

Design, Science and Conceptual Analysis*

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Abstract: Philosophers expend considerable effort on the analysis of concepts, but the value of such work is not widely appreciated. This paper principally analyses some arguments, beliefs, and presuppositions about the nature of design and the relations between design and science common in the literature to illustrate this point, and to contribute to the foundations of design theory.

Introduction

Discussions in the design literature about the nature of design and the relations between design and science are in need of more rigorous conceptual analysis, not least because much can turn on the assumptions made about these matters. It is the aim of this paper to briefly demonstrate the need for such analysis, and to indicate something of its value. This paper samples work in progress. To begin, however, I discuss a case from the voluminous research in the behavioural science literature on crowding and the built environment, because it nicely illustrates the cognitive, pragmatic, and social costs of overlooking or failing to understand the need for such analysis.

A Cautionary Tale

In "Crowding Perceptions, Attitudes, and Consequences among the Chinese", Chalsa Loo and Paul Ong set out to test the seemingly common belief that, at least in residential settings, "the Chinese prefer crowding".¹ Their research is largely barren, however, not to mention a waste of time and

money, and all for the want of a little time spent in the cool of the verandah sorting out the meanings of the crucial term 'crowding' and its cognates.² Instead, Loo and Ong dash into the field where an answer to their question is simply not to be had. Let me explain.

In ordinary English, 'crowding' and 'crowded' are typically value-laden words, or preference-laden or desire-laden words.³ So to say that crowding often occurs at the local bus stop after school or that my house is crowded when my relatives come to stay is not just to mean that such places are densely populated at these times - which meaning would *not* be value-laden or preference-laden. It is typically to mean *in addition* that such densities are, to some degree, *not desired or preferred* - so far, at least, as the speaker is concerned.⁴

So, Loo and Ong sampled residents of Chinese descent in San Francisco's Chinatown, a densely populated neighbourhood by North American standards, and asked them, amongst other things, to evaluate a crowded dwelling on a five-point scale from 'very good' to 'very bad'.⁵ Not surprisingly, 94% of respondents thought that a crowded dwelling was "somewhat bad" or 'very bad'.⁶ Since

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'crowded' means 'undesirably densely populated', however, it is not surprising that when people are asked, in effect, 'How desirable (or otherwise) is it that your dwelling should be undesirably densely populated?', they should respond that it is indeed not desirable.

Further, Loo and Ong 'discovered' that *everyone* who reported being crowded in his or her dwelling also "felt the need for more space", which shows only that these respondents did not want to contradict themselves.⁷ Having judged that there was not sufficient space in their dwellings to satisfy their needs they agreed that more space was needed. And when asked whether or not crowding causes problems, 99% of all respondents thought that it did, which again is not surprising and shows only that (at least) 99% of their respondents understand the logical relations between the concepts 'crowding' and 'problem'.⁸ If one has an unsatisfied or frustrated need or desire of some importance it *follows* that one has a problem. No empirical inquiry into this need is required to establish the existence of a problem.

Other ambiguities in their use of 'crowding' and its cognates are common. For example, they report that when asked whether or not their dwelling was crowded 1 in 5 of respondents *who lived alone* reported that it was. In all probability, however, what such people meant was that their dwellings were cramped or confined. But Loo and Ong decide that this response shows that crowding has an important "non-social component".⁹ On the contrary, all it shows is that 'crowded' is not univocal. A dialogue about, for example, the financial attractiveness of investing in a bank does not have a geographical component because a question like, 'Is the bank a good place to leave

one's money' can also be appropriate in a dialogue about going for a swim in the local creek.

To sum up, a research grant and extensive interviews are not required to determine whether anybody *likes* crowding, any more than to determine whether some married men are bachelors.

But there is also an important *social* implication of the conceptual mistake Loo and Ong have made. They seem to be aware that if the claim that the Chinese *like* crowding goes unchallenged then such people are at risk of being thought irrational or morally inferior beings. How could someone like what is simply not likable or what no-one else decently likes? Thus, Loo and Ong are worried, it seems to me, that this claim will breed racism, which is probably true.

