# Foundational and Instrumental Design Theory
Per Galle

**Introduction: Two Questions about Design Theory**

It seems fairly commonplace that the way designers conceive of the nature and purpose of design will affect their practice. To illustrate, consider three designers: For the first, design is a crusade against boredom and indifference; for the second, the goal is to minimize a cost-benefit ratio; and design for the third empowers socially disadvantaged people. Each of these designers would probably come up with rather different proposals even if working from the same brief. No doubt, the nature of such *direct* connections between individual designers' conceptions of design and their practice is complex and interesting. However, what I consider here is a different way in which basic conceptions may affect design practice: *indirectly*, via research.

Just as designers produce design proposals, design researchers produce design theory. And just as the *raison d'être* for design is that (some) proposals give rise to artifacts that people appreciate and use, the *raison d'être* for design research is that (some) design theory conveys facts and possibilities that facilitate, accelerate, or improve design practice, if taken into account by a designer. I call such theory *instrumental* (design) *theory*. Examples include theory about design processes (*method* if actions are prescribed); about function or aesthetics of particular artifact types; and about historical, cultural, and technical contexts of design.

Furthermore, just as designers have conceptions about the nature and purpose of design that affect the proposals they produce, so too, I submit, do design researchers have such conceptions that affect the instrumental theory they produce; thereby, they indirectly affect design practice—provided such instrumental theory is adopted by designers. This proviso is crucial. A designer who thinks of design as an artistic endeavor, for example, is not likely to adopt an instrumental theory for optimizing technical efficiency. For an instrumental theory to be adopted by a designer, the basic conceptions of the nature and purpose of design on which the theory was based must match those of the designer. If the basic conceptions underlying instrumental theory are left implicit or remain unclear, even designers who could benefit from adopting it may ignore the theory, or regard it with suspicion. Therefore, instrumental design theory should not stand alone, but should be supported by theory

expressing its underlying conceptions about the nature and purpose of design—what, accordingly, I call *foundational* (design) *theory*.[1]

So foundational and instrumental theory should be developed in a *coordinated* manner. This coordination does not mean, however, that every design researcher must produce both kinds of theory, nor indeed that even the most specialized instrumental theory must be supported by an equally specialized foundational theory of its own. On the contrary, workers in "basic research" might see it as their mission to produce whatever foundational theory is needed to support instrumental theory produced by colleagues in "applied research," while the latter should consciously and critically use foundational theory already available. To prevent excessive fragmentation of design as an intellectual discipline, only a limited number of incompatible foundational theories should be tolerated, so as to reflect whatever genuine disagreement exists in the field.

In the remainder of this paper, I explore the idea of coordinated theory development, focusing on two questions:

(1) What, more precisely, is the relationship between foundational and instrumental design theory?

(2) Given the nature of that relationship, what is *good* foundational design theory? *Instrumental* theory is "good," by definition, in the sense that it "conveys facts and possibilities that facilitate, accelerate, or improve design practice, if taken into account by a designer." This explains the limitation of the second question to *foundational* theory.

To provide empirical background for the two questions, I first revisit three landmarks of the design research literature. Herbert Simon's book, *The Sciences of the Artificial*,[2] and Donald Schön's, *The Reflective Practitioner–How Professionals Think in Action*,[3] are widely recognized in the design research community as cornerstones of two major "schools of thought" (although both books deal with a wider range of phenomena than design). Arguably, each of these books has initiated or at least epitomized a design research *paradigm*, in Kuhn's sense.[4] My third landmark is Klaus Krippendorff's more recent book, *The Semantic Turn—A New Foundation for Design*.[5] Whether it will create a paradigm of its own remains to be seen, but it certainly aspires to do so. None of the three authors distinguishes foundational and instrumental theory in quite the way I propose to do. However, I show that they can be read and compared in the light of that distinction. Let us keep the two focus questions in mind, so as to consider some answers to them toward the end of the paper.

**Simon: Design is Problem Solving**

Simon defines design very broadly: "Everyone designs who devises courses of action aiming at changing existing situations into preferred ones." And "so construed," he says, "design is the core of all professional training; [what] distinguishes the professions from the sciences."[6] These professions include engineering, architecture,

1   Foundational and instrumental theory are mutually exclusive concepts, and not exhaustive. Conceivably, there could exist design theory that is neither foundational nor instrumental (but useless, perhaps). Furthermore, what is foundational or instrumental theory to one person may not be so to another, or only to a lesser degree.

2   Herbert A. Simon, *The Sciences of the Artificial*, third ed. (Cambridge, MA: MIT Press, 1996 [1969]).

3   Donald Schön, *The Reflective Practitioner. How Professionals Think in Action* (New York: Basic Books, 1983).

4   Thomas S Kuhn, *The Structure of Scientific Revolultions*, third ed. (Chicago: University of Chicago Press, 1996 [1962]).

