The Method in Their Madness
Understanding How Designers Think

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Minheer de Rector-Magnificus, collegae en andere leden van de Universiteitsgemeenschap, beste vrienden, Dames en Heren, geachte toehoorders

I first became attracted to design methodology when I was a student of architecture in the 1960s. I was particularly attracted by the work of John Christopher Jones, and I was later fortunate enough to be able to study and work closely with him for several years. In his seminal work, *Design Methods: Seeds of Human Futures* (1), he suggested that the various, then-new methods of design might be viewed as representing three different perceptions of design activity: that of creativity, that of rationality, and that of control over the design process. 'Each of these three views of designing', he wrote, 'can be symbolized in a cybernetic picture of the designer. From the creative viewpoint the designer is a *black box* out of which comes the mysterious creative leap; from the rational viewpoint the designer is a *glass box* inside which can be discerned a completely explicable rational process; from the control viewpoint the designer is a *self-organising system* capable of finding short cuts across unknown territory.'

Like Jones, I found the concept of the designer as a self-organising system to be the most attractive view, and it is that concept that has guided my teaching and research in design methodology. Viewing the designer as a black box device, or 'magician', means that designing will always remain mysterious, and that seems an unsatisfactory position for any teacher (or researcher) to adopt. Viewing the designer as a glass box device, or 'computer', means accepting a potential that someday the viewpoint will be reversed and we will see the 'computer as designer', and that seems an unhappy position to adopt for anyone who sees design as one of the highest levels of cognitive abilty that human beings possess.

These two viewpoints - the designer as magician or as computer - are usually contrasted against each other, and some commentators on design seem to fall very definitely into holding one viewpoint or the other very strongly.

Viewing the designer as a self-organising system means adopting a viewpoint that recognises the full intelligence of the designer, and yet also recognises that intelligent behaviour is self-reflective and capable of improvement, and can benefit from tuition and from using some forms of external aids. That is my view of how design methodology relates to design education and practice. In particular it has influenced my interests in certain aspects of design research to do with developing our understanding of how designers design and how designers think. To be able to operate as a self-organising system means having a certain level of self-awareness, and knowledge of what one is trying to do, which can be drawn upon to guide one's activity. Design methodology can help to develop that self-awareness.

During my six years in the Faculty of Industrial Design Engineering here at Delft University of Technology, I was very happy to be able to work with my colleagues, Norbert Roozenburg, Kees Dorst and Henri Christiaans, in pursuing research in 'how designers think'. In particular, we held two international research workshops on this theme, which helped establish the Faculty as an internationally-recognised centre for this kind of work. I am proud to have shared with my colleagues in editing the proceedings of these two workshops (2, 3), which are now so often cited elsewhere.

Metaphors and Models

Understanding how designers design has been pursued in several different ways. One of these is the use of metaphors - the development of analogies that help to explain what it is that designers do, and the complexity of that task.

One of the most powerful metaphors has been that used by Herbert Simon, of the designer as an ant (4). Simon compared any creative problem solver to an ant going back to its nest across a stony terrain. At any given moment, the ant's horizon is very close, and all it can see are the rocks around it. The terrain is not all visible in advance, and the ant 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. The creative problem solver, like the ant, is likely to take what would appear to an observer to be a circuitous route 'home' to the solution goal. What Simon meant to communicate by this metaphor was his view that the apparent complexity of the ant's (or problem-solver's) behaviour is largely a reflection of the complexity of the environment in which it finds itself, whilst the underlying cognitive processes that control the behaviour may be relatively simple.

Christopher Jones used a metaphor of the designer as an explorer, searching for a hidden treasure. Interestingly, this shares some features with Simon's metaphor: there is a definite goal, which will be recognised once it is reached; there is an unknown and difficult terrain; and the route to the goal may in retrospect appear to have been unnecessarily circuitous. However, unlike Simon, Jones assumes that the explorer has a significant intelligence. This intelligence can be used to help plan a search strategy, and to respond to any clues about the path to take that might be found during the search.