They approve of a remark, attributed to Jane Jacobs, that "*every* one hates crowding" (my emphasis), and suggest that this remark "reflects a perspective of cultural universality".¹⁰ Does the possibility of finding a human universal in respect of preferred densities appeal to Loo and Ong because it would deny racism a foothold? I think so. Jacobs' remark, however, is merely a semantic or logical truth, as should now be clear. But it can seem to pick out a contingent truth that is universal for that very reason. Just as the remark that it may or may not rain on the first Tuesday in November can seem to be informative about the weather on *every* such Tuesday, though in fact it tells us nothing about the weather on any such day.

Since Loo and Ong conflate crowding with high density their research is not designed to bear on the possibility that preferences or tolerances in respect of density *is* causally related to culture. Thus, they shy away from the interesting question whether their

respondents might not regard as crowded densities which *non*-Chinese North Americans, who are otherwise relevantly similar, would so regard. They do so because, given their conflation of crowding with high density, this question will appear to them to leave open the possibility that the Chinese like or tolerate crowding.

For the same reason, Loo and Ong fail to interpret or understand some obvious evidence which others have provided that there is a causal relation between culture and density. For example, they cite an interesting paper, "Some Chinese Methods of Dealing with Crowding", by the anthropologist E. N. Anderson Jr., who lived and worked in two Chinese communities in Malaysia.¹¹ In this paper, Anderson details the mores and beliefs of these communities which led them to prefer or enabled them to cope with household densities greatly in excess of those which Anderson and most other North Americans would prefer or could even manage.¹² (To ease the pressure of such densities, Anderson occasionally took solitary walks, which practice he discovered was "unheard of" amongst his hosts. Such walks were "misconstrued" and the subject of "much speculation".¹³) If Anderson's paper had been more accurately titled, "How some Chinese Identify or Deal with High Density Living", and key terms like 'crowding' replaced by 'high density' whenever the latter was meant, it would have been difficult for Loo and Ong to misconstrue Anderson's evidence that these high densities were freely chosen.¹⁴

The way to combat the incidence or spread of the racism Loo and Ong rightly deplore is not by trying to show, having conflated high density with crowding, that 'The Chinese prefer crowding' is false because of how the Chinese happen to be. That tack merely leaves the way open for the racist to exploit

this conflation, finding evidence of Chinese communities who prefer or are indifferent to densities which members of the racist's audience would find crowded.

The Act of Design (1)

I turn now to the specific matters at hand. In the design literature, such general questions as, 'What do we mean by "design"?', 'What is it to produce a design for something?', or 'What does the act of design consist of?' are usually passed over, or else receive a desultory treatment by authors anxious to move on to what they regard as the important questions about design. This can easily be a mistake, as the analysis of 'crowding' above suggests, and two such cases are briefly discussed below.

In *How Designers Think*, Bryan Lawson says that searching for a definition of 'design' is "probably much more important" than finding one.¹⁵ It is evidently not sufficiently important, however, to detain him, for he turns away to consider accounts of "the design process". Lawson asserts that because design occurs in many areas and differs so much from one area to another, a definition of 'design', such as that which he attributes to Chris Jones ("to effect change in man-made things"), would be "too general and abstract to be useful in helping us to understand design".¹⁶

There is no substance to this objection, however, for if design *is* a feature of human activity generally, as Lawson (correctly) believes, then it is no fault of any such definition that it should try to capture this generality. Lawson's argument is self-defeating for his aim is supposedly to understand *design*, not some species of design such as architectural or graphic design. So it just is this *general* feature of human activity that is the object of his concern.

Similarly, where is the point in turning to models of "the design process"? On Lawson's account, would not any such model likewise be too general or abstract to do justice to the differences between kinds of design. Lawson also complains that when definitions of 'design' are provided they often betray the peculiarities of the area of design which their authors happen to practice or teach, overlooking his own chauvinism both in talking of design generally on the basis of examples drawn largely from architecture and in calling his book *How Designers Think* (my emphasis).¹⁷

In "On not Getting it Wrong", Tom Heath likewise eschews a definition of 'design', preferring to tackle the question, 'Why do we design?'¹⁸ His answer reveals, however, that he thinks of design partly as a kind of simulation or rehearsal and partly as a kind of rethink. But design cannot be the former and it need not involve the latter. Heath says:

Instead of simply doing something, we are going to do it in anticipation, so to speak; we are going to simulate what we are going to do before we actually do it. Now we would surely not go to all this trouble if we believed that success was inevitable. We do it because we fear that things will go wrong. Our intended action is likely to fail, and it is to avert that failure that we plan or design. Design seeks to stop things going badly.

