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Design Thinking as a Form of Intelligence

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Abstract

This paper re-visits the concept of 'design as a form of intelligence', first suggested by Cross (1990) and based on a development of Gardner's (1983) 'theory of multiple intelligences'. The premise of the concept was that there are sufficient significant features embedded in design thinking that, taken together, they constitute a form of intelligence that is different from, but comparable with, Gardner's other six (now increased to eight) forms of intelligence. Although the concept has re-surfaced occasionally in the last twenty years, it has not received the attention that perhaps it deserves. Recent extensions of the concept of design thinking have the potential to undermine the core concept of 'designerly ways of knowing' and therefore of the concept of design thinking itself. This paper re-states the concept of 'design as a form of intelligence' and identifies the progress that has been made in the past twenty years in understanding its key cognitive components. Significant aspects of this progress have arisen from the body of research in design thinking, including especially the DTRS series, but also from more distant but relevant work in the cognitive sciences.

1. Shifts of perspective

The series of symposia on Research in Design Thinking (DTRS), initiated in 1991 at the University of Delft by Cross, Dorst and Roozenburg (1992), and now here in its eighth version, has provided a broad base of research results and reflection on the nature of design ability, how designers think, and designerly ways of knowing. However, 'design thinking' has now also become such a common-place concept that it is in danger of losing its meaning. The new consensus seems to be that design thinking encompasses many forms of thinking and intelligence. The current extension of concepts of design thinking beyond the core design disciplines (so that managers, medics and administrators might all be 'design thinkers') is an indicator of the undermining and weakening of the very concept of design thinking. At its *Business Week* worst, design thinking becomes merely another way of making a profit. It is time to reclaim design thinking as a fundamental aspect of the discipline of design, something that pertains to the skilled, educated practice of designing.

The origins of a research focus on design thinking lie in the attempts to define design as a discipline in its own right in the mid-1970s and early 1980s (Archer, 1979; Cross, 1982). Lawson (1980) introduced the study of 'how designers think', and a little later Rowe (1987) produced his studies of 'design thinking'. Previously, a dominant view in design research had been represented by Simon's (1969) interpretation of design as a 'science of the artificial'.

The limitations of this previous interpretation were perhaps betrayed by Simon himself, when he likened the activity of a designer to that of an ant. He compared any creative problem solver, such as a designer, to an ant returning to its nest across a stony terrain. To an ant, the horizon is very close, the terrain is not all visible in advance, and it cannot foresee all the obstacles lying in its path on its way to its goal. All it can do is deal with the obstacles as it comes to them – working a way around or over them. The ant, like a creative problem solver, according to Simon, is likely to take what would appear to an outside observer, with much more of a global view, to be a circuitous route 'home' to the solution goal. What Simon tried to communicate by this metaphor was his view that the apparent complexity of the ant's (or designer's) behaviour is largely a reflection of the complexity of the environment (or design situation) in which it finds itself, whilst the underlying cognitive processes that control the behaviour may be relatively simple. So in this view, understanding designing is more about understanding design problems than about understanding design thinking.

This view was significantly challenged by Schön's (1983) interpretation of professional ability as reflective practice. Probably the most influential study of a designer at work has been that reported by Schön. The influence of the study is largely due to it being set within his broader series of studies of professional practice (ranging from psychotherapy to management) that he used to establish his theory of reflective practice, or 'how professionals think in action'. The study has also been influential because Schön's analysis of what he observed is acute and sensitive; both designers and design researchers (those with personal design experience) recognise the veracity of the analysis. What is surprising is that such an influential study is based on just one, partial example of design activity – and even that is not a 'real' design example, but is taken from observing an experienced designer tutor a student in a university architectural design studio.