Both Simon and Jones seem to me to be wrong in their metaphors in one important respect. In design there is not an already-known goal; the designer creates the goal in creating a solution concept. Where there is an already-known goal, then problem solving is a matter of searching for that goal, as Jones and Simon suggest. But searching for something that is lost is not what designers do. They do not search for a lost city or a buried treasure. Rather, they construct a fantasy city or magical treasure of their own. In a sense, they are genuine explorers, mapping unknown territories and returning with mysterious finds, rather than the searchers after certainties that both Jones and Simon describe.

As most of my students and colleagues will know, instead of exploring or searching as analogies for design, I prefer a metaphor based on the game of football. Designing is a team activity, and a design team, like a football team, has to have a strategy. The football team's strategy for defeating the opposition will consist of an agreed plan to use a variety of plays or moves (i.e. techniques or methods), to be applied as the situation demands. During the game, the choice of a move, and whether or not it is successful, will depend on the specific circumstances, on the skill of the players, and on the response of the opposition. The repertoire of moves used in a game is partly decided in advance, partly improvised on the field, and also amended at the half-time briefing by the team coach. The role of the coach is important because he maintains a wider view of the game than the players can actually out there on the field. In designing, it is necessary to adopt a similar role from time to time, in reviewing the project's strategy and progress. For an individual designer, or member of a design team, tackling the problem and reaching the goal will involve both the strategic skills of the coach and the tactical skills of the player. This is the metaphor I use to try to convey to students the idea of the designer as a self-organising system. I also like the metaphor because it compares designing to playing a game - something done for its own sake and for enjoyment.

Another significant approach to explaining how designers design has been the use of models - usually flow diagrams of various kinds. Such models are usually at the opposite end of the spectrum from that of the metaphors I have just discussed - the models are paths to be followed, thus avoiding the circuitous wanderings of the ant or the explorer. In general, I have found such models not to be very useful as educational tools, because they tend to be too complex for students to understand. Before they can recognise the paths set out in the models, students need to have done some exploration for themselves.

One of the first pieces of collaborative work that I did in this University was to write a paper on models of design activity with Norbert Roozenburg (5). In this paper we explored some of the history of model-building in design methodology, and the divergence that had occurred between models of engineering design and those of architectural design. We pointed to the differences of intention between prescriptive and descriptive models of design, and we tried to show how the diverging models might begin to be reintegrated. We concluded that, 'Above all it is in education that models of the design process must be employed that are reliable and robust, and formative of good design behaviour. Good methods are built upon rationality, adapted to the characteristics of the tasks to be performed, and to the cognitive properties of the designer. This calls for an integration of descriptive and prescriptive insights.'

We had just both written textbooks of design methods (6, 7) which shared many similarities and which we hoped embodied some of this integration. In particular, I had attempted in my book to develop a 'hybrid' model of the design process which combined insights from both the prescriptive and descriptive approaches. It is this pragmatic approach to models of the design process that has been embodied in our design methodology teaching in the Faculty.

A different but nonetheless most interesting pieces of work in model-building has been that of Corinne Kruger, who has been working for her PhD at Delft under the supervision of myself, Norbert Roozenburg and Jan Buijs, and Professor Bob Wielinga of the University of Amsterdam (8). She has developed a novel, descriptive model of design activity from observations of design practice (conducted in think-aloud protocol study experiments), and using the CommonKADS conceptual modelling language to help build a computer simulation of this observed and modelled design activity.

This work is an example of studying 'the designer as computer'. Will Corinne's simulation turn out to be 'the computer as designer'? I doubt it. For me, the aim of undertaking such work is not to build machines that will replace the human activities they seek to emulate. The aim is to further our understanding of design activity and of the nature of the cognitive processes that are brought into play in design activity. Through such research, we further our understanding of ourselves. I regard design as a highly-valued, pleasurable human activity - like playing a game - and so for me a machine that can design is as useful as a machine that can play football.