In this passage, Heath mistakes a simulation, rehearsal, or model of something, *X*, with a plan or design for *X*. If I can simply go ahead and do or make *X* then *X* has already been planned or designed (however badly), or no such planning or design is required. A simulation, rehearsal, or model can itself be designed, of course; but the point is that in doing so one is not simulating a simulation or rehearsing a rehearsal.

Moving on, in *Method in Architecture*, Heath's analysis is more thorough than Lawson provides, but his concept of design still has to be teased from the text. At one point, he says, "*the process of converting system information into form information just is the process of design*".¹⁹ Elsewhere, however, he tells us that design constraints consist of information of these two types.²⁰ But how can this be? No process of thought or action can consist of converting one set of constraints *on* that process into another. Heath adds the qualification that this process of information conversion is "more exactly, the end towards which design aims".²¹ But this is no help for the process by which *X* is achieved cannot be *X*. Elsewhere, Heath says that a design can be "progressively matched" to this "information network" but we do not *match* a thing to itself.²²

This conceptual muddle seems to derive from a mistaken notion of what constitutes a design constraint and from the failure to distinguish information about different sorts of thing, namely, a form requirement and a possible form.

Take, firstly, the notion of a design constraint. Broadbent states a seemingly plausible, no-nonsense approach to design constraints, for example, when he says that "before he starts designing, the architect must recognize that the real world will impose certain constraints on what he does. The site is 'there', solid."²³ Now it is true that certain properties of the site, or information about those properties, will typically figure in the causal history of the architect's design constraints, but that is all. Consider the following example: suppose I *falsely* believe that a site is exposed to cooling summer breezes and protected from cold winter winds. Now although there are no summer breezes my design will be constrained as if there were - given certain user requirements, my desire to satisfy those

requirements, and my beliefs about certain properties of such breezes. On the other hand, the fact that the site is wind-swept in winter will not constrain my design for I do not believe that this is the case. In the final analysis, design constraints consist principally of such beliefs and desires on the part of the designer. One can ask, of course, how those beliefs and desires are themselves formed or constrained, but that is another matter.²⁴

Secondly, recalling Heath's notion of the process of design as one which produces form information, he says of such information that it "consists of physical descriptions of objects".²⁵ This statement is either vague or false. A physical designer *qua* physical designer produces what she knows or supposes is a description of a *physically possible* object. (Real estate agents describe extant physical objects, or at least that is what they would have us believe.) Heath's would-be example of such form information is, "The minimum clear dimensions *for* an operating room are 6m x 6m x 3m high" (my emphasis).²⁶ What Heath actually exemplifies here, however, is a *form requirement* - derived, one supposes, from the performance requirements for surgery - not the description of a possible form.²⁷ This piece of information does not tell us how big any operating room is or is intended to be.

To sort out Heath's muddle, then, we need to distinguish a possible form from a form requirement. (The notion of information, moreover, is otiose in this context.) Any form or performance (system?) requirement the designer adopts is a design constraint, one against which the design is or ought to be matched.

The Act of Design (2)

A cursory review of the literature for definitions of 'design', or the concepts of design writers implicitly

adopt, shows that they too often suffer from one or more of the following three defects.

Firstly, definitions are typically too broad, or too narrow, or both. For example, Jones's conclusion cited above that "the effect of designing is to initiate change in man-made things" is often taken as a definition of 'design' (though that was not his intention).²⁸ It will not do as a definition of 'design', however, for it is both too broad and too narrow. It is too broad because if I knock over the bedside lamp in my sleep I initiate a change in a (so-called) man-made thing though I have not designed anything; and it is too narrow because if I design something in my head, which I then forget or reject, no change in any man-made thing need be initiated.

Secondly, definitions that are too narrow are often not of 'design' but of 'good design', or aspects thereof. For example, in a detailed step-by-step analysis of "the nature of the act of designing", Bruce Archer last step is "selecting the optimum proposal".²⁹ There is no place in a definition of 'design', or in an account of what the design process or the act of design consists of, however, for such success or achievement assertions. Archer even remarks that "no attempt is made here to define 'good design' ", but his account is shot through with such success assertions.³⁰ We must allow for failed or unsatisfactory designs rather than suggest that those who produced them were not thereby engaged in design. If by 'design' we mean 'good design', then we cannot, on pain of contradiction, describe or condemn anything as bad design.

