# Design in Mind
## Ann Heylighen, Humberto Cavallin, and Matteo Bianchin

Research on the relationship between design and the creation of knowledge is a relatively recent phenomenon. In architecture, for instance, it was not so long ago that designers tended to view knowledge with disdain, as a hindrance to unfettered creativity or an encapsulation of "freeze-dried prejudices."[1] Recently, however, the American Institute of Architects (AIA) devoted the December 2004 issue of its *AIA Journal* entirely to the theme of knowledge, which strongly suggests that times are changing.

Increasingly, the act of designing is considered to be or involve some kind of knowledge production.[2] This directly follows from the type of knowledge designing relies on, which is practice-based and tacit,[3] (i.e., embedded within the very act of designing).[4] On the other hand, it is possible—at least in a rough and ready way—to appreciate the distinction between the aim, or intention, of producing knowledge and other aims,[5] such as designing an object or a building. To state it a bit more bluntly, a client typically hires an architect to design a building, not to produce knowledge.

Why then is it so difficult to set clear boundaries between design and scholarly research? Questions about the relationship between both are far from new. According to Nigel Cross, they reappear about every forty years,[6] and have been written about by many authors before. Already in 1973, Horst Rittel and Melvin Webber pointed out the difference between the kind of problems designers and planners deal with and those that scientists handle.[7] More recently, Johannes Eekels and Norbert Roozenburg made a methodological comparison of the structures of design and research in engineering, and concluded that both are strongly interwoven and mutually dependent, yet fundamentally different.[8] Although it seems time to move on from making all sorts of comparisons between design and research, this paper tries to shed more light on the issue from a conceptual and psychological point of view. To this end, it calls in the philosophy of mind—rather than the philosophy of science, as is usually the case[9]—and more precisely the notion of intentionality. Instead of considering design as a mix of knowledge creation and application, the process is decomposed into distinct yet interacting mental acts, in which designers establish relationships with (objects in) the world. A detailed analysis of this relationship forms the basis for a nuanced, yet fundamental, comparison with

the relationship researchers establish with the world and may help address the question about design's contribution to the creation of new knowledge.

After introducing the notions of intentionality and direction of fit as advanced by philosopher John Searle,[10] the paper analyzes in detail the directions of fit involved in design both as hypothesized by theoretical models, and as experienced by design practitioners. This nuanced, yet fundamental, analysis of the nature of design should enable us to start addressing the question whether and how design has a role to play in the creation of new knowledge.

## Intentionality

The notion of intentionality stems from late-nineteenth-century German philosophy, and refers to mental activities that are *directed at* objects or processes in the world. These activities result in beliefs, hopes, and desires that are *about* the world but not, strictly speaking, physical properties of the world. Intentional states thus have a first-person ontology (i.e., they exist only because some individual exists who enjoys mental phenomena). In this sense, intentional psychology is not entirely reducible to physics, even though it is rooted in the biology of some sort of natural entities (human and nonhuman animals). As we will point out, this makes for some peculiar traits of mental facts, such as their holistic nature, subjectivity, normativity, and individuation by content.

Searle defines intentionality as a property of individual mental states.[11] The individuation of these states is bound to two factors: the type of state (e.g., a belief is not a desire; perception is not memory), and how the object or state of affairs is presented to the mind (e.g., you can think of Venus as the morning or evening star: the object is the same, but the states have different contents because the object is conceived in different ways). The individuation of intentional states thus depends on content, not just on the object they intend to direct their mental activity to. Moreover, a state's content depends on its being interlocked in a network of other beliefs, hopes, desires, etc., and backed by a set of nonrepresentational capacities. This is why the mental is holistically organized. In order to entertain an intentional state, it is necessary to entertain many others: there may be no such things as a mind with only one belief or desire. In order to believe that Bush is President of the U.S., you need to believe many other things about government and representation. Thus, when analyzing mental events and processes, we should not expect to find simple states occurring in series, independently of other states being tacitly entertained or, in the case of background abilities, being active.[12]