Reflection and Reason

It seems that designers are not like other people. Certainly there are differences in personality types that have been observed between designers and other professionals. Given that we want to understand 'how designers think', one of the simplest ways of researching this is just to ask designers themselves how they do it. Again, my students and colleagues will know that I am fond of quoting from designers. My selection of such quotations is unashamedly biased in favour of illustrating the points I want to make!

When designers are asked to reflect on their abilities and to explain how they work, I believe that a few common themes emerge. One theme is the importance of creativity and 'intuition'. For example, the engineering designer Jack Howe has said:

> 'I believe in intuition. I think that's the difference between a designer and an engineer.....I make a distinction between engineers and engineering designers....An engineering designer is just as creative as any other sort of designer.'

Another theme that emerges from designers' own comments is based on the recognition that problems and solutions in design are closely interwoven - that 'the solution' is not always a straightforward answer to 'the problem'. For example, commenting on one of his more creative designs, the furniture designer Geoffrey Harcourt said:

> 'As a matter of fact, the solution that I came up with wasn't a solution to the problem at all. I never saw it as that.....But when the chair was actually put together [it] in a way quite well solved the problem, but from a completely different angle, a completely different point of view.'

It is for this reason of the interwoven nature of solution and problem that the architect Richard MacCormac has said:

> 'I don't think you can design anything just by absorbing information and then hoping to synthesise it into a solution. What you need to know about the problem only becomes apparent as you're trying to solve it.'

A third common theme is the need to use sketches, drawings and models of all kinds as a way of exploring problem and solution together, and of making some progress when faced with the complexity of design. For example, the engineer-architect Santiago Calatrava has said:

> 'To start with you see the thing in your mind and it doesn't exist on paper and then you start making simple sketches and organising things and then you start doing layer after layer . . . it is very much a dialogue.'

Another theme that emerges is the sense of risk-taking that accompanies creative design. The racing car designer Gordon Murray said:

> 'There are patches of quite - loneliness, really, when you sit there and you think . . I'm committed to this crazy idea!'

Given the complex nature of design activity, therefore, it hardly seems surprising that the structural engineering designer Ted Happold should suggest that:

> 'I really have, perhaps, one real talent; which is that I don't mind at all living in the area of total uncertainty.'

If that seems a little too modest, there are certainly other designers who seem to make more arrogant claims, such as the architect Denys Lasdun:

> 'Our job is to give the client, on time and on cost, not what he wants, but what he never dreamed he wanted; and when he gets it he recognises it as something he wanted all the time.'

Despite the apparent arrogance, there is the truth in this statement that clients usually do want designers to transcend the obvious and the mundane, and to produce proposals which are exciting and stimulating as well as merely practical.

Ladies and Gentlemen, do these quotations convey enough sense of the 'madness' of designers? They are risk-taking novelty-seekers living in uncertainty, relying on their intuition and some apparently simple skills of sketching and drawing!

Above all, these designers I have quoted (all of them famous and highly successful) seem to be resolutely set against method. And yet the most reflective work of many design methodologists has served only to confirm the

effectiveness of this 'madness' of the natural ways of working of successful designers.

The first of our workshops on research in design thinking reviewed some of the studies of designing which have been undertaken over the past thirty years. We were able to note how eminent researchers such as Bruce Archer have confirmed the 'commutative' nature of problem and solution in design; Donald Schön has confirmed the importance of the 'dialogue' going on in designers' sketches; Bryan Lawson has identified the 'solution-focused' nature of design thinking; and Lionel March has identified the essentially 'abductive' nature of design reasoning.

