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Reflections on the Concept of Design Ability: Telling Apples from Pears

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ABSTRACT

In design research, the term 'design ability' has been widely used to describe what designers need to have to be able to handle in order to do their job. I argue that it has been too loosely used and that some order is needed, so that the research community knows what is meant by the term. This essay tries to tangle out the concept of design ability in the light of factor-analytic studies on cognitive abilities, and I suggest alternate ways of conceptualising what designers do. I propose that it is more rewarding to talk about a designerly way of thinking, as a set of cognitive styles that designers prefer to utilize, since the nature of their work is constituted the way it is. I also suggest consequences for design education.

Keywords

Design ability, design cognition, cognitive style, cognitive abilities, design education

INTRODUCTION

The term 'design ability' has now been in use in the design research and education community for some years. But what do different authors mean by it? This essay will tangle out the concept and pinpoint some weaknesses in it in the light of theories from cognitive science. It will also suggest more refined definitions of designerly ways of thinking. Consequences for design education will finally be discussed.

Cross (1992, 1995) has put together a review and summery of research into the nature of design ability. In that review, design ability is defined as what a designer needs to be able to handle. The literature from thirty years of research has identified six key aspects of design ability: coping with ill-defined problems, problem structuring, managing goals and constraints, generating solution concepts, thinking by drawing, and intuitive reasoning. Designers typically employ problem-solving strategies that fit ill-structured problems by for example changing the goals and the constraints, even when such strategies are not appropriate. The ill-defined nature of design problems leads to the fact that they cannot be understood in isolation from design solutions. It is natural that alternative solutions are used as means for exploring and understanding the problem formulation. Designers tend to experiment with early alternative solutions that help them understand the problem-solution-space (e.g. Schön, 1983). In this experimentation they tend to change goals and constraints in the middle of the design process in order to avoid changing the fundamental concept of the design too much, and thereby having to start all over. It is important to find such a structuring principle or fundamental concept in order to make the design coherent; it is also a starting point for exploration. Cross also brings into attention that designers think by drawing. The sketch is typically used as a means for exploring the problem-solution-space, and is conversational to its nature. The designer draws a line and the line talks back to the designer giving him or her suggestions on how to proceed. Schön (1983) called this the "back-talk" from the situation to the designer. The appreciation and assessment of a design during back-talk, is often based on a feeling and a judgement of the goodness of a solution. Since the design work is complex, everything cannot be tested and measured, the designer has to trust his or her intuition.

In summary, Cross argues that designers must be able to:

- Produce novel, and unexpected solutions
- Tolerate uncertainty, work with incomplete information
- Apply imagination and constructive forethought to practical problems
- Use drawings and other modelling media as means of problem solving
- Resolve ill-defined problems
- Adopt solution-focusing strategies
- Employ abductive/productive/appositional thinking
- Use nonverbal, graphic/spatial modelling media
- Work with several alternative design solutions in parallel in order to understand the problem-solution-space. Later on in the process all these alternatives form conjunctures

Viewed as taxonomy, this list wouldn't be considered pure; some parts of it concern the situation that a designer is in, others are about the goals of design, and some things concern methods for design. Therefore I choose to express the same thing in a slightly different way:

The goals of design include producing novel and unexpected solutions to ill-defined practical problems, in an uncertain situation with incomplete information. In order to produce those solutions, the designer applies imagination and constructive forethought in a solution-focused strategy characterised by abductive, productive and appositional thinking. Several parallel design solutions are explored, by means of drawings and other graphic/spatial modelling media, as a way of understanding the problem-solution-space

Löwgren and Stolterman (1998) separate between the craftsmanship of design with its skills and its body of knowledge on the one hand, and the ability that a designer needs in order to function well as a designer on the other hand. With the view of design as the process that, under resource constraints, is organised in order to give form and decide all the properties (functional, structural, ethical and aesthetical) of an object for a client, they conclude that a designer needs a number of different abilities:

- Giving form requires creative ability and analytical ability.
- Deciding requires critical ability.
- To work with a client requires rationality and communicative ability.
- Design of functional properties requires insight and knowing about usage.
- Design of structural properties requires insight and knowing about technology.
- Design of ethical properties requires insight and knowing about values and ideals.
- Design of aesthetical properties requires the ability to give form and compose.