5   Klaus Krippendorff, *The Semantic Turn. A New Foundation for Design* (Boca Raton: Taylor & Francis, 2006).

business, education, law, and medicine. However, Simon's idea of design soon narrows considerably because, according to him, solving a design problem amounts to finding a solution to a constraint satisfaction problem—and sometimes maximizing an "objective function" as well, thereby turning the problem into an optimization problem. A solution is given by a combination of values of a set of "command variables," representing the sought-after artifact in its environment. Constraints on the values may represent natural laws, or goals to be attained.[7]

This brief outline roughly suggests what I see as Simon's foundational theory. At a more political level, he laments what he sees as an unfortunate tendency of universities and professional schools, after World War II, to replace the teaching of design with the teaching of "applied" natural sciences: physics and mathematics in engineering schools, biology in medical schools, finite mathematics in business schools. This development, he says, was driven by a hankering after academic respectability, combined with a lack of respect for traditional design theory, which was perceived as "intellectually soft, intuitive, informal, and cook-booky."[8] However, despite the label of "applied," such sciences do little to provide students with the design competence they need. So to resume their responsibility for relevant training, while achieving the desired academic respectability, Simon suggests that professional schools introduce and teach a new kind of design theory: "a science of design, a body of intellectually tough, analytic, partly formalizable, partly empirical, teachable doctrine about the design process"[9]—his version of what I call instrumental theory.

Simon develops no instrumental theory but recommends a number of topics for a design curriculum: utility theory, statistical decision theory, computational methods of optimization and constraint satisfaction, formal logics, and more. In the third edition of his book (cited here), he notes that some steps in this direction have been made, under the influence of the first edition, and contends that "[t]he need to make design theory explicit and precise in order to introduce computers into the process has been the key to establishing its academic acceptability."[10]

This research paradigm of technical rationality underlies a huge amount of design research, particularly in the field known as "design computing." I do not attempt a review here. Suffice it to note that, after spending many years working with design computing under the research paradigm represented by Simon, I eventually became disenchanted with it. One reason was its underlying assumption that a design problem can be specified with a high degree of completeness prior to the "search for solutions." As my awareness of this assumption grew, I regarded it with mounting suspicion because it seemed at odds not only with my own experience, but also with persistently reported observations about the tendency of design problem and design solution to "co-evolve."[11]

6    Simon, *The Sciences of the Artificial*, 111.
7    Ibid., Chapter 5.
8    Ibid., 112.
9    Ibid., 113.
10   Ibid., 114.
11   Bruce Archer, "Whatever became of Design Methodology?" *Design Studies* 1:1 (1979): 17–8. Nigel Cross, *Designerly Ways of Knowing* (London: Springer, 2006). Steve Harfield, "On Design 'Problematization': Theorising Differences in Designed Outcomes." *Design Studies* 28:2 (2007): 159–73. Schön, *The Reflective Practitioner*. Kees Dorst and Nigel Cross, "Creativity in the Design Process: Co-evolution of Problem–solution." *Design Studies* 22:5 (2001): 425–37. Chua has pointed out that in the second and third editions of *The Sciences of the Artificia*l (1981 and 1996, respectively), Simon actually left room for co-evolution, *before* Schön explored it in his 1983 *The Reflective Practitioner* (Soo Meng Jude Chua, "Donald Schön, Herbert Simon and The Sciences of the Artificial." *Design Studies* 30:1 (2009): 60–8). But Simon's endorsement of formal methods persisted throughout and dominated the general reception of his work (see Chua, 62).

Furthermore, the formalization of design solutions in terms of a given set of "command variables" (even if organized into sophisticated data structures, "objects," or clauses of logic programming) seemed to me increasingly a straitjacket to the agile creativity called for in real-world situations. Thus, notwithstanding the benefits that formal methods offer in specialized contexts (e.g., layout and routing of integrated circuits), I've come to believe that, on the whole, Simon's idea of a new general "science of design" (e.g., instrumental design theory) along these lines is a dead end.[12]

**Schön: Design is Conversation with the Materials of a Situation**
Like Simon, Donald Schön leveled a severe criticism against professional training in the United States after World War II. However, what Schön saw as the problem was not undue reliance on applied science, but a more general "positivist epistemology of practice"[13] that led precisely to the kind of technical rationality advocated by Simon. His main objection to Simon's proposed "science of design" is that it "can be applied only to well-formed problems extracted from situations of practice."[14] According to Schön, this is seldom possible because, as he puts it, "[i]n the varied topography of professional practice […] there is a swampy lowland where situations are confusing 'messes' incapable of technical solution." He admits that there is also "a high, hard ground" where problems *are* amenable to technical methods. However, such problems "are often relatively unimportant […], while in the swamp are the problems of greatest human concern."[15] Schön describes this challenge to developers of instrumental design theory as *the dilemma of rigor or relevance.* Either you can apply sophisticated technical methods to relatively unimportant problems; or you can face the "messy but crucially important" problems that leave you to your own devices of "experience, trial and error, intuition and muddling through."[16] The "messiness" involves such phenomena as "complexity, uncertainty, instability, uniqueness, and value-conflict," which do not fit methods of technical rationality.[17]