Schön established his theory of reflective practice as a counter to the prevailing theory of technical rationality, or the constrained application of scientific theory and technique to practical problems. He was seeking a new 'epistemology of practice' that would help explain and account for how competent practitioners actually engage with their practice – a 'kind of knowing', he argued, which is different from the knowledge found in textbooks. In his analysis of the case studies that provided the foundations for his theory, he began with the assumption 'that competent practitioners usually know more than they can say. They exhibit a kind of knowing-in-practice, most of which is tacit.' He identified a cognitive process of reflection-in-action as the intelligence that guides 'intuitive' behaviour in practical contexts of thinking-and-acting – something like 'thinking on your feet'. At the heart of reflection-in-action is the 'frame experiment' in which the practitioner frames, or poses a way of seeing the problematic situation at hand.

So in the early 1980s there was a significant shift in perspectives on design thinking, from criticising the limitations of design cognition to recognising its strengths and potential. The emphasis changed from trying to formulate design as a science to recognising the merits of the natural, 'intuitive' processes of designing. This was well represented in the work of Davies and Talbot (1987), who studied the processes of a large number of outstanding designers. They summarised the characteristics that seemed key to making these people successful in dealing constructively with uncertainty, and the risks and opportunities that present themselves in the process of designing, as follows. 'One of the characteristics of these people is that they are very open to all kinds of experience, particularly influences relevant to their design problem. Their awareness is high. They are sensitive to nuances in their internal and external environments. They are ready, in many ways, to notice particular coincidences in the rhythm of events which other people, because they are less aware and less open to their experience, fail to notice. These designers are able to recognise opportunities in the way coincidences offer prospects and risks for attaining some desirable goal or grand scheme of things. They identify favourable conjectures and become deeply involved, applying their utmost efforts, sometimes "quite forgetting" other people and/or things only peripherally involved.' So, for outstanding designers, at least, design thinking is an absorbing, demanding, sometimes obsessional activity.

Cross (1990) drew upon the growing number of such studies and investigations into design activity and designer behaviour in order to clarify and categorise the nature of design ability. In this paper I summarised design thinking as comprising abilities of resolving ill-defined problems, adopting solution-focussed cognitive strategies, employing abductive or appositional thinking and using non-verbal modelling media. I identified these abilities as highly developed in skilled designers, but also suggested that they are possessed in some degree by everyone. I went on to outline a case for design ability as a fundamental form of human intelligence, thus seeking to provide a much broader foundation for establishing 'designerly ways of knowing'.

2. Design intelligence

The interpretation of design thinking as a form of intelligence was based on the work of Gardner (1983). Gardner's view is that there is not just one form of intelligence (as conventionally identified in standard forms of 'intelligence tests'), but several, relatively autonomous human intellectual competences. Originally, he distinguished six forms of intelligence:
linguistic
logical-mathematical
spatial
musical
bodily-kinaesthetic
personal.

Aspects of design ability seem to be spread through these various forms of intelligence in a way that does not always seem entirely satisfactory. For example, spatial abilities in problem-solving (including thinking 'in the mind's eye') are classified by Gardner under spatial intelligence, whereas many other aspects of practical problem-solving ability (including examples from engineering) are classified under bodily-kinaesthetic intelligence. So in this classification, for example, the inventor's competence is placed together with that of the dancer and the actor, which doesn't seem appropriate. It seems reasonable, therefore, to try to separate out design ability as a form of intelligence in its own right.

We have seen many aspects of this 'design intelligence' emerge in the various studies reported in the DTRS series and elsewhere. For example, we have seen that good designers have a way of thinking that involves operating seamlessly across different levels of detail, from high level systemic goals to low level physical principles. Rather than solving merely 'the problem as given' they apply their intelligence to the wider context and suggest imaginative, apposite solutions that resolve conflicts and uncertainties. They have cognitive skills of problem framing, of gathering and structuring problem data and creating coherent patterns from the data that indicate ways of resolving the issues and suggest possible solution concepts. Design intelligence involves an intense, reflective interaction with representations of problems and solutions, and an ability to shift easily and rapidly between concrete representations and abstract thought, between doing and thinking. Good designers apply constructive thinking not only in their individual work but also in collaboration in teamwork.