This list is, in my view, not exclusive to designers. For example, any consultant work with clients and do therefore need communicative ability. The overarching definition for design ability that Löwgren and Stolterman use is that of constructive intentional intelligence. This definition points in two main directions: The designer must be constructive in the meaning of creative and innovative, and he or she must also be intentional, which means that he or she must intend to change the world in some way. Design intelligence requires the ability to think logically but is also characterised by synthesis thinking. Synthesis is about being able to create composite artefacts from parts, but also putting together information about details in order to support a holistic thinking. Holistic thinking is important in design, Löwgren and Stolterman state, since the thing that is supposed to be designed should work not only in itself but also in context. To see how a totality can be composed based on incomplete information is a fundamental component of design intelligence. The ability to judge or assess the quality of a particular design solution from many different perspectives is also important in design. Only by changing perspectives purposefully can a holistic assessment be made. Design intelligence is of course about having imagination and having the capability to externalise and give shape to that imagination. A vital part of design intelligence is to be able to work with the material; with the sketch or the model in order to reach a finished design solution (Schön, 1983, 1992; and Bennet, 1996). Löwgren and Stolterman consider design ability as a general human ability that all of us possess, but the aptitude for the different parts of design ability may vary.

David Bernstein's (1988) account of the "design mind" is similar to that of Löwgren and Stolterman. He argues that the designer sees associations and makes relationships that have to be communicated. He or she have to relate all the small pieces to the whole: "The object to its purpose, the object to the user, and, most importantly, he has to relate the object to the user to the environment in which that object is being used." [Bernstein, 1998, p. 204.] In Bernstein's eyes, the designer is a synthesiser: the ability to synthesise all sorts of factors to a coherent whole. Design is also about making sense of relationships, always seeking for new relationships and new associations. Furthermore, the designer is an explainer that uses visual thinking to understand and communicate. Every designer must also love things and have a product passion. Other abilities that are vital for a designer, in Bernstein's eyes, are imagination, creativity, lateral thinking, and curiosity. Bernstein also notes that designers always ask reframing questions; they ask: What if, and what might have happened if the question was asked in another way? The designer seeks for logic in the design solution but will employ seemingly illogical means of reaching that solution. The purpose is to try to solve not just any problem but the right problem. Design does not happen in isolation. It happens where ideas collide. Openness and extroversion is hence vital in Bernstein's view.

Cross (1995, 1998) tries, just like Löwgren and Stolterman, to pinpoint a kind of design intelligence and by that suggesting that at least parts of it is based on abilities. In his article "Natural intelligence in design" (1998) he bases the argument on statements made by famous designers and concludes that design is rhetorical, exploratory, emergent, opportunistic, abductive, reflective, ambiguous, and risky. By sketching the designer can handle different levels of abstraction simultaneously, which allows him or her to simultaneously think about the fundamental concept of the design, while reflecting on critical details. Sketching is the activity that enables the designer to move freely between different levels of detail, which is important especially in early phases of the process. Designers also use sketches to identify issues and as cues to remember important pieces of information that they have picked up. Yet another key characteristic of sketching is that it assists problem structuring through solution attempts, and finally it promotes the recognition of emergent features and properties of the solution concept. Even though Cross gave the article the title "Natural intelligence in design" he did not come much closer to identifying what human abilities that are necessary for designing.

I wish to end this review of the literature with Nigel Cross, since he is the one that has worked most with the concept of 'design ability.' Cross (1995, p. 115) views design

ability as "a multi-faceted cognitive skill, possessed in some degree by everyone." A few lines below he claims "that there are particular "designerly" ways of knowing, thinking and acting." So what is it? Is it an ability, a skill or a styles of thinking? What way is the most fruitful way to talk about what characterises designers?

ABILITIES

The term 'ability' is used both in common language use and in professional and academic settings of psychologists, educators and others. It is usually used to characterise attributes of human individuals, en terms of a kind of potential. English and English (1958), quoted by Carrol (1993, p. 4), define ability as: "actual power to perform an act, physical or mental, whether or not attained by training and education." Carrol himself continues by providing a more precise definition:

"*As used to describe an attribute of individuals,* ability *refers to the possible variations over individuals in the liminal levels of task difficulty (or in derived measurement based on such liminal levels) at which, on any given occasion in which all conditions appear favorable, individuals perform successfully on a defined class of tasks."* [Carrol, 1993, p. 8]

Liminal values are in this definition threshold values where the most accurate measurements are obtained. Carrol views the term 'ability' as neutral and even uninformative as to whether a given ability is an aptitude or an achievement. In the text above the achievement aspect has been presented, but if there is some core of design ability that to some extent is stable and resistant to experience and education, and also predictive of future success, we can regard it as an aptitude for design. Such cases has been reported in for example musical aptitude (Stanton & Koerth, 1930) where training did not affect the aptitude measures even though they were highly predictive of training success. Carrol (1993, p. 17) states that such clear pictures seldom are seen in the tests of abilities, and asserts "that that an ability measured at time *A* in a suitable sample of individuals is an aptitude if it contributes significantly to the prediction of achievement at time *B* over and above the prediction obtainable from a measurement of achievement at time *A*." Time *A* is a measurement before training and time *B* is after training. An ability is, in other words, an aptitude if it helps in predicting degree of learning beyond a prediction from degree of prior learning. If not, it is an achievement.