Thirdly, one consequence of paying scant attention to the meaning, or rather meanings, of 'design' is that design as a cognitive activity is then easily conflated with design as a social or institutional practice, or profession. Let us call such practices or

professions, like architecture or engineering, 'Design', to distinguish them from the cognitive activity. Clearly, much design is done by people other than Designers, and Design consists of more than just design.

One occasion when we especially need to be mindful of this distinction, as many are not, is in considering the relations between science and design (either sense). This is because there is no equivalent distinction to be drawn in science; there is no cognitive activity called 'sciencing'. So confusion is likely. Thus, if someone says, 'Science is unlike design because it is descriptive whereas design is prescriptive', we need to ask what sense of 'design' the speaker has in mind.³¹ For whilst Design is prescriptive design is not, as the next section makes plain.

The Act of Design (3)

Let me now spell out what it is for someone to formulate a design for something, so that we can glimpse the value of this enterprise. (Some of it has already been deployed in the analysis of Heath's account.) Someone, S , designs or formulates a design for some logically possible thing, A , (or type of thing, T_A) at some time, t , just when,

- (1) S imagines or describes A (or T_A) at t ;
- (2) S supposes in (1) that A (or some token of T_A) would be such as to at least partially satisfy some set of requirements, R , for A (or T_A) under some set of conditions, C ;
- (3) The partial satisfaction of R that S supposes in (2) is a problem for which . . .
- (4) . . . the solution candidate S imagines or describes in (1) is novel or original for S at t .

These four conditions are: Description, Function, Problem-Solving, and Novelty/Originality.³² The

purpose of (1) is obvious. (2) removes day-dreaming or idle thought. (3) removes cases where S already knows or believes what satisfies what, and so no design is needed. Design is typically a form of empirical inquiry. (4) eliminates choosing from a range of pre-existing designs to solve a problem. Choosing a garden shed from a manufacturer's catalogue, for example, may comprise (1) to (3), but no shed is designed in this act. (This act of choosing may, however, be part of some larger act of design, such as landscaping the garden or opening a new front in a cold war with one's neighbours.)

At least three further points of explanation or clarification about this analysis are needed. Firstly, the distinction between particular and type: some designs are designs for a particular thing, for example, an arrangement of freshly picked flowers. Further, only one arrangement of these flowers is possible at any one time. Other designs are type designs, for example, the design of the Holden Commodore. From this type, many tokens can be made - all of which may exist at any one time and satisfy R . Secondly, I have not specified that A (or that tokens of T_A) should be *physically* possible, for we need to include such things as bridges that fall down, along with those that do not, for the former have nonetheless been *designed*. And whilst there can be no perpetual motion machine, there *can* be designs for such a machine. Thirdly, the design constraints discussed earlier consist of R and C .

Finally, I remarked in the previous section that design was not prescriptive though Design was. Let me now explain this point. The set of conditions above for S to formulate a design for A , which I claim are necessary and sufficient, involves no act of commending or advocating or prescribing A (on the part of S or anyone else). S may formulate several designs for A and reject all of them as

unsatisfactory or inappropriate. If designing were prescribing then, if *S* did eventually prescribe a design for *A*, *S* would be prescribing a prescription. The practice of Design, however, is another matter. As a matter of historical fact, Designers do not present clients or users with every option they have considered and no advice as to which to select. As with the medical practitioner's script, 'Take three times daily after meals . . . ', the prescriptive language of Design is evident in the working drawings, 'Fix battens at 300 centres . . . '.

Science and Design (1)

I turn now to consider some relations between science and design relevant to this discussion. A recurrent theme in the design method literature has been the concern to form a view of designing or of method in design by casting sideways glances at science. But whereas it was once thought that design ought to be more like science, many now think that design just is not like science so the project was doomed from the start. As I have indicated above, however, the distinction between design as cognitive activity and as social practice is usually overlooked or glossed over in this debate. I shall explore some implications of this mistake below, but I begin with a salutary reminder about similarities and differences.

Everything is like every other thing in *some* respect, and unlike every other thing in *some* respect. I am like Margaret Thatcher, for example, in that there is only one of each of us, and I am unlike her in that she does not, to my knowledge, claim to bowl leg-spin. Thus, *no* argument in the above debate can turn on the mere enumeration of the similarities or differences between things, and it is no objection to any argument from analogy that the two things compared are unlike in some, indeed many, respects.