For Schön, good design is a prime example of *reflective practice*:[18] the flexible process of trial and error that a practitioner engages in to deal with the "messy" problems of life. To cite Schön's characteristic phrase that summarizes his foundational theory, design is "a conversation with the materials of a situation."[19] The designer "shapes the situation, in accordance with his initial appreciation of it, the situation 'talks back,' and he responds to the situation's back-talk."[20] This conversation should be "reflective" in that the designer is critically aware of his or her current understanding of problem and actions, and is ready to revise that understanding. Schön develops this account in detail, notably by means of an elaborate case study of architectural design.[21] Rather than an abstract and self-sufficient "science of design," above and beyond practice, Schön seeks "an epistemology of practice implicit in the artistic,

12  For a less idiosyncratic critique of Simon's idea of design as problem solving, see Kees Dorst, "Design Problems and Design Paradoxes." *Design Issues* 22:3 (2006): 4–17. Dorst finds the notion of a "design problem" useless as a unit of description because of the co-evolution of problem and solution. Instead, he proposes what amounts to a foundational theory in terms of "paradoxes." He does not, however, indicate implications of this lens for instrumental design theory.

13  Schön, *The Reflective Practitioner*, 48.

14  Ibid., 47.

15  Ibid., 42.

16  Ibid., 43.

17  Ibid., 39. Schön's distinction between "high, hard ground" and "swampy lowland" corresponds rather closely to Rittel's famous distinction between "tame" and "wicked" problems (Horst Rittel, "On the planning crisis: systems analysis of the 'first and second generations'." *Bedriftsøkonomen* 8 (1972): 390–6).

18  Schön, *The Reflective Practitioner*, 345.

19  Ibid., 78.

20  Ibid., 79.

21  Ibid., Chapter 3.

intuitive processes which some practitioners do bring to situations of uncertainty, instability, uniqueness, and value conflict."[22]

When it comes to a possible instrumental design theory, Schön's view is more balanced than Simon's. He acknowledges the value of applied science to "some parts of some practices,"[23] yet he strongly opposes the conventional (positivist) separation of *research* from *practice* (as well as *means* from *ends*, and *knowing* from *doing*).[24] He proposes a radical change in our conception of research versus practice, which makes it difficult to distinguish instrumental theory from practice itself. For, according to Schön, a good practitioner, whenever faced with the messiness and uncertainty of a unique professional situation, is triggered into "reflection-in-action," which involves undertaking "on-the-spot experiments" that conform to certain standards of "rigor" of their own[25]—standards that significantly depart from those of conventional experiments under laboratory conditions. Schön accepts these alternative standards without qualms, which leads him to the remarkable conclusion that "*research is an activity of practitioners.*"[26] The controversial nature of that view is exacerbated by Schön's discussion of the practitioner's on-the-spot experiments in such terms as "the sort of science that does not appear in the scientific journals."[27] I suspect this idea may have contributed to the widespread confusion about "practice-based research" in design, and may have fueled the heated debate that still goes on about whether design practice, in itself, should count as research in academic contexts.[28]

This being as it may, Schön nevertheless adds that "there are kinds of research which can be undertaken outside the immediate context of practice in order to enhance the practitioner's capacity for reflection-in-action"—*reflective research*, he calls it.[29] And just as Simon saw elements of a "science of design" emerge, so Schön holds that there are four kinds of reflective research, "each of which already exists at least in embryo." Here, I discuss the four kinds of research in the context of design and evaluate them only for our current purposes—namely, as proposals for instrumental design theory.

(1) "Frame analysis"[30] is a study of how practitioners frame (e.g., understand and state) the problems they deal with, and the roles they assume. For example, at a general level, an architect may see himself as a historicist, a modernist, or an advocate of good craftsmanship. At a particular level, one frame (e.g., guiding idea) for addressing a site-planning problem might be the effect that slopes of the site have on the geometry of clusters of buildings placed along them.[31] Each such frame directs the designer's focus of attention and shapes his or her actions in a certain way. Often the frames are not consciously acknowledged, so bringing them to light can help practitioners actively *construct* their professional reality, rather than taking some version of it for granted.

It seems both desirable and feasible that *frame awareness* be kindled in design students during their training. One way to do

22  Ibid., 49.

23  Ibid., 308 (an admission he repeats in similar form on p. 325).

24  Ibid., 165.

25  Ibid., 141–56.

26  Ibid., 308 (emphasis added).

27  Ibid., 145.

28  For a summary of the controversy, see, e.g., Michael A. R. Biggs and Daniela Büchler, "Rigor and practice-based research." *Design Issues* 23:3 (Summer 2007): 62–9.

29  Schön, *The Reflective Practitioner*, 309–25.

30  Ibid., 309ff.

31  Ibid., 85ff, 93–4.

so would be by asking them to reflect on and make explicit their own framing of a particular project, and to explain how these basic assumptions and guiding ideas affect design products. This exercise, in effect, amounts to asking the students to produce instrumental theory of their own. Another way would be to expose students to research by others on the history of existing artifacts, where the research aim is to reveal how the artifacts were shaped by their designer's (implicit) framing. (This paper may be seen, incidentally, as an attempt to analyze basic frames of design *research*—its foundational theories—rather than design *practice*.)