Design can be seen as a class of tasks where the individual is engaging in a design activity in order to achieve a design solution. Using Carrol's definition of ability when it comes to design ability will, however, most likely prove difficult since it is so hard to determine any threshold values of design-task difficulty with accurate measurements. This is due to the ill-defined nature of design problems, their inter-dependency to design solutions, and the constant redefinition of goals and constraints that are necessary in any design activity. A reformulation of the definition given by Carrol, with the nature of designing in mind, would lead to an understanding of general design ability as:

Variations over individuals' in the level of design task difficulty at which, when all conditions appear favourable, individuals perform successfully on a design brief.

The problem in this definition is still the difficulty to decide what success is and what task difficulty is. It is, however, possible to evaluate a design solution with respect to a design brief or a, by the designers, fruitfully reformulated design brief. Since the task difficulty still is hard to determine, this definition should be viewed as a tentative definition that that must be revised in order to be useful. The difficulty of a design task will always vary with the background and repertoire of the designer. A graphical designer will not perform well on architectural design briefs for example. It is obvious that performance on a brief is affected by prior experience learning. Any measure of design ability in the sense of potential to present performance on a task can be regarded as a measurement of achievement; of how well something has been learned.

Any measurement of design ability in this manner will have poor reliability (that is poor accuracy of a score) due to the ill-defined nature of design problems. It will also vary over time and it will be highly dependent on the certain design brief that is given. A measurement based on one design brief can therefore not be generalized to any general design ability, but only to a limited class of briefs. Several aspects of general design ability, at a more narrow level, have however been identified in the literature on design ability. These may be assessed or even measured in a better way. It is not likely that design ability as defined by Cross and others will have a predictive power, and it can hence be considered to be a matter of achievement rather than aptitude even though some elements of aptitude may exist within the more complex construct of design ability.

In view of the theory on abilities it would, according to Carrol, be wise to establish sets of design-tasks. Each set would consist of design-tasks that are highly similar and differ only in level of difficulty. The sets of tasks must be highly different from each other, in order to show that each set of tasks measures a single ability. When a series of tasks is established so that tasks in every set conform to a model of a single ability, an analysis of how much the performances on different task sets correspond to each other. That would show if each set of tasks measures one ability or if one or more abilities are in common for two or more sets of tasks. After that more detailed analysis can take place.

Cognitive abilities in design ability

Carrol (1993) made a reanalysis of all the research in cognitive abilities up to 1993 and compiled an impressive factorial analysis of 461 datasets. He identified some thirty separate cognitive abilities. Among all the different abilities identified in his reanalysis some seem to fit the research on design ability. First out is *communication ability,* which is regarded important in design by Bernstein (1988) and Löwgren & Stolterman (1998). It involves talking and listening without reference to reading and

writing abilities. Since written tests cannot be used it has proven difficult to measure communication ability.

Second out is *inductive reasoning ability*, which is the ability to see a common underlying characteristic in a material—for example a pattern, a concept, a class membership, a rule, a process, a trend or a causal relation. The usual way do define inductive reasoning is as the generalization from cases we have seen to cases we haven't seen, but in order to do that one must have identified an underlying pattern in the seen cases. This ability has on the one hand, been considered important for designers by authors like Bernstein, but Cross (1995) has on the other hand argued that abductive reasoning ability is even more important. This is however not covered by the literature on cognitive abilities. However, if abductive reasoning is defined as reasoning in which explanatory hypotheses are formed and evaluated (Thagard & Shelley, 1997) (reasoning from observed fact to inferred cause), then abductive reasoning ability can to some extent be seen as part of inductive reasoning ability as defined above. No valid abduction (if there is such a thing) can be made if no pattern has been observed.

Thirdly, Carrol has identified several ability factors in the domain of learning and memory that are related to design ability. Apparent from reading Bernstein is that design work requires *associative memory* (the ability to form arbitrary associations and remember what stimulus are paired to each other), and *visual memory* (the ability to form an image and use it for recognition or recall).