When I began talking about 'abductive reasoning' in my design methodology lectures to students here in Delft, Norbert Roozenburg soon drew my attention to the complexities of this concept, and I realised that my own understanding was woefully inadequate! Fortunately, Norbert has helped my understanding over the years, and I hope that, in return, I have at least encouraged him to continue to pursue the relevance of understanding design reasoning. In his paper 'On the logic of innovative design' at the first Delft Workshop on Research in Design Thinking (9), Norbert carefully explained how C. S. Peirce's original concept of 'abduction' actually contained two different forms of reasoning: explanatory abduction and innovative abduction. Most of us in design theory had been confusing the two, whereas, as Norbert pointed out, innovative design clearly requires a logic of innovative abduction. He also pointed out that computer modelling of design reasoning does not - and perhaps cannot - go beyond explanatory abduction.

This kind of reflective, theoretical study of the underlying logic and reasoning of design thinking seems fundamentally important to me, and I hope that Norbert Roozenburg will continue to worry about it, even though he doesn't have my naïve misunderstandings to cope with any more! What this reflective research on design reasoning shows to me is that the designers who appear to be so 'mad' in their ways of working, and so weak in articulating how they think, have actually found appropriate strategies and tactics for pursuing the very difficult cognitive task of innovative abduction. When they talk about 'intuition' and 'uncertainty' and finding solutions that 'aren't a solution to the problem at all' they are expressing what it feels like to engage in innovative abduction. Theoretical research in the logic of design can strengthen our arguments that designing is one of the highest cognitive abilities of human beings. It helps to ensure that design ability is not regarded as something trivial, just because it is difficult to articulate the reasoning that underlies it.

Protocols and Paradigms

I have emphasised that a significant goal of design methodology is concerned with understanding how designers design and how designers think. A particular reason for this emphasis, for me, is the need to try to be more articulate about the 'natural intelligence' of design for the purposes of design education. Whilst I am quite happy to accept that designers themselves may

find it difficult to articulate their skills, I believe that design educators must attempt to be more articulate if they are to develop the pedagogy of design.

Educational programmes in Schools of Design, whether they are Schools of Architecture, Engineering or Industrial Design, are based on the premise that students gradually develop expertise as a designer. As students progress through their School's programme, not only does their specialised domain knowledge become more extensive, but they are also expected to integrate this knowledge with their developing skills of design in projects of increasing complexity. The setting of gradually more complex projects is the principal pedagogical method for the development of design expertise in students, and senior students are expected to display more developed expertise than junior students. But we have to be clear about the nature of the expertise that we are claiming to develop in our students, and this is one of the main aims of design methodology.

Therefore, when I came to Delft, I was very interested in the work on design education that was already under way by Henri Christiaans, and I was very glad to be able to become involved as one of the promoters of his PhD (10). In particular, just after I arrived, Henri began a series of protocol studies of design students. In these experiments, students (from our Faculty) at two different levels of development - second-year and final-year students - were given a design project and asked to 'think aloud' as they tackled the project. The design project, for a new litter system for a new railway carriage of the Dutch Railways, was developed by Kees Dorst, who also participated in the design and conduct of the experiments. As the students worked and thought aloud, they were videotaped for later analysis.

Henri was particularly interested in the study of creative ability, and how that developed during design education. The results of his protocol studies were surprising. His experiments found no positive correlation between the creativity of the solution concepts generated by the students and either their level of educational development or their previous records of performance in design projectwork. It therefore seemed that one significant aspect of design expertise, creative ability, was not being reliably developed in our educational programme.

In a joint paper with Henri and Kees (11), we also looked at other aspects of design expertise that I have claimed can be identified, such as coping with uncertainty and the constructive use of drawing. We looked at the students' use of information sources as one indicator of 'coping with uncertainty'. In general, the junior students collected and used substantially less information than the senior students. But several of the senior students spent large amounts of time simply gathering information and not using it. For them, gathering data seemed to be a substitute activity for actually doing any design work; the antithesis of 'coping with uncertainty'. The more successful senior students tended to vary their attention quite rapidly between gathering small amounts of information and reflecting upon it. This is behaviour that I expected to be typical of experienced designers, but again this was not something that seemed to be developing uniformly in our students.