(2) According to Schön, "repertoire-building research"[32] would help practitioners become familiar with a stock of precedents or exemplars to which situations encountered in practice may be seen as analogues and that may provide guidance in dealing with those situations. For example, an architect's repertoire might comprise historical buildings and Italian hill town architecture, as well as patterns of reasoning used in certain situations.

Case studies as part of a design curriculum might draw on research on design history, which would thus provide instrumental theory by contributing to the students' "repertoires" (in addition to enhancing their frame awareness, as already discussed).

(3) "Research on fundamental methods of inquiry and overarching theories"[33] is the examination of episodes of practice so as to discover how competent practitioners overcome difficult situations by restructuring (*reframing*) them in the light of theories from apparently unrelated domains. As an example, Schön describes how a product development team was trying to devise a new kind of synthetic bristle for paintbrushes, but did not make headway until one member saw the paintbrush as a kind of *pump*, and brought pumping-theory to bear on the case.[34]

Schön's discussion is rather sketchy at this point and unrelated to design; but if I interpret him correctly, the third kind of "reflective research" is subsumed under the more general fourth kind.

(4) "Research on the process of reflection-in-action"[35] is a systematic recording (by means of "protocols"), observation, and analysis of actual practice, possibly involving some degree of intervention by the researcher.

The case studies reported in his book exemplify this approach—notably the architectural site planning case[36] in which Quist, a teacher of architecture, reviews work by Petra, one of his students. Their conversation and sketching during the review session was meticulously analyzed and interpreted in terms of Schön's conceptual apparatus of "reflective practice."[37] This case study became a model for many subsequent protocol studies of designers' work.[38] A good example is the study of student design teams by Valkenburg and Dorst, where Schön's terminology is explicitly used and clarified.[39] No doubt exposure to results of such studies can prepare prospective designers for the "messiness" of the

32  Ibid., 315ff.
33  Ibid., 317ff.
34  Ibid., 184.
35  Ibid., 320ff.
36  Ibid., Chapter 3.
37  According to Goldschmidt, credit is due to Roger Simmonds, at the time a Ph.D. student under Schön's supervision, for his "help in providing the material and interpreting it." (See Gabriela Goldschmidt's review of "The Cognitive Artifacts of Designing" by Willemien Visser, *Design Studies* 29:1 (2008): 93–6.)
38  Curiously enough, protocol analysis as a means of studying human cognition was pioneered by Simon, in collaboration with Newell (Krippendorff, *The Semantic Turn*, 226).
39  Rianne Valkenburg and Kees Dorst, "The reflective practice of design teams." *Design Studies* 19:3 (1998): 249–71.

"swampy lowlands" of design practice in a way that supplements and reinforces their own evolving experience. In this sense, Schön's fourth kind of reflective research has something valuable to offer by way of generating instrumental design theory.

**Krippendorff: Design is Making Sense of Things**
The level of ambition of Krippendorff's book is daunting. His opening sentence reads: "This book introduces a new way of conceptualizing design as a professional practice and as an activity that is constitutive of human beings generally."[40] As clearly as one could wish, this statement sets the goal of developing a foundational theory. The essence of Krippendorff's theory is partly suggested by his dictum: "Design is making sense of things."[41] He urges that the design profession undergo a *semantic turn* away from merely "shaping the appearance of mechanical products" to "conceptualizing artifacts, material or social, that have a chance of meaning something to their users."[42] The semantic turn is a turn away from "technology-centered design" toward "human-centered design."[43] Schön's foundational theory was human-centered, too, by virtue of its focus on the designer. Krippendorff's theory more broadly emphasizes the importance of "stakeholders" in design, including the users of design products.

His semantic turn is supposed to do for design what *the linguistic turn* did for philosophy in the twentieth century. The linguistic turn in philosophy involved a re-orientation toward *language* as a source of insight into philosophical problems.[44] Given this view, the importance of *discourses* (roughly, socially institutionalized ways of thinking, talking, and acting) becomes evident, and Krippendorff's explicit aim on behalf of the design profession is to make it "redesign" itself by "starting to talk differently about design, the world it can affect, what to do, and how to proceed"[45]—in short, by consciously changing its professional discourse so as to bring about *the semantic turn*. In this respect, Krippendorff's endeavor is similar in nature to what Schön called "frame analysis," but in Krippendorff the exercise is not to be undertaken at the scale of a single design problem, design project, or designer, but at the scale of the entire profession.

The semantic turn itself rests on the "axiomatic" assumption of human-centered design: that "meaning matters more than function" (inherited from product semantics).[46] Construing the import of Krippendorff's semantic turn as a foundational design theory, it seems fair to say that, in accordance with its axiom, it amounts to regarding *design* as a matter of *proposing realizable artifacts in such a way as to anticipate and justify what they will mean to others*[47]—that is, what their "technological, social, and cultural consequences" will be to the stakeholders.[48] According to Krippendorff, designers should lay claim to expertise in a "second-order understanding" of artifacts: an understanding of how others understand artifacts.[49] Such "extraor-

40 Krippendorf, *The Semantic Turn. A New Foundation for Design* (2006), viii.

41 Ibid., xv.

42 Ibid., xvii.

43 Ibid., 39.

44 Ibid., section 1.3.7.

45 Ibid., 37.

46 Product semantics can be traced back to work by Klaus Krippendorff and Reinhard Butter in 1984 (*The Semantic Turn* viii, n 3; 1 ff 47).