Fourthly, visual abilities, such as *manipulating spatial relations, perceiving gestalts or closures, gestalt or closure flexibility*, and *visualisation*, has been argued to be important parts of design ability even though the exact terms not have been used (Bernstein, 1988; Schön, 1983, 1992; Bennet, 1996; Cross, 1992, 1995; and Löwgren & Stolterman, 1998). *Perceptual speed* would also be a vital ability in order to get a fast doing-seeing loop in sketching. Carrol (1993) points out that there are real problems in the field of visual abilities since test takers apparently utilises a number of different strategies for arriving to their answers. Different cognitive styles or ways of thinking leads to wide fluctuations in the factor loadings of visual ability tests.

Finally, idea production is a field that Carrol takes up, which has a clear relation to design. Designers need to have high *associational fluency* (speed in thinking of a series of different but semantically associated responses to a given stimuli), *sensitivity to problems* (speed and success in thinking of solutions to practical problems, or new ways of using objects), *originality/creativity* (speed and success in thinking of unusual or original responses to specified tasks), *figural fluency* (speed and success in giving figural responses to specified tasks), and finally *figural flexibility* (speed and success in in dealing with figural tasks that require a variety of approaches to a solution). (Bernstein, 1988; Löwgren & Stolterman, 1998; and Cross, 1992, 1995)

In the domain of idea production Carrol points out that further research is need in order to clarify the extent to which the factors may be differentiated from each other and what the basis for the differentiation is. There is also a lack of reliability for the measurements, and producing such measurements seem to be a hard task in design research.

This paper has shown that design ability is complex. It cannot be regarded as a unitary factor, but the definition of the term falls back on the purpose of talking about design ability. Is it for describing and predicting individual differences in performances of design tasks? Abilities are often thought of as something on an interval scale; something that an individual can have more or less of. Is that the best way to view what designers do? Especially since it seems so difficult to measure performance on design tasks with any validity and reliability, and since it is so hard to establish levels of task difficulty. What is the point of using a term that we cannot define for research purposes? In such an endeavour the design research community would probably run into similar difficulties as they have in the field of visual perception. Another way to think about what designers do is in terms of styles of thinking, in this case a designerly style of thinking. Would that prove more useful?

COGNITIVE STYLES AND DESIGN EDUCATION

A designerly way of thinking would be a profile of cognitive styles. A cognitive style has been defined as a preferred mode of thinking. In contrast to abilities it is not something that you have more or less of but rather that you prefer to think in one way or another (for example thinking verbally or thinking visually). Linking the research on abilities to that on cognitive styles is not unproblematic. Carrol states that there is little reliable information about the relations between cognitive abilities and cognitive styles, but that linear correlational and factor analysis may be inappropriate for such studies. He also suggests that the preferred way of thinking that a person has can be the result of the abilities that the person has.

Cross and Nathenson (1981), and Cross (1995) pointed out that it is important to understand cognitive styles for design education and design methodology. Newland, Powell and Creed (1987) took up this work, as they studied learning styles among architects. They conclude (p.7), "*architects* show a strong requirement for interpersonal engagement that enable them to *act with confidence* and be perceived as *being in control*." Newland et al. continue by dividing architects into four groups. The basis for their testing of the architects is Kolb's (1976) learning styles that place 'concrete experience' in contrast to 'abstract conceptualization', and 'active experimentation' in contrast to 'reflective observation'. People that prefer active experimentation and concrete experience in their learning are called 'accommodators'; the ones that prefer active experimentation and abstract conceptualisation are called 'convergers'; if they favour reflective observation and abstract conceptualization they are 'assimilators'; and the people that prefer reflective observation and concrete experience are 'divergers'. Newland et al identified four kinds of design learners in their study:

1. *Common-sense designer-learners* are abstract thinkers but survive as designers by combining it with active experimentation or with the opposite to abstract conceptualization: concrete experience. These learners are efficient planner architects.
2. *Dynamic designer-learners* that base their understanding on "the incidents of life, the dynamic, dramatic, active events and the continuous awareness of the changing present and the future possibilities they create" (Newland et al, p. 11). These designers are accommodators. They continually sense the world and get quick feedback, working in an opportunistic fashion, which allows them to switch rapidly from being entrepreneurs to rapidly producing designs.
3. *Contemplative designer-learners* have a learning style that is a combination of reflective observation and abstract conceptualization. A small subset of them can complement their reflective nature with concrete experience or active experimentation.
4. *Zealous designer-learners* employ both poles of the axis between active experimentation and reflective observation. They are based in reflection but need to engage in the world in order to understand, which make them appear to be 'doers' rather than 'watchers'. Zealous learners are practical, and knowledge that is focused on the present and local possibilities are important.

