rowe's research contributes to the notion that designers are solution-focussed (as opposed to problem-focussed) "'ill-behaved' problem solvers". It is important to note that in the many years since Rowe (1987) conducted his investigation, researchers have not criticised his study—neither with regards to the methods he employed, nor with respect to his conclusions on the subject of inductive reasoning.

Rowe's (1987) position—together with the lack of critique on his position—adds further evidence to suggest that the oft-cited distinction between Design Thinking and scientific thinking may potentially be flawed.

6. Conclusion

This paper has reflected on research which questions the validity of the much-posited differentiation between Design Thinking and scientific thinking. Such research identifies commonalities between the way designers and scientists think. Through exploring Rowe's (1987) position on inductive reasoning, this paper has contributed to this body of knowledge.

This paper has argued that the much-cited differentiation between Design Thinking and scientific thinking may potentially be flawed. With this in mind, this research calls for further investigation on the connection between the ways designers and scientists think. Through this, it may be possible to move further towards optimising design activity in the bid to help tackle important issues facing society.

In addition, research which highlights commonalities between Design Thinking and scientific thinking may be of vital importance to the future of design at UK universities. As the UK government continues to support STEM subjects over and above arts disciplines, design's ability to access increased central funding may in the future depend on its association with scientific subjects. This may facilitate the future prosperity of design education and research in UK universities. This situation will work to help safeguard the long term health of the design industries.

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5. References

Archer, L. B. (1979) Whatever became of design methodology? Design Studies 1(1), pp.17-18.

Blizzard, J., Klotz, L., Potvin, G., Hazari, Z., Cribbs, J., & Godwin, A. (2015). Using survey questions to identify and learn more about those who exhibit design thinking traits. Design Studies, 38, pp. 92-110.

Buchanan, R. (1992) Wicked problems in design thinking. Design issues, 8(2) pp. 5-21.

Burns, C., Cottam, H., Vanstone, C. and Winhall, J. (2006) Red Paper Number 2: Transformation Design .London: Design council, http://www.designcouncil.info/mt/RED/transformationdesign/TransformationDesignFinalDraft.pdf (Accessed 31 July 2012).

Coldron, J., & Smith, R. (1999) Active location in teachers' construction of their professional identities. Journal of Curriculum Studies, 31(6), pp.711–726.

Cross, N. (2011). Design thinking: Understanding how designers think and work. Berg.

Cross, N. (2001) Designerly ways of knowing: Design discipline versus design science. Design issues, 17(3), 49-55.

Cross, N. (1982) Designerly ways of knowing. Design Studies, 3(4), 221–227.

Cross, N. (2004). Expertise in design: an overview. Design studies, 25(5), 427-441.

de Vries, M., Cross, N., & Grant, D. P. (Eds.) (1993) Design methodology and relationships with science. Dordrecht: Kluwer Academic Publishers.

Design Calls (n.d.). 10th Design Thinking Research Symposium (Oct 2014, Indiana USA), http://designcalls.wordpress.com/2013/11/28/10th-design-thinking-research-symposium-oct-2014-indiana-usa/#more-1694 (Accessed, 2nd July 2015).

Dorst, K. (2011) The core of 'design thinking' and its application. Design Studies, 32(6), pp. 521-532.

Dorst, K. (2010) The Nature of Design Thinking. In Proceedings of the 8th Design Thinking Research Symposium (DTRS8), Syndey, October 19-20, pp. 131-139.

Downton, P. (2003) Design Research. Melbourne: RMIT University Press.

Farrell, R. and Hooker, C. (2013) Design, science and wicked problems. Design Studies, 34(6), pp.681-705.

Hassi, L. and Laakso, M. (2011) Conceptions of Design Thinking in the Design and Management Discourses: open questions and possible directions for research. In, N.F.M. Roozenburg, L.L. Chen

& P.J. Stappers (Eds), Proceedings of IASDR2011, the 4th World Conference on Design Research, http://www.mindspace.fi/wp-content/uploads/2013/12/HassiLaakso_IASDR_FINAL.pdf (Accessed, 10th November 2015).

Higher Education Funding Council for England (2015, January 27). Policy Guide: Science, technology, engineering and mathematics (STEM), http://www.hefce.ac.uk/kess/stem/ (Accessed, 15 September 2015)

Higher Education Funding Council for England (n.d.) Funding for universities and colleges for 2013-14 to 2015-16: Board decisions, http://www.hefce.ac.uk/pubs/year/2015/cl,032015/ (Accessed, 15 September 2015)

Ho, C. H. (2001) Some phenomena of problem decomposition strategy for design thinking: differences between novices and experts. Design Studies, 22(1), pp.27-45.

Johansson-Sköldberg, U., Woodilla, J., and Çetinkaya, M. (2013) Design thinking: past, present and possible futures. Creativity and Innovation Management, 22(2), pp.121-146.