47 The closest Krippendorff comes to a concise, explicit *definition* of design is "design proposes realizable artifacts to others" 25, but he offers this description only as a corrective comment to Simon's definition (about "changing existing situations into preferred ones").

48 Krippendorff, *The Semantic Turn*, 209.

49 Ibid., Section 2.5.

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dinary sensitivity to what artifacts mean to others, users, bystanders, critics […] has always been an important but rarely explicitly acknowledged competence" of designers, he says; it is an expertise they should now bring into focus and promote as something that no other profession offers, and they should appreciate it as "a solid rhetorical ground from which to justify their work."[50]

Krippendorff unfolds this *foundational* theory at length in terms of the meaning of artifacts in relation to their use, to language, to their life cycle, and to "an ecology of artifacts." Eventually, he proposes a "new science for design"[51]—an *instrumental* theory—in a manner similar to what Simon and Schön had done. He offers a list of five features of his "science for design."[52] The list may seem rather speculative at first, but subsequently Krippendorff associates a number of *methods* with each feature. In brief summary, the features and methods are as follows:

(1) Design is concerned with what does not yet exist, with innovation and "making things happen." Thus, the science for design should not mimic methods and traditions of natural sciences, which are "searching for generalizable patterns that existed in the past." Associated methods include brainstorming, creativity-enhancing techniques, and systematic combinatorial techniques.[53] (Some of the latter are related to methods proposed by Simon.)

(2) Designers need to know which "futures" (proposed changes) constitute improvements and which do not, and for whom. Thus, designers must acknowledge and take into account the visions of people affected by a proposal, and the science for design must support the requisite second-order understanding. Associated methods include the use of fiction, interview techniques and focus groups, observation of user behavior, analysis of think-aloud protocols recording user interaction with artifacts, ethnography, and participatory design.[54]

(3) Second-order understanding (e.g., obtained by the methods just identified) should inform design decisions. Describing this feature, Krippendorff contrasts *design* with *engineering*: "Engineering has it easy," he says, because it "is concerned [only] with the functional aspect of technology" and therefore does not require any second-order understanding, whereas design methods must be concerned with the users' understanding, and with social aspects of artifacts. The methods associated with this feature are *design methods* proper; they focus on how stakeholders attribute meanings to artifacts, and "at least in principle," they render design proposals that are *empirically testable* (or rather, that can be *evaluated*, because "a projected future cannot yet be observed" [see item 1]). Krippendorff sketches "five proven methods" of this kind.[55] One of them, for example, is about "designing artifacts that are informative (expressive) of their workings."

(4) Designers need a rhetorical understanding on which to base the validity of their claims about design proposals. Rather than

50  Ibid., 48.
51  Ibid., Chapter 7.
52  Ibid., 210–13.
53  Ibid., Section 7.2.
54  Ibid., Section 7.3.
55  Ibid., Section 7.4.

making feeble appeals to aesthetic sensibilities and unsupported predictions of cultural trends, or borrowing validity criteria from other disciplines, designers should be able to rely on the science for design to provide ways for them to "substantiate the claims made for their designs." Such "semantic claims" must convince "skeptical stakeholders about the virtue of a design"[56] and, as noted under item 1, they always concern the future. In contrast to claims of engineering, a designer's semantic claims are not justifiable by mathematical theories, and Krippendorff lists five ways (if not exactly methods) of convincing the skeptical stakeholders.[57] For example, "methodological validity" consists of a critical examination of the design process that led the designer to a proposal, in analogy to a natural scientist's critical examination of the circumstances under which an experimental result was obtained.

(5) Apart from critically investigating design *from within* and supplying designers with "reliable concepts, methods, and knowledge," the science for design "has to sustain the viability of its own discourse"—but not through a philosophy of science, for a "philosopher of science who would target the science for design is condemned to remain outside it and therefore [to remain] only of marginal importance to designers."[58] The science for design should be both "*a science of making and a philosophy of realizing artifacts with and for others*." Apparently, the notion of the "viability of discourse" is to the entire practice of the design profession what "validity of claims" is to the particular design project (see item 4). The methods proposed to ensure viability[59] include systematic collection of experience from successes and failures of projects, scholarly documentation of design discourse, institutionalization of design research, and self-reflection in collaboration with relevant stakeholders to ensure that design research develops its own research paradigm.