We were therefore left with some uncertainty as to whether the educational programme of our Faculty could justifiably be claimed to be developing design expertise successfully in all our students. Since these experiments took place, the design education programme of the Faculty has been remodelled, and it would be interesting to conduct similar experiments again in the near future to see if the same uncertainty exists, or whether the new programme has been more successful.

Perhaps at this point it would be appropriate to raise the spectre of 'the Delft method'. I use the term 'spectre' deliberately, because there is considerable uncertainty as to whether a 'Delft method' of designing does or does not exist. When I gave my first lectures on design methodology in Delft, and emphasised the self-organising system approach that I favoured, several students commented to me that this was refreshing because they had previously felt constrained to follow 'the Delft method'. But when I asked my colleagues what this 'Delft method' is, they denied that it existed! However, when I reviewed the various design course documentation I did find that a consistent approach to design activity was being promoted. I do not think that it is bad to have a consistent approach - quite the contrary, in fact - but we must be sure that our approach is one that genuinely develops design expertise. I have always emphasised that design methods teaching must provide students with life-jackets not strait-jackets.

After Henri Christiaans' work based on protocol analysis of students' design behaviour, other researchers here in Delft also began to make use of protocol analysis for helping to understand design behaviour more generally, and several PhD theses and other projects have been based upon this technique. The work of Kees Dorst deserves special mention because he has helped and advised some of these other researchers, as well as continuing to develop the use of protocol analysis in his own PhD work (12). Kees has set up probably the most comprehensive protocol analysis of design activity yet, through his study of twelve expert designers working (once again) on the railway litter-system design problem. This study of expert designers confirmed some of our observations about the successful and less-successful strategies also exhibited by the students (13). For example, the more successfully creative experts also alternated rapidly between gathering information and reflection.

In analysing the data from these experiments, Kees Dorst became dissatisfied with the normal, rationalising forms of analysis, because these seem inadequate in capturing and interpreting conceptual design activity. He has therefore suggested that the paradigm of rational problem solving (derived largely from Herbert Simon) has a limited scope of application in analysing design activity, and that when it comes to the generative, conceptual design parts of the process, the paradigm of 'reflection-in-action' (from Donald Schön (14)) seems more appropriate.

Donal Schön was one of the keynote speakers at the first of the Delft Workshops on Research in Design Thinking, and it is encouraging to see that his perceptions on the nature of design ability are now being taken up very widely. At that first Workshop I complained that there has been a number of previous but unsatisfactory paradigms of design thinking, and that 'the lack of an adequate simplifying paradigm is perhaps something which inhibits the

transfer of knowledge from research into practice and education.' Unfortunately, Kees Dorst has found that attempting to apply Schön's paradigm of 'reflection-in-action' to the analysis of design activity leads to the frustrating conclusion that the paradigm is not very well developed: it is perhaps little more than what Schön himself claimed - a 'primer' for a new theory of design. The work that Kees is doing in comparing the paradigms of 'rational problem solving' and 'reflection-in-action' will enable us to see more clearly the strengths and weaknesses of these competing paradigms. We are perhaps on the cusp of developments that will lead to a new paradigm of design thinking, and this is very exciting.

The credit for the second Delft Workshop on Research in Design Thinking is also largely Kees Dorst's. The idea for this Workshop originated with Kees, in conversation with colleagues from Australia and the USA at a design methodology conference in 1992. Kees's idea was to move protocol analysis of design activity forward in one major leap, by getting many different researchers around the world to analyse the same data. Previously, protocol analysis in design had been limited to isolated, small studies (except the work of Kees and Henri) producing little better than anecdotal results. We were fortunate that our Faculty was able to provide support for this idea, and that colleagues at XeroxPARC and Stanford University, California, were also sufficiently enthusiastic to work with us in developing the idea, providing facilities for the videotaping and finding the expert designers to act as the subjects. They also had a major influence by including small teams of designers as subjects as well as individual designers.