Jones, J. C. (1977) "How My Thoughts about Design Methods Have Changed during the Years." Design Methods and Theories 11 (1), pp. 45-62.

Kimbell, L. (2011) Rethinking Design Thinking: Part I. Design and Culture, 3(3), pp.285-306.

Loughborough University - A (n.d.) Design Ergonomics – Course Information, http://www.lboro.ac.uk/departments/lds/ug/design-ergonomics/ (Accessed, 10 November 2015)

Loughborough University - B (n.d.) Industrial Design and Technology (BA) - General Information, http://www.lboro.ac.uk/departments/lds/ug/archivedcourses/industrial-design-technology-old/ (Accessed, 10 November 2015)

Löwgren, J. and Stolterman, E. (2004) Thoughtful interaction design: A design perspective on information technology. Cambridge, MA: MIT Press.

Lloyd, P., McDonnell, J., Cross, N. and Row, S. (2007). Analysing design behaviour: the design thinking research symposia series. IASDR07. International Association of Societies of Desing Research. The Hong Kong Polytechnic University, pp. 12-15.

Plymouth University (n.d.) MRes Design Thinking, http://www1.plymouth.ac.uk/courses/postgraduate/3575/Pages/CourseOverview.aspx (Accessed, 10 November 2015)

Manzini, E. (2011) Design Schools as Agents of (Sustainable) Change: A Design Labs Network for an Open Design Program. Paper presented at: CUMULUS // DRS SIG on Design Pedagogy 1st International Symposium for Design Education Researchers La Bourse du Commerce, Paris 18–19 May, pp.9-16.

Meinel C., and Leifer L. (2011) Design Thinking Research. In Platter, H., Meinel C., and Leifer L. (Eds.) Design Thinking: Understand – Improve – Apply. London: Springer, pp. xiii-xxi.

Meng, J.C.S. (2009) Donald Schon, Herbert Simon and The Sciences of the Artificial. Design Studies, 30(1), pp. 60-68

Morgan, J. (2010, October 20) Fears Made Flesh: only STEM teaching grants spared CSR scythe., https://www.timeshighereducation.com/news/fears-made-flesh-only-stem-teaching-grants-spared-csr-scythe/413956.article (Accessed 12th October 2015)

New, S. and Kimbell, L. (2011) Chimps, designers, consultants and empathy: A "theory of mind" for service design. In Moultrie, J., Keränen, K, Liu, W and Miller, K. (Eds) proceedings of 2nd Cambridge Academic Design Management Conference, 4 - 5 September 2013, pp. 139-152.

Norman, D.A. (2009, June 25) Design Thinking: A Useful Myth, http://www.core77.com/blog/columns/design_thinking_a_useful_myth_16790.asp (Accessed 12th October 2015)

Open University (n.d.) Maths, Computing and Technology-Research-Design Thinking, http://mct-research.open.ac.uk/research/subtheme_designthinking (Accessed 12th October 2015)

Owen, C. (2007). Design thinking: Notes on its nature and use. Design Research Quarterly, 2(1), pp.16-27.

Oxman, R. (2002) The thinking eye: visual re-cognition in design emergence. Design Studies, 23(2), pp. 135-164.

Paton, G. (2014, October 10) Nicky Morgan: pupils 'held back' by overemphasis on arts, http://www.telegraph.co.uk/education/educationnews/11221081/Nicky-Morgan-pupils-held-back-by-overemphasis-on-arts.html (Accessed 12th October 2015)

Prince, R. (2010, November 5) Higher education – universities with arts courses bear the brunt, http://www.telegraph.co.uk/news/politics/8111054/Higher-education-universities-with-arts-courses-bear-the-brunt.html (Accessed 12th October 2015)

Rowe, P.G. (1987) Design Thinking. Cambridge, MA: MIT Press.

Sanders, E. B. N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. Co-design, 4(1), 5-18.

Schon, D. A. (1983) The Reflective Practitioner. London: Temple-Smith

Simon, H. (1996) The sciences of the artificial (3rd ed.). Cambridge, MA: The MIT Press.

Stanford University (n.d.) Welcome to the Virtual Crash Course in Design Thinking, http://dschool.stanford.edu/dgift/ (Accessed 12th October 2015)

Stempfle, J. and Badke-Schaub, P. (2002) Thinking in design teams-an analysis of team communication. Design studies, 23(5), pp. 473-496.

Young-Powell, A. and Gil, N. (2015) Students occupy Central St Martins in Protest against Cuts, http://www.theguardian.com/education/2015/mar/24/students-occupy-central-st-martins-in-protest-against-cuts (Accessed, September 15)

Zimmerman, J., Forlizzi, J. and Evenson, S. (2007) Research through design as a method for interaction design research in HCI. In Proceedings of the SIGCHI conference on Human factors in computing systems, pp. 493-502. New York: ACM.

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