Within the context of this paper, it may be useful to distinguish between "directedness" as a property of intentional states, and "aboutness" as the relation between intentional states and the objects in the world. The former indicates that every intentional

state intends or means something: for every desire there is something desired, for every belief something believed, etc. Sadly enough, however, not every intentional state reaches its target: we believe false things, desire inexistent states of affairs, etc. Thus, although intentional states are *directed at* something, they are not always *about* something, since they may as well be about nothing. Furthermore, they may be about something and represent it falsely—as being in a way it is not. That is, there may be no actual referential relation between the mind and the world, as when the object intended does not exist; and there may be a mismatch between the two even when reference is attained, so that a state of affairs is represented which does not exist. As a result, any theory of intentionality must allow for the possibility of misrepresentation. This implies that intentionality is a normative notion, since it is characterized by the way a state's representational content is to fit with the world in some way or another, and tokens of intentional states are evaluated in terms of success under this respect. For example, the content of your desire to eat an apple is the representation of an action, and the content of your belief that Berkeley is sunny is the representation that Berkeley is sunny. These contents represent the condition under which the intentions are fulfilled.

Thus far, it looks as if an intention can be evaluated with respect to a norm of adequacy. Yet this standard bifurcates for cognitive and conative states. According to Searle, intentional states have one of two possible "directions of fit." Beliefs, for instance, which can be true or false, have a "mind-to-world" direction of fit, while desires, which cannot be true or false but rather fulfilled or unfulfilled, have a "world-to-mind" direction of fit.[13] As Veikko Rantala puts it:

> In a sense it is the responsibility of a belief to match the world in order to be true or satisfied (since the world is what it is). If it does not match the world, it can be changed so as to match it. Instead, if desires are not fulfilled, the world is responsible, since the desire is what it is and cannot be changed to match the world; rather the latter is to change.[14]

Thus cognitive and conative states are asymmetrical with respect to how the content determines their condition of satisfaction. The content represents the condition under which a state would be satisfied when matched with the world. To satisfy cognitive states, they must fit the world as it is; while, to fulfill conative states, the world must adapt to fit them. In other words, whenever you discover you have a false belief, you may want to change your belief in order to make the representation fit how the world is; but whenever a desire is unfulfilled, you rather may want to change the world. Suppose you believe you live in a penthouse, when in fact you live in a basement. If you are rational and have full information about your

apartment, you eventually will abandon your former belief and start believing that you do not live in a penthouse. But if you desire to live in a penthouse, while you live in a basement, the desire will not disappear as you discover the truth, nor will you develop the desire not to live in a penthouse. The only way to satisfy your intention is by moving. It looks as if truth and falsity do not apply to, or have an impact on, conative states.[15]

The point about truth is particularly relevant in the context of this paper. We may say that cognitive states such as belief aim at—or are committed to—truth; while conative states such as desire and will do not. In these latter cases, it is appropriate to say that the aim is the satisfaction of the desire (or will). Of course, in both cases, the conditions under which the aim would be reached are *represented* in the content of the state as the state of affairs that would make the belief come true or satisfy the desire; but the aim is different. In the first case, one is committed to the existence of a state of affairs that is obtained independently. In the second, this is not the case; nor does the state of affairs represented need to be actual. If you believe that tomorrow will be a rainy day, you are ready to abandon the belief in case it turns out to be sunny. However, if you desire that tomorrow will be rainy, you are not necessarily ready to abandon the desire in case it turns out to be sunny: you might, but you are not irrational if you do not.

**Directions of Fit and the Activity of Designing**
What does it tell us about design, and about its contribution to the creation of new knowledge? The activities of a designer, like those of a researcher, are directed at or about objects in the world. However, when looking at the direction of fit between the mind and (these objects in) the world, both differ considerably.

Across the board, the mental activities of a scientist are characterized by a mind-to-world direction of fit. Researchers seek knowledge as an end in itself, "because it is better to know than to be ignorant."[16] The beliefs and insights they produce may be true or false, and it is their responsibility to match the world in order to be true and therefore successful. This may be obvious for the natural sciences, yet perhaps less so for the humanities or social sciences. Without entering the debate about the differences or similarities between these fields, we would like to point out that social scientists engage in mental activities with the same direction of fit as those of natural scientists, by calling in Searle's distinction between ontological and epistemic subjectivity/objectivity.[17] While the phenomena studied in the humanities and social sciences can be seen as ontologically subjective (when we human beings no longer exist, these phenomena cease to exist, too), this does not imply that social scientists cannot expect to have epistemologically objective knowledge about them.[18] In other words, social scientists also have the responsibility to produce knowledge that matches the world—

albeit a world that is ontologically subjective—so their mental activities display a mind-to-world direction of fit.