So to begin, whilst astronomers or archaeologists are not Designers, it does not follow that they are not designers. Much cognitive activity in science is or can be properly described as design. I have in mind not merely the design of a piece of research or of an experiment, in respect of which the use of the word 'design' is indeed a commonplace, but also the formulation of theories or hypotheses. It is quite appropriate to ask of, say, the various trans-Uranian hypotheses formulated by Leverrier and Adams what they were *designed* to do. (The answer is that these hypotheses were designed to explain the residual perturbations in the orbit of Uranus without generating any sensible perturbation in the orbits of the other known Jovian planets.) Moreover, some practices that are ordinarily classified as science, such as the work of a team of scientists charged with genetically engineering a 'super pig' or finding a cure for AIDS, can equally well be described as a branch of Design.³³

In an influential passage in "The Logic of Design and the Question of Value", however, Lionel March says,

Just as Popper draws a distinction between logic and empirical science, so too must a distinction be made between these and *design*. To base design theory on inappropriate paradigms of logic and science is to make a bad mistake. Logic has interests in abstract forms. Science investigates extant forms. Design initiates novel forms. A scientific hypothesis is not the same thing as a design hypothesis There has been much confusion over these matters, hence the illusions about scientifically testable design hypotheses . . .

.³⁴

So the confusion remains. In several places above, 'design' is ambiguous. Is "design theory", for

example, the theory of the cognitive activity we call design or is it the theory of Design? When medical science claims to have formulated a vaccine for AIDS, for example, will that vaccine not have been *designed* to prevent the onset of the disease (as well as, say, to have negligible side effects, not to be unstable or difficult to administer, and so on)? Where, then, is the line between March's "design hypothesis" and his "scientific hypothesis"? The hypothesis, 'X is a vaccine for AIDS', will be *called* a scientific hypothesis because of certain institutional arrangements in our society, but that cuts no ice in the light of the above discussion.

And whilst I take it we can agree that this hypothesis is "scientifically testable", why does March not think the same goes for the so-called design hypotheses, that is, the empirical claims, that are the stock-in-trade of the Design professions? The claim that a bridge built to some design, for example, will carry a certain load and deflect no more than a certain amount is so testable. And so too is the claim that given certain social conditions, a tower block will lead to more dissatisfaction amongst residents or neighbours than a three story walk-up?

Further, what of March's thumb-nail sketch of the allegedly crucial differences between logic, science, and Design? What is more abstract than the point masses of Newtonian mechanics? Which designer *qua* designer "investigates" no "extant form"? Which science "initiates" no "novel form", be it a particle accelerator or an AIDS vaccine? How can 'form' have the same referent for science and design in March's analysis when clearly Newtonian physics does not have to re-investigate the world because of the "novel forms" of the subsequent industrial society? And so on.

I carry no brief to 'scientise' design. But it is important not to be misled by supposedly knock-down arguments about the differences between the two practices and the cognitive work involved in each, when these arguments do not stand up to scrutiny.

Science and Design (2)

I conclude with more of the same, this time in relation to design method. March and several others have also claimed that the Popperian view of science, whatever its merits, is "pernicious" or "untenable" in Design, again on the basis of certain alleged differences between the two practices.³⁵ Two reasons are given for this claim; both are false and neither is relevant.

Firstly, it is said, correctly, that Popper denies there is induction or inductive reasoning in science. "Yet in design", says March, "the chief mode of reasoning is inductive in tenor, that is to say, synthetic rather than analytic".³⁶ But March misses the point, for Popper denies that there is induction *tout court*. Thus, Popper would deny there is induction in design and so March would need to show that this latter denial is unwarranted. Induction is a feature of neither practice, if one believes Popper, or, like deduction, it is a feature of both; so no distinction between the two practices is to be found here. Moreover, Popper does not deny that there is synthetic reasoning in science. On the contrary, he says,

[A] new theory should proceed from some . . . *unifying idea* about some connection or relation (such as gravitational attraction) between hitherto unconnected things (such as planets and apples) or facts (such as inertial and gravitational mass) or new 'theoretical entities' (such as fields and particles).³⁷