As should be clear by now, there are significant parallels among Simon, Schön, and Krippendorff. While Simon and Schön open their discussion by thoroughly criticizing the status and role of professions in society, Krippendorff's critique of the design profession is equally acute, only more implicit. It surfaces in the form of occasional warnings about making unsupported claims, uncritically adopting research paradigms from other fields, mimicking natural science, or surrendering one's territory of expertise to other disciplines. Krippendorff's ideas on the validity of semantic claims (see item 4) are crucial to the project of ensuring academic respectability through instrumental theory ("science for design"). It seems to be analogous to, but far more level-headed than, Simon's "hard" program of achieving academic respectability by forcing design theory to fit computerization, or indeed Schön's "soft" endorsement of practitioners' "on-the-spot experiments" as a yardstick of theoretical rigor.

But there are significant differences as well. Where Simon focused on the prospective artifact as a system, and on technical

56   Ibid., 261.
57   Ibid., Section 7.5.
58   Ibid., 271.
59   Ibid., Section 7.6.

methods for determining it, Schön introduced the designer as a human element, and Krippendorff expands the scope of his foundational theory—partly by extending the range of designed artifacts under consideration and partly by including other relevant stakeholders in addition to the designer.[60] This extreme degree of human-centeredness and the central position accorded to the notions of meaning and second-order understanding are probably what lead Krippendorff, in one important respect, to *narrow* the scope of his instrumental design theory: As noted, he draws a sharp distinction between design and engineering, excluding the latter form consideration. Indeed, Krippendorff seems to endorse the somewhat simplistic view succinctly rendered by Owen: "In simplistic terms, it is sometimes said, 'designers work with thing-to-people relationships, engineers work with thing-to-thing relationships.'"[61] In contrast, Horváth's survey and classification of topics in engineering design research readily accommodate them both:[62] thing-to-people relationships and thing-to-thing relationships.

**Discussion: What is the Foundational–Instrumental Relationship?**
As we have seen, Simon, Schön, and Krippendorff have contributed to design as an intellectual and academic discipline by assuming a foundational design theory and suggesting instrumental design theory, albeit without making that distinction. However, their instrumental theories would point in very different directions if consulted by a designer for practical guidance.

Is it because their foundational theories are logically incompatible and therefore entail incompatible instrumental theories? The answer is negative, in that a foundational theory is not literally an axiom system, and an instrumental theory is not a system of theorems that follow by deduction. Simon, for instance, might have maintained his position that design is essentially a matter of problem solving in planning the improvement of existing situations, without being forced to conclude that such problems be solved mathematically or computationally.

Nor are the basic tenets of Simon's, Schön's, and Krippendorff's foundational theories logically incompatible. Design as problem solving could, conceivably, be conducted as a Schönian "conversation with the materials of a situation" (although frequently redefining "command variables" would be cumbersome), while also being conceived of as a search among numerous prospective artifacts that are anticipated to make sense to their stakeholders, along the lines of Krippendorff's "semantic turn."

Judging from these observations of the foundational theories in Simon, Schön, and Krippendorff, it would seem that, by way of answer to our first focus question (see the introduction), the relationship between foundational theories and the instrumental theories that emerge from them is not well-defined at all; it is rather too subtle—or merely too fluid—to be described in precise terms of

60  Something I haven't discussed, but see his Section 1.2.
61  Charles L. Owen. "What is Design?" (Institute of Design, Illinois Institute of Technology, 2004). http://www.id.iit.edu/141/getdocument.php?id=64 (accessed September 11, 2008).
62  Imre Horváth, "A treatise on order in engineering design research." *Research in Engineering Design* 15 (2004): 155–81.

logic. Perhaps the adequacy of the three sample foundational theories for supporting powerful instrumental theory is best described metaphorically—in terms of the potential a flashlight might have for lighting up a dark room. The clarity and concentration of the beam of light it emits determine what we see, but only up to a point, for very much of what we see depends on where we point it.

Thus, even though in hindsight we may consider Simon's instrumental theory a dead end, and therefore tend to reject his foundational theory of design as problem solving, we should ask ourselves if this rejection is justified. Is it possible, after all, that nothing was wrong with the idea of design as problem solving, but only with the particular way Simon used it as a flashlight in the darkness—and with the way many of us pointed it in the wrong direction as well?

In comparison, Schön's flashlight may seem a bit dim (powered as it is by a low-wattage idea of design proceeding by trial and error); yet he managed to light up what Simon missed: the human power of creativity. However, this fresh insight does not exhaust the potential of Schon's flashlight; as noted, "frame analysis" was one of the more promising possibilities he suggested.

The beam of light from Krippendorff's flashlight is bright and firmly directed toward the stakeholders of design. It appears to reveal bits and pieces of an answer to the practitioner's request for guidance. However, its light is oddly monochromatic and, no matter where we might point it, it lights up only the *meanings* involved in thing-to-people relationships. The thing-to-thing relationships it leaves in the dark—with the engineers.

**Discussion: What is "GOOD" Foundational Theory?**
What the readings would suggest is that instrumental theories might well be affected by one's foundational theories, but in rather obscure ways. Furthermore, foundational theory tends to be stipulated without justification regarding its usefulness in supporting instrumental theory. Thus, when it comes to answering our second focus question, about what a *good* foundational theory is, we are at a loss for guiding principles.