When the Workshop was held here in Delft in September 1994, researchers from eighteen different centres around the world presented their studies of the common videotaped material, and this same original experimental material continues to appear in different analyses in papers at other conferences and in other publications. The 'Delft Design Protocols Workshop' has perhaps been the most significant event in the history of design methodology research, and I am proud to have been associated with it. There is now a much sounder basis from which to develop empirical studies of design activity.

One aspect that emerged particularly strongly from the protocols workshop, for me, was the concern with teamwork. The paper that I wrote for the workshop, with my wife and colleague Anita Clayburn Cross, was based on our observations of the team protocols. I was reminded that one of the original motivations of the 'design methods movement' of the 1960s had been the need to develop design procedures for working in teams. This has become even more relevant in more recent times with the need for 'concurrent' design procedures. In our paper we concluded:

> Design methodology, particularly in the engineering domain, has tended to treat the design process as a technical process - as a sequence of activities based on a rationalised approach to a purely technical problem. More recently, and more particularly in the architecture, product design and software design domains, attention has also been directed to designing as a cognitive process - to the cognitive skills and limitations of the individual designer. Just a few studies have begun to

suggest that designing is also a social process, to point out how designers interact with others such as their clients or their professional colleagues, and to observe the social interactions that influence the activities of teamwork in design. Design methodology now has to address the design process as an integration of all three of these - as a technical process, as a cognitive process and as a social process.

The Faculty of Industrial Design Engineering, with its mix of disciplines within it, is well-placed to pursue this integration and to advance the study and application of design methodology. I have concentrated in this lecture on some of the recent research in our design methodology group. I hope that I have been able not only to draw attention to the strengths and successes of this small group, but also to identify and suggest where some exciting possibilities and important new developments lie ahead.

Madness and Method

Ladies and Gentlemen, in this lecture I have tried to address our understanding of one of the highest cognitive abilities of human beings, that of designing. If I have not had much success, then I can plead that it is the complexity of the terrain that I have been traversing that makes my route seem so faltering and circuitous. But it is possible to summarise what we have learned about how designers think, in terms of how they formulate problems and generate solutions, and the cognitive strategies they use.

Problem Formulation

- Designers explore problem-and-solution together, using 'languages' of drawing and modelling
- Designers use alternative solution conjectures as the means of developing their understanding of the problem

Solution Generation

- Designers impose additional constraints that narrow the solution space and help to generate concepts
- Designers add 'missing ingredients' to the problem space in order to make a solution possible
- Designers change solution goals and adjust problem constraints during the process of designing

Cognitive Strategies

- Designers use a solution-focused cognitive strategy for problem resolution
- Designers rapidly alternate between analysis/synthesis/evaluation during creative activity
- Designers use an abductive form of reasoning
- Designers habitually treat problems as ill-defined problems

Like professors, designers can also seem at times to display traits of madness. There is no doubt that designing still retains some aspects of mystery, but I and my colleagues in the Faculty of Industrial Design Engineering have been gradually developing a better understanding of that mystery. We hope that we might be able to suggest, quoting William Shakespeare, that

Though this be madness, yet there is method in't.

Ladies and Gentlemen, it has been an honour to be Professor of Design Methodology in the Faculty of Industrial Design Engineering.
In concluding, I would like to express my gratitude to all my colleagues in the Faculty, who made it such a pleasure to spend time here in Delft.

In English we have many phrases that embody a concept of 'Dutch-ness'. For instance, there is 'double-Dutch', which is a language that no-one understands! There is 'going Dutch', which means sharing costs equally, and I suppose reflects the reputation for fairness of the Dutch people. There is 'Dutch courage', which comes with a few drinks of alcohol, and which perhaps reflects the Dutch person's love of *jenever*, which I also have come to appreciate. And there is the 'Dutch uncle', who is someone who takes an avuncular interest in your well-being, even though he is not really your uncle. In Delft I have benefited from several 'Dutch uncles' who have looked after me, but I would like to thank two in particular who have overlooked my faults and ensured that my interests were always obtained: Jan Buijs and Norbert Roozenburg.

Thank you for your kind attention.

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