Cross also took up his own challenge together with Durling and Johnson (Durling, Cross & Johnson, 1996a; 1996b). They explored the cognitive styles among art-based design students, and concluded that there today is a match between students' preferred way of learning design and teachers' preferred way of teaching in UK design schools. Concern is, however, expressed regarding whether this will be the case in the future. Durling et al. used Myers-Briggs Type Indicator in their studies, which showed that architects prefer intuition and fine-artists also prefer feeling as well as intuition. Among design students (interior design; graphic design; furniture design; and design marketing) over three quarters have preference for intuition and a majority also prefer perception. A quarter of the design students are of one type, ENTP (Extroversion, Intuition, Thinking, Perception), which means that they find intuition more interesting than thinking, and will strive for maximum freedom for the pursuit of intuitive goals. Because intuition is a perceptive process they will deal with the world in the perceptive attitude.

They conclude that designers broadly prefer teaching which begins with the big picture, with concepts, and then explains details; is focused toward future possibilities and gives alterative viewpoints; has lightweight structure, allowing guided exploration; and mostly shows objective data, is logical and analytical, and is based on exemplars showing things. A third of designers will, although, be happier with more subjectivity, a person-centred approach, and value judgements. By comparison, no-designers prefer teaching which begins with details and facts, and then generalises, and that offers more guided instruction, which proceeds step-by-step. It does, however, also follow that no single kind of design learning is suitable for *all* designers.

Sternberg and Grigorenko's (1997) approach to styles is called the theory of mental self-government and the basic idea is the different styles of government that are observed in the world may be external reflections of the styles that can be found in the mind. Therefore, one can understand styles of thought by looking at aspects of government for a sense of what that goes on cognitively. According to the proposed theory, everybody possesses every style to some degree. It is the strength of preferences that varies between individuals, and the situations and tasks that evoke these preferences to some extent. When possible, people choose a style of managing themselves, with which they are comfortable. People are, however, also flexible and can adapt their use of styles to the demands of the current situation. According to Sternberg and Grigorenko, thinking styles appear to be largely a function of people's interactions with others as well as a function of their interactions with different tasks and situations. Some set of styles are more suitable for certain tasks. Preferred styles aren't fixed and may change over time, the socialization into a value system will probably reward some styles over others, leading to preferences for these styles. The fact is, however, that despite environmental pressure some people keep their preferred styles. This suggests that socialization alone can't count for the origin of styles and some part may be dispositions that are difficult to change.

Given the literature and research presented in this paper I would argue that there are designerly styles or in other words: designerly ways of thinking. Not all designers would, however, fit into it, but a majority would. I hypothesize a designer's preferred set of thinking styles would be constituted in the following manner (re-interpreted in the mental self-government approach to styles):

A designer would prefer to carry out *legislative* functions, which means that he or she would enjoy creating and formulating. "Such an individual like to create their own rules, do things their own way, and build their own structures when deciding how to approach a problem. They prefer tasks that are not prestructured or prefabricated" (Sternberg & Grigorenko, 1997; p. 707). In order to be able to focus on both parts and the whole picture of a design task he or she wouldn't prefer a *local* style over a *global*, or vice versa. A designer would also like to work with other people, according to an *external* style. He or she is also likely to be *liberal* in the sense of going beyond existing rules and procedures and allowing substantial change from the way things are currently done. I also hypothesize that a designer would have a *non-monarchic* form of self-government. That means that a designer wouldn't prefer to focus on one task or aspect until it is completed. It is difficult to work as a designer if you single-mindedly focus on one goal or need at a time.

CONCLUSIONS

Different designers employ different styles for thinking, but some styles are more common. They all involve creating things, thinking about the broad picture, communicating with others, visualising, going beyond the taken-for-granted, and working with several things at the same time. Even though design teachers tend to be similar in style, sometimes there may be a dissonance between teachers' styles and students' styles. This has to be handled in some way in design education.

In order to work successfully in design one has to adopt a way of thinking, but some designers seem to prefer working in some ways and others in other ways. Styles are also socialized and developed in interaction with others. Therefore styles are in the interim between studies of cognition and studies of practices. This is where design research ought to be in order to contribute to the field of design and not only to the field of research. I would argue that talking of *designerly ways of thinking* is more rewarding than talking about design ability since the former implies that people can work as designers by adopting particular ways of thinking, even if it is hard. The term design ability implies that a student of design either has the ability to an acceptable level, or he or she does not have it. This is not a very fruitful view of personal development for that student. Some cognitive abilities must, however, be present to some extent, especially those regarding visual abilities and idea production. I would like to conclude by saying that there is more than one way to be a designer, but not an infinite number of ways to be a designer. Design education would benefit from investigating this issue further, in order to understand its consequences for project- and studio-based pedagogies.

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