Once more, let us turn to a lighting metaphor for help. When deciding how to light a room, generally the recommendation is to distinguish among and combine three kinds of lighting: (1) *general lighting* to provide overall illumination that allows you to walk about the room safely; (2) *task lighting* for more concentrated illumination where you perform certain kinds of recurring activities (e.g., cooking, reading, sewing, etc.); and (3) the occasional *accent lighting*, to provide visual interest or drama to the room by locally highlighting particular features (e.g., the texture of a wall, drapery, or prized possessions, such as a painting or a house plant).[63]

If the problem with current major foundational design theories is that they work somewhat erratically, like flashlights

63  American Lighting Association, "Lighting your life" (2009). http://www.americanlightingassoc.com/info_lighting3.php (accessed February 10, 2009).

lighting up only what they happen to be pointed at, then perhaps we should begin to look for foundational theories that work more like, say, a ceiling lamp that provides *general lighting* to the room of design. The light source of such a theoretical fixture would be a good *definition* of design—one that is not unduly colored by values and that illuminates the subject matter that our instrumental theories should address to serve design as a professional and intellectual discipline. However, it should illuminate nothing beyond that subject matter.

The instrumental theories, on the other hand, should work by analogy to task or accent lighting: like *task lighting* if they are intended to support a particular type of design task (e.g., graphic design or design of databases, furniture, diesel engines, sculptural ceramics, or organizations), and like *accent lighting* if they are intended to draw useful lessons from the study of individual cases (e.g., prized possessions, such as the Life & Work of Jørn Utzon, or the success of Philippe Starck's "Juicy Saliff" lemon squeezer). This elaborate metaphor of task and accent lighting is a conjecture that I pursue no further here. As an afterthought to our discussion in the previous section of our first focus question, the metaphor explains how instrumental theories might fit into and supplement a foundational theory, whose purpose (more to the point of the present section), is to endow the entire body of theory with some measure of unity and to determine what should count as design research and what should not.

In terms of the lighting metaphor, our concern here is the notion of a foundational theory that works like a fixture for general lighting, with a *definition* of design as its source of light. Of the three theorists whose work we have reviewed, only Simon offers an explicit definition: design as devising courses of action for "changing existing situations into preferred ones." Persuasively elegant though it is, it covers many situations that are obviously irrelevant to design research or design as a profession. For example, it includes as "design" the neighbor's cat planning when and from where to jump at the mouse she has spotted in my garden, or me contemplating an impulse to kick off my shoes under the conference table because my feet are getting hot. As we saw, Simon overcompensated for this hyper-generality by, metaphorically speaking, encapsulating his definition in a dark lampshade with a single narrow opening toward formally specified constraint satisfaction and optimization problems.

Any definition of design focuses attention on a particular range of phenomena, and the less "shading" we need to add subsequently to modify that range, the better. Still, there is no fact of the matter that dictates a single "correct" definition. As Buchanan once put it, "battles over the correct definition of design are fruitless." But we should recognize "that definitions serve the purpose of shaping a particular line of inquiry and that the field

will be vital as long as definitions come and go [...]."[64] However, as I have argued elsewhere,[65] too much coming and going of definitions may disintegrate the body of design theory and compromise the credibility of design research. In addition, developing one's definition(s) of design in a more principled way than picking whatever might provoke a lively debate is surely possible. I would suggest that definitions of design be developed according to the following criteria:

(1) *Public acceptability*. The definition should resonate intuitively with the use of the word "design" in common parlance, as well as in relevant professional, educational, and research organizations. (Otherwise, communication is hampered by confusion.)

(2) *Suitable coverage.* The definition should cover a range of phenomena that is neither too narrow nor too broad (or heterogeneous) for the concept of design to be useful as a tool for thinking. (If too little is covered, the concept is seldom relevant; if too much is covered, attributing the concept to a particular phenomenon conveys very little meaning.)

(3) *Explorative potential*: The definition should explicate design in terms of other concepts that suggest fruitful avenues of research and understanding. (This potential may be dispensable but is obviously desirable.)

Even so, Buchanan is right that there is no single "correct" definition. However, in the interests of unity and credibility, we should use these (or similar) criteria in making an effort to *converge*—if not on a single definition, then on at most a small handful of alternative definitions, representing whatever genuine disagreement may exist among competing schools of thought. To illustrate my point, let me suggest a definition and briefly evaluate it according to the criteria.

*Design*: Creatively proposing an idea,[66] so as to enable yourself or others to make an artifact according to the idea.[67] Following Hilpinen, I take an *artifact* to be "an object [not necessarily material] that has been intentionally made or produced for a certain purpose."[68]

To argue for the *public acceptability* of this definition, I would point out that it does not imply actual making of an artifact. This circumscription is quite in accordance with common parlance, where "design" is used not only in cases where an artifact is eventually made, but also in cases where a designer merely *proposes* an artifact, as is often the case for students of architecture. Furthermore, I believe the definition corresponds well to what people of various professions do who call themselves "designers," and to what students learn to do when taught to "design," whether for engineering or for more artistically based disciplines. No doubt there are good reasons to differentiate the various design professions, but there are good reasons, too, for clearly conceptualizing and addressing what they have in common: in Margolin's words, "to define new points of

64  Richard Buchanan, "Design as Inquiry: The Common, Future and Current Ground of Design." (paper presented at DRS Futureground International Conference, Melbourne, 2004).