Secondly, it is said, not quite correctly, that for Popper a good scientific hypothesis is one that is falsifiable.³⁸ But "a good design hypothesis", protests March, "is chosen in the expectation that it will succeed, not fail".³⁹ (Do March *et al.* seriously believe that anyone would hold that a good scientific hypothesis is chosen in the expectation that it will *fail*?) The falsifiability criterion is a *logical* criterion. Put simply, it is intended to divide hypotheses that *can* be inconsistent with observation statements from those that cannot. There is no additional requirement that hypotheses of the former kind should *as a matter of fact* be false, or be chosen in the expectation that they are false. 'My dog is a labrador' is falsifiable, yet it may be true (whereas 'My labrador is a dog' is unfalsifiable). Popper does not suggest that veterinary science should prefer the view that my dog is, say, a *poodle*, on the ground that this belief would have the added advantage of being false!

Contra March and others, the influence of Popper's thought on design theory has been largely beneficial. It has consisted principally in the replacement of the false and debilitating analysis/synthesis model of design with the more accurate conjecture/test model, thanks to the intelligent reading of Popper's philosophy by Bill Hillier and others in their seminal paper, "Knowledge and Design".⁴⁰ Popper's account of method in part grew out of his criticism of the traditional inductivist account of scientific method, which largely formed the basis of the analysis/synthesis model in design, whether we were aware of this or not. Moreover, Popper's theory of method, in its most general form, is a theory of problem-solving by trial and error, a point which Popper himself makes abundantly clear.⁴¹ As such it applies equally to Design, or to trying to negotiate

an arms embargo or sell a used car, as it does to science.⁴²

* In Jim Plume, ed, *Architectural Science and Design in Harmony: Proceedings of the joint ANZAScA / ADTRA conference, Sydney, 10-12 July, 1990*, pp. 229-38. Kensington, NSW: University of NSW School of Architecture, 1991.

¹ Chalsa Loo and Paul Ong, "Crowding Perceptions, Attitudes, and Consequences among the Chinese" *Environment and Behavior* 16 (January 1984): 55 - 87.

² An exercise that would also seem to be worthwhile for several others cited in their paper.

³ The use of 'crowding' or 'crowded' is not always value-laden, though when it is not the referents are often inanimate objects. For example, *The Shorter Oxford English Dictionary* gives this usage from 1848, "The experience of years is crowded into hours" (p. 463). The relatively common use of 'over-crowding' and 'over-crowded' in ordinary English indicates that 'crowding' and 'crowded' are not strong value terms, which makes it easier to overlook the fact that the latter *are* value terms. Also, 'crowd' is not value laden when used as a noun, which probably further conceals this fact.

⁴ Loo and Ong, "Crowding Perceptions", p. 61, recognize that density is "objective" whilst crowding is "subjective", but they immediately suggest that whereas density in a dwelling "will be indicated by persons per room . . . crowding will be indicated by the respondent's perceptions of crowdedness" in that dwelling. This shows clearly that their idea of crowding is incoherent and that they cannot separate objective from subjective matters, as this definition or 'indication' of crowding is circular.

⁵ *Ibid.*, p. 63. Less than a third of their interviews were conducted in English, so the translation(s) of 'crowding' and its cognates they employed are clearly important for their claims, but this matter is not discussed.

⁶ Loo and Ong, "Crowding Perceptions", pp. 67 - 68.

⁷ *Ibid.*, p. 78.

⁸ Ibid., p. 68.

⁹ Ibid., p. 80.

¹⁰ Ibid., p. 57.

¹¹ E. N. Anderson Jr. "Some Chinese Methods of Dealing with Crowding" *Urban Anthropology* 1 (1970): 143 - 50.

¹² Ibid., p. 143

¹³ Ibid., p. 144.

¹⁴ Ibid., p.143 - 44.

¹⁵ Bryan Lawson, *How Designers Think* (London: The Architectural Press Ltd., 1980), p. 23.

¹⁶ Ibid., p. 24.

¹⁷ Ibid.

¹⁸ Tom Heath, "On Not Getting it Wrong" in *Design and Science: Proceedings of the 18th Conference of A.N.Z.A.Sc.A.*, eds. J. D. Kendrick, T. J. Williamson, and S. Coldicutt (Adelaide: n.p., 1985), p. 3.1. In his *Method in Architecture* (Chichester: John Wiley and Sons Ltd., 1984), p. 1, Heath remarks that "the definition of the terms of ordinary language is in general a useless practice". Clearly not a view I share.