The nature of design intelligence becomes particularly, and tragically highlighted in rare cases where it is impaired through neurological damage in the brain, such as through a stroke. One such case was reported by Goel and Grafman (2000), who studied an architect who had had a seizure, associated with a meningioma tumour in his right prefrontal cortex, a region at the front of the brain that is associated with high level cognitive functions. Before his attack, this person had practiced successfully as an architect. Goel and Grafman compared his post-attack design ability with that of a control participant, another architect with similar education and design experience, on being given a relatively simple task of re-designing a laboratory space. The sequences of design sketches that the two subjects produced are dramatically different. Each began by making a survey drawing of the existing laboratory and its furniture. The healthy control participant then produced a coherent series of sketches, beginning with abstracted considerations of circulation and organisation, then developing alternative proposals and refining the preferred one. The neurological patient produced three separate, basic and incomplete proposals, finishing with a 'final proposal' that was still inadequate and incomplete.

The differences in the thinking processes of the two participants become clear in graphs of the amount of time each devoted to different cognitive activities, as revealed by their 'think aloud' comments made during the experiments. The control participant focused initially on 'problem structuring', with periodical returns to this. He then moved to 'preliminary design' and on to 'refinement' and 'detailing'. The graph of the control participant clearly shows a controlled but complex pattern of activities, with overlap and quick transitions between activities. In contrast, the neurological patient spent a huge amount of time on attempting 'problem structuring', and only small amounts of time on 'preliminary design' and 'refinement'.

The experimenters reported that: 'The patient understood the task and even observed that "this is a very simple problem". His sophisticated architectural knowledge base was still intact and he used it quite skilfully during the problem structuring phase. However, the patient's problem-solving behaviour differed from the control's behaviour in the following ways: (1) he was unable to make the transition from problem structuring to problem solving; (2) as a result preliminary design did not start until two-thirds of the way into the session; (3) the preliminary design phase was minimal and erratic, consisting of three independently generated fragments; (4) there was no progression or lateral development of these fragments; (5) there was no carry-over of abstract information into the preliminary design or later phases; and (6) the patient did not make it to the detailing phase.' In short, the patient simply could not perform the relatively simple design task.

In this unhappy case we can see exposed some of the considerable complexity that there is in normal design thinking, and evidence that the brain has high level cognitive functions that control or process activities that are essential aspects of design ability and that contribute to design thinking as a form of intelligence.

Studies of brain activities have identified specific areas of the right hemisphere of the brain as being active during design thinking. The two hemispheres of the brain, right and left, appear to have different cognitive specialisms. Neuroscience studies tend to confirm that the right hemisphere of the brain is more specialised in spatial and constructional tasks, in aesthetic perception and emotions. The left hemisphere is more specialised in language abilities and verbal reasoning. Damage to the left hemisphere often results in the loss of some speech functions, whereas damage to the right hemisphere, as we have seen, can result, amongst other things, in the loss of design ability.

It has been known for some time that damage to the right hemisphere can impair brain functions that relate strongly to intuitive, artistic and design abilities. This has been confirmed by studies of, for instance, drawing ability. One classic case is that of an artist who suffered right-brain damage. Although the artist could make an adequate sketch of an object such as a telephone when he had it in front of him, he could not draw the same object from memory and resorted instead to 'reasoning' about what such an object might be like, producing strange, clumsy new 'designs'.

Several examples of the problematic behaviour and perception of people with right-brain damage were reported by Sacks (1985), including 'the man who mistook his wife for a hat' and who could not recognise a glove. When Sacks held up a glove and asked 'What is this?', the patient described it as 'A continuous surface, … infolded on itself. It appears to have five outpouchings, if that is the word … A container of some sort.' There is a weird logic to this reasoning, but no intuitive perception of the object and its obvious function. Of course, perceiving and creating relationships between form and function is a central aspect of design thinking.