65  Per Galle, "Candidate Worldviews for Design Theory." *Design Studies* 29:3 (2008): 267–303.

66  I am grateful to Helle Egsgaard for her constructive criticism of an earlier version of the definition, which led to a greater emphasis on the initial cognitive process.

67  Adapted from Galle, "Candidate Worldviews for Design Theory," 272.

68  Risto Hilpinen, "Artifacts." *Stanford Encyclopedia of Philosophy* (Fall 2004). http://plato.stanford.edu/archives/fall2004/entries/artifact/ (accessed August 24, 2011).

69  Victor Margolin, "The need for design studies." in *Design at the Crossroads: A Conference Report*, M. Diani and V. Margolin, eds. (Evanston, IL: Design/Technology/Society Work Group, Center for Interdisciplinary Research in the Arts, 1991).

70  Per Galle, *The CEPHAD Bibliography* (initiated 2007). http://www.dkds.dk/Forskning/Projekter/CEPHAD/literature/bibliography (accessed September 29, 2010).

71  Per Galle, "Design as Intentional Action: A Conceptual Analysis." *Design Studies* 20:1 (1999): 57–81.

72  Gerald Vision, "Reference and the Ghost of Parmenides." in *Non-Existence and Predication* (Grazer philosophische Studien, Band 25/26. Amsterdam: Rodopi, 1986) 297–326.

73  In a recent paper (Ann Heylighen, Humberto Cavallin, and Matteo Bianchin, "Design in Mind." *Design Issues* 25:1 (2009): 94–105), design (as contrasted to research) is analyzed in terms of Searle's notion of intentionality (directedness) of mental states: *Beliefs* are true or false depending on how they fit, or change to fit, the world (their "direction of fit" being "mind-to-world"). *Desires* are fulfilled or unfulfilled depending on how the world fits, or changes to fit, *them* (their "direction of fit" being "world-to-mind"). What I call an "idea" in my definition might be construed as a "desire" in this sense, and the "production of an artifact" as a way to fulfill it by changing the world. In the terminology of Heylighen et al., what I call "prediction" would have to be construed as forming a "belief" during the "evaluation" stage. However, at that stage, there is nothing to determine the truth or falsity of that belief, for "what is evaluated [e.g., the artifact being designed] does not yet exist" op. cit. 99. Yet for the evaluation to be of any use to the designer, the resulting belief must have some measure of *reliability*. Heylighen et al. seem to contend that *imagination* can somehow make up for the missing target for the beliefs a designer forms when evaluating a proposal 99. They do not explain how, nor do they address the issue of reliability (for which they are not to be blamed because their aim was to compare design with research, not to explain how design is possible in the first place). I have had some stabs at the reliability problem in "Candidate Worldviews for Design Theory," *Design Studies* (2008), and more recently in Per Galle, "The Ontology of Gero's FBS Model of Designing." *Design Studies* 30:4 (2009): 321–39.

contiguity and to facilitate greater collaboration between different types of designers while making it possible for individual designers to address a greater range of problems than most now do."[69] The definition offered is an attempt at just that, and by the same token, it would appear to have *suitable coverage*: It does not restrict attention to a narrow professional specialty or product type, or to a particular methodological approach; nor does it, on the other hand, include blatantly irrelevant phenomena, such as mouse hunting or shoe kicking.

The *explorative potential* of the definition is more difficult to assess in advance. No doubt it is possible to *define* design in some other way, without referring, as I did, to *creativity*, to *ideas* of prospective artifacts, and to the *purposes* (be they utilitarian or artistic) that these artifacts should serve if eventually produced. But I cannot imagine that it is possible to *practice* or *teach* design without familiarity with these concepts. And familiarity deepens with exploration.

We should not forget, however, that just as it takes more than a light bulb to make a lamp, it takes more than a definition to make a foundational theory. Part of this additional material is already available in the literature on (the nature of) creativity, artifacts, etc.,[70] and more is likely to emerge from using the explorative potential of the definition (or that of other definitions). In particular, it seems to me that, to obtain a sufficiently deep understanding for coming up with a full-fledged foundational design theory, we need to address the vexed questions that arise from the simple fact (highlighted by the definition, but inescapable no matter how we define design) that at the time a given artifact was designed, it did not exist.[71]

For example, according to a widely accepted understanding of properties, they are always properties of some existing entity.[72] From this perspective, as long as the artifact did not exist, it could not have had any properties. Thus, at the time of its design, the artifact could not have had the particular property of *serving its purpose*. How then, could the designer know (or be confident) at that time that the artifact would eventually serve its purpose? *Prediction* rather than *predication* of properties appears to be involved, but what exactly does that mean, and what, if anything, makes it reliable?[73] How, indeed, is design possible—thrusting forward, as it does, into an empty space of non-existence?

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