¹⁹ Heath, *Method*, p. 202.

²⁰ Ibid., p. 204.

²¹ Ibid., p. 202.

²² Ibid., p. 211.

²³ Geoffrey Broadbent, "Notes on Design Method", in *Design Methods in Architecture*, eds. G. Broadbent and A. Ward (London: Lund Humphries, 1969), p. 198.

²⁴ If design constraints consisted of information, as Heath believes, then information about constraints would be information about information.

²⁵ Heath, *Method*, p. 199.

²⁶ Ibid.

²⁷ This form requirement can be unambiguously stated thus: 'The minimum clear dimensions required for an operating room are 6m x 6m x 3m high'.

²⁸ J. Christopher Jones, *Design Methods: Seeds of Human Futures* (London: John Wiley and Sons Ltd., 1970), p. 4. See Heath, "Wrong", p. 3.1, in addition to Lawson,

Designers, p. 24. I am indebted to Bill Greig for correcting me on this point.

²⁹ Bruce Archer, "The Structure of the Design Process," in *Design Methods*, eds. Broadbent and Ward, p. 89.

³⁰ Ibid., p. 76. Success words like 'identifying', 'establishing', 'ensuring', and 'determining' abound (p. 89).

³¹ See, for example, H. A. Simon, *The Sciences of the Artificial* (Cambridge, Mass.: MIT Press, 1969), pp. 58 - 59, who holds or seems to hold the view that science is descriptive and Design prescriptive. He says, "The natural sciences are concerned with how things are. . . . Design, on the other hand, is concerned with how things ought to be. . . ." (pp. 58 - 59).

³² As with any attempt to divide the world into what is *X* and what is not *X*, there will be difficult or borderline cases. Consider, for example, the rehoused Italian peasant, mystified by the w.c. in his modern flat, who surmises that the cistern can be used to cure olives. Should this peasant be counted as having designed an olive curer? I think so, and the above analysis bears this out, though the cistern already exists and may not need or be thought to need any modification.

³³ Nigel Cross, John Naughton, and David Walker, in "Design Method and Scientific Method", *Design Studies* 2 (October 1981): 195, propose that instead of regarding design, that is, Design, *as* a science, we should regard it *as* a technology. But many branches of Design *are* technologies.

³⁴ Lionel March, "The Logic of Design and the Question of Value", in *The Architecture of Form*, ed. Lionel March (Cambridge: Cambridge University Press, 1976), p. 15. See also Cross *et al.*, "Design Method", p.196. Philip Steadman, in *The Evolution of Designs: Biological Analogy in Architecture and the Applied Arts* (Cambridge: Cambridge University Press, 1979), p. 237, says that the relationship between science and design has been made "very clear" above by March.

³⁵ Ibid., p. 15; and Cross *et al.*, "Design Method", p. 196.

³⁶ Ibid.

³⁷ Karl Popper, *Conjectures and Refutations: The Growth of Scientific Knowledge*, 4th ed., rev. (London: Routledge and Kegan Paul, 1972), p. 241. In denying that this process is inductive, Popper is denying that the theory is derived from or justified by observation.

³⁸ For Popper, falsifiability is a necessary condition for a scientific hypothesis, not for a good scientific hypothesis. For the latter, see Popper, *Conjectures*, pp. 240 - 48.

³⁹ March, *Logic*, p. 15; and quoted in Cross *et al.*, "Design Method", p. 196. In any event, a design hypothesis, that is, a hypothesis of the form, 'A (or some token of T_A) would be such as to satisfy R given C ', is logically a testable claim.

⁴⁰ Bill Hillier, John Musgrove, and Pat O'Sullivan, "Knowledge and Design", in *Environmental Design: Research and Practice 2. Proceedings of the EDRA 3/AR 8 Conference, University of California at Los Angeles, January 1972*, ed. William J. Mitchell (n. p., 1972), pp. 29-3-1 to 29-3-14.

⁴¹ See, for example, Karl Popper, *Objective Knowledge: An Evolutionary Approach* (Oxford: Clarendon Press, 1972), ch 3.

⁴² This is not to say that Popper's philosophy of method is unproblematical; far from it. See Greg Bamford, *Popper, Refutation, and 'Avoidance' of Refutation* (PhD. dissertation, The University of Queensland, 1989).