In contrast, a designer's mental activities seem to be dominated by a world-to-mind direction of fit. Designers are concerned not only with what is, but with what should be. Their attention is focused on possibility: "the search for new or better solutions to problems encountered in everyday living."[19] Thus, even if design contributes to the creation of knowledge, the knowledge created usually is a by-product of an activity with another aim. Moreover, the solutions designers produce cannot be true or false. As Rittel and Webber posed it, in the case of design and planning problems:

> There are not true or false answers. Normally many parties are equally equipped, interested, and/or entitled to judge the solutions, although none has the power to set formal decision rules to determine correctness. Their judgments are likely to accord with their group or personal interest, their special value-sets, and their ideological predilections. Their assessments of proposed solutions are expressed as "good" or "bad" or, more likely, as "better or worse" or "satisfying" or "good enough.[20]

Furthermore, if and when these "good" or "bad" ideas are effectively turned into an object, this object changes the world so as to match the designer's ideas. As Richard Buchanan points out, "Change has always been an essential part of design, because designers are concerned with creating new possibilities in human experience, mediated or facilitated by human-made products."[21]

So far, it looks like design and research fundamentally differ in terms of both ontology and epistemology. When having a closer look at what designers and researchers do, however, the story becomes more intricate. Design and scholarly research are activities rather than states of mind. Moreover, because both are highly complex in nature, they both involve various kinds of mental acts. The following sections will zoom in on the micro-level of these acts.

**In Theory**

In the case of design, the intrinsically complex nature has inspired the advancement of various theoretical models which attempt to capture steps or stages designers go through while designing. For the purpose of this paper, we put under the microscope two different approaches to design: design as a staged process, and design as a transformation process. These two examples should provide an idea of how directions of fit may vary towards the inside of a design process.

Starting with the work by Morris Asimow,[22] several models dissect the design process into a sequence of stages, roughly boiling

down to "analysis-synthesis-evaluation."[23] This coarse model of how designers think progresses in recurring loops throughout the design process. Asimow described the design process as being composed of two structures: a vertical one that involves a sequential phasing of activities—from the definition of needs, feasibility study, and preliminary design over detailed design and production planning to actual production—and a horizontal one in the form of an analysis-synthesis-evaluation-communication cycle, common to all phases.

When analyzing this formalization of the design process in the light of Searle's theories of intentionality, the *analysis* stage may be characterized by a mind-to-world direction of fit: designers collect information that enables them to know more about the design situation at hand. Subsequently, designers transform this information through a process of *synthesis*, which switches the direction of fit. The ultimate goal of this stage is to come up with a design proposal that, when realized, changes the world such that the needs defined are addressed. Once a proposal has been produced, the *evaluation* stage tries to assess to what extent the needs will indeed be addressed. Because what is evaluated does not exist yet, but has to be actively imagined by the designer, this stage may be considered to have both a world-to-mind (imagination) *and* a mind-to-world (evaluation) direction of fit.

In a similar vein, Bruce Archer proposed a model of the design process that emphasizes a linear sequence of activities, with numerous feedback loops between them.[24] An updated version of this model by Gero and Kannengiesser considers the staged process from an information process perspective.[25] It assumes the existence of three classes of variables, which are transformed into one another through design: function, behavior, and structure. According to this model, the purpose of designing is to transform the function into a design description in such a way that the structure or artifact being described is capable of producing this function.[26]

This transformation extends the analysis-synthesis-evaluation sequence with three extra steps: formulation, reformulation, and documentation. "Formulation" (or "specification") is the first step in the sequence, and transforms the function into behaviors of the structure that are expected to enable this function. When structures are being synthesized and evaluated, however, they may produce their own behaviors, which occasionally may lead to the "reformulation" of the structure, expected behavior, or function. Finally, "documentation" transforms the structure into a design description.

Table 1 lists the different stages of this transformational model and their corresponding directions of fit. The equivalent stages of analysis, synthesis, and evaluation have directions of fit identical to those of Asimow's staged process. The additional phases—formulation, reformulation, and documentation—all display the world-to-mind direction of fit. When formulating a

**Table 1**

Directions of fit for the transformational model of the design process[28]

| Stage | World-to-Mind | Mind-to-World |
|---|---|---|
| Formula or Specification | ↑ | |
| Analysis | | ↓ |
| Synthesis | ↑ | |
| Evaluation | ↑ | ↓ |
| Reformulation | ↑ | |
| Documentation | ↑ | |

problem, designers and/or their clients dissect the world according to their values and necessities, thus defining what is considered a problematic situation. Such situations do not present themselves in the world. Designers must make sense of them by imposing their viewpoints and values. In this process, designers act by imposing conditions of satisfaction in a direction of fit that goes from their minds to the world, splitting and grouping objects to define the problematic situation.