Recently, Alexiou et al. (2009) undertook experiments comparing design thinking with more conventional problem solving activities (comparing ill-defined against well-defined problems), using functional magnetic resonance imaging of the brain during these activities. Their findings suggest that designing and problem solving are indeed distinct kinds of thinking, involving distinct cognitive functions associated with distinct brain networks. They concluded that: 'The discovered activation in the right dorsolateral prefrontal cortex for design versus problem solving is consistent with previous studies focussing on features of design and problem solving such as insight and the ability to perform lateral transformations and set-shifts. Additionally, the results are consistent with the view that design cognition essentially also involves evaluation and modulation of alternative goal states, or conditions of satisfaction, which may be supported by the anterior cingulate cortex. Compared to problem-solving, [cognitive activity in] design tasks recruits a more extensive network of brain areas. We suggest that these brain areas work together in order to undertake semantic operations, evaluate means and ends of appropriate responses and representations, support the resolution of conflicts, and modulate decision making under uncertainty.'

These experiments provide evidence for the distinct location of design cognition within certain areas of the brain. This was one of the principal criteria that Gardner proposed for the recognition of a distinct form of intelligence. At the time he proposed these criteria, 'potential isolation by brain damage' as Gardner expressed it was perhaps the only way to identify such distinct centres of brain activity. As well as the continuing development of this kind of evidence, with specific attention to design cognition such as in Goel and Grafman (2000), we also now have much better ways of identifying specific centres of cognitive activity, again with some specific attention to design cognition as in Alexiou et al. (2009). We therefore now have a much stronger case for design thinking as a form of intelligence.

Gardner's original set of criteria was as follows:
Potential isolation by brain damage.
The existence of idiots savants*, prodigies and other exceptional individuals.*
An identifiable core operation or set of operations.
A distinctive developmental history, and a definable set of expert, end-state performances.
An evolutionary history.
Susceptibility to encoding in a symbol system.
Support from experimental psychological tasks.

In 1990, I concluded that 'If asked to judge the case for design intelligence on this set of criteria, we might have to conclude that the case is "not proven". Whilst there is good evidence to meet most of the criteria, on some there is a lack of substantial or reliable evidence.' Twenty years later we do indeed have much more of that evidence, thanks especially to the Research in Design Thinking symposia, but also thanks to the general growth of design research with a focus on design thinking. This research (quite apart from DTRS proceedings) includes considerable work on the 'core operations' (e.g. Gero, 1990, *et seq.*; Lawson, 1994; Dong, 2009), on 'expert performance' (e.g. Bucciarelli, 1994; Lawson and Dorst, 2009), on 'symbol systems' (e.g. Goel, 1995; Purcell, 1998), and especially on protocol studies and other 'experimental psychological tasks' (e.g. Cross, 2001; Visser, 2006).

Whatever the current strength of the case may be, viewing design thinking as a form of intelligence is a productive view; it helps to identify and clarify features of the nature of design thinking, and it offers a framework for understanding and developing design ability through design education. A view of design thinking as a distinct form of intelligence does not necessarily mean that some people 'have it' and some people do not. Design ability is something that everyone has, to some extent, because it is embedded in our brains as a natural cognitive function. Like other forms of intelligence and ability it may be possessed, or may be manifested in performance, at higher levels by some people than by others. And like other forms of intelligence and ability, design intelligence is not simply a given 'talent' or 'gift', but can be trained and developed.

A stronger re-formulation of the concept of design thinking as a form of intelligence could have the effects not only of re-establishing design thinking as key within the discipline of design but also of clarifying some boundaries and limits to the extensions of design thinking. Perhaps most importantly, it can also help to support the role of design as a fundamental, distinct aspect of education at all levels, and to assist design educators in formulating their aims, objectives and methods.

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