This world-to-mind direction of fit also characterizes the documentation process. Documents produced in this stage do not intend to represent the world "as is," but to communicate to other actors how to change it. In the documentation stage, designers produce drawings intended to support the communication of their ideas to others, who eventually should enable them to change the world such that these ideas are materialized.[27]

**In Practice**

Having analyzed design from a theoretical perspective, the question arises as to how design occurs in practice, and whether our ontological and epistemological assumptions still hold in this realm.

Judging from in-depth interviews with "star"[29] and "local"[30] designers, some practitioners seriously consider their activity a form of research. Several interviewees admitted to having a personal agenda of interests, which they explore through the projects they design. This agenda may pursue quite specific objectives, as the work of Santiago Calatrava illustrates.[31] His repertory can be seen as one big exploration of the phenomenon of dynamic equilibrium. Specific design projects are used as places for experimentation, for trying out and developing design knowledge. In fact, a distinction can be made between the project design task itself and a more general design process, or rather research process, which affects

and is affected by each design project. The latter process may transcend the immediate urgencies of a single project, and pursue quite specific objectives (exploring potential design concepts, investigating the possibilities of a site or, in case of Calatrava, studying a structural issue). Nevertheless, its course is seriously influenced by the specific projects themselves. Often it is only afterwards, when reconsidering several projects, that one can extract a supposable "research" program.

Two aspects can be analyzed using the categories previously described. First of all, each project is characterized by a world-to-mind direction of fit, because ultimately the building (or other object) being designed must match the designer's ideas. However, inside this bigger frame, other sub-activities take place which may either conserve or reverse this direction. Indeed, during the sub-activities involving experimentation, the designers' ideas about the world may need to be reshaped based on the nature of the world itself as perceived by them, rather than vice versa.

As explained above, intentional contexts have a holistic organization: mental states do not exist in a vacuum, but depend on many other states being tacitly entertained which, in turn, depend on an active background ability. This kind of complexity is found in design as in every human activity. As far as a design project is planned, the design process may be described as the planning of an action or series of actions: some end is targeted and means are searched in order to realize it. Obviously, this planning not only has to do with values from the design domain, but also with what designers know about the world and with examples of "good" design that influence the content of their values. What is considered good design may depend on a tacit knowledge of the world, which has a mind-to-world direction of fit and will be imbued with interpretations of examples that contribute to what we mean by "good" or "bad" design. A modernist architect, for instance, may find deconstructivist projects puzzling in a way that results from the unintelligibility of post-modern values and practices. One may ask what learning process led architects educated in a modernist context to develop such projects, and the answer may be very complex. On the one hand, changes in architectural values can depend on some piece of knowledge about the world (e.g., that contemporary society shows differentiation and fragmentation in a way that may not be synthesized in a modernist narrative). On the other hand, examples coming from these new contexts may suggest new interpretations of these very same values.

In such cases, the content of the intentional states with a world-to-mind direction of fit that directs the design process may depend on representations and pieces of tacit knowledge that have a cognitive character (i.e., a mind-to-world direction of fit). Moreover, this raises a troubling question about the relationship between the cognitive contents and direction of fit in design processes. If we

see design as a case of (very complex) action planning, we should attribute this to the intentional states involved a world-to-mind direction of fit. But now it looks like the representation of the ends targeted may reflect intentional states that have a cognitive character, and thus a mind-to-world direction of fit (e.g., intentional states expressed as the belief that deconstructivist buildings *are* valuable, or beautiful, etc.). For instance, one can imagine an ex-modernist explaining her change of mind as follows: "I was persuaded that architecture should respond to functional values, but then, in the late-1980s, I came to realize that this was no longer working well enough and to *believe that* a building should resonate a meaning…" What is central is that the change of mind is expressed in cognitive terms as something that is literally true of the world although it refers to values. That is, it seems that, in explaining design practice, values are envisioned as facts one can be right or wrong about according to how the world is.

It is important to notice, however, that such complexity does not invalidate the principled distinction between research and design. Indeed, the way in which cognitive states are recruited in the design process is coherent with this distinction: they all are means to an end, which is not cognitive but productive in nature. It is a desire rather than a belief that prompts designing, although cognition is involved in the representation of the state of affairs to be produced in order to satisfy the desire and of the way to make it real. As mentioned earlier, intentional states are individuated in terms of contents, but they are differentiated as kinds of psychological attitudes in terms of aim or direction of fit. So the fact that cognitive acts are involved in every activity of design should not tempt us to see design as a kind of cognition or as a way to produce beliefs and knowledge. Cognition is rather presupposed by design in two important ways: as providing the means to navigate the world in order to reach a goal, and as providing the conceptual tools, the knowledge, and the vision necessary to represent the goal.

**Taking Stock**
If we consider design as characterized by the kind of mental states that dominate it in the sense of governing the activity, cognitive states may serve design processes without being part of the very nature of design. That is, they may occur at many levels in the design process, and be incorporated in more or less complex ways, but they do not contribute to its very nature.

This may help clarify the intuitive distinction between design and scholarly research. Both are activities rather than states of mind, but the aims they pursue is different: in the first case, knowledge of truths, and in the second, the production of artifacts. Since both are complex activities, both typically involve very different kinds of acts. One may have to design a research project or a series of experiments in order to obtain some results. Similarly, research may

be needed for designing an artifact, and may be part of the actions taken in a design process, but it is not what design is about. Different aims govern the activities, ordering their acts in a means-to-an-end reasoning: knowledge is a means to design, while it is an end for research. So the way in which design may depend on cognitive states of mind is instrumental: beliefs and knowledge are necessary, but they are necessary as the means to an end which is defined independently. However, the nature of research is the pursuit of truth: to believe truly is not a means, but the end which is constitutive of such activity.

**Discussion**
The main aim of this paper was to develop an ontological and epistemological comparison between the nature of design and that of scientific research, the underlying assumption being that, once you get the ontology straight, the answers to questions associated with the contribution of design to the creation of new knowledge follow automatically.

For this analysis, we have called in Searle's notions of intentionality and direction of fit, which allowed us to compare the activities of designers and researchers in terms of the relationship they establish with (objects in) the world. However, we should not be excessively concerned with the precise terms characterizing this relationship. What is more important here is using these or other terms to identify the central issues that occupy our attention (i.e., to what extent design can contribute to the creation of new knowledge).

Based on its relationship with the world, design in itself does not seem to be a kind of scholarly research. Complications arise, of course, but overall the results of our analysis play in favor of the presence of a cognitive component that can play a role in design, yet cannot be articulated or elaborated by design. In other words, design as such is not a form of research, but may incorporate concepts that need elucidation through research—precisely because their source is not so much design practice, but a much more complex network of reflective thinking or implicit cultural learning. These concepts are part of the tacit knowledge designers use as a kind of cultural know-how, or even make explicit in a kind of know-how. Yet making these explicit is not part of the design process. Or rather it can be considered as part of it, but it does not work in the same way. It is a form of theoretical reflection incorporated in the process, but it has and follows its own logic. Thus, one may say that knowledge is *incorporated in* a design project, but not *the aim of* a design process, precisely because it has the opposite direction of fit. In fact, it is something that is produced otherwise and can influence design as a piece of information (e.g., about what is "good" or "bad" design; or, more radically, about what is a design and what is not).

By consequence, very different logics of discovery may be at work in design practice, and the way they are mixed varies from one case to another. However, this variation cannot be used to question the fundamental distinction in principle between design and research. For whatever the mix, you still need a theory to account for what happened, and this is something that just continuing designing will not be able to give you. You need some theoretical model, concept, strategy, or the like to come to grips with what has or has not worked, and to explain why. In more technical words, you need an explicit interpretation of what constituted the tacit understanding just displayed by your practice.

In this respect, the relevance of our analysis for the discussion on design's contribution to the creation of new knowledge seems twofold. It has attempted to set straight the limits of knowledge creation through design, as well as provided strong arguments for teaching research methods to design students. These serve to establish a fundamentally different relationship with the world than the methods typically learned in the design studio.

1   Joseph Press, "Soul Searching: Reflections from the Ivory Tower," *Journal of Architectural Education* 51:4 (1998): 233–242.

2   For examples, see the recent discussion on the doctorate by design.

3   Michael Polanyi, *The Tacit Dimension* (Garden City: Doubleday, 1976).

4   Donald Schön, *The Reflective Practitioner: How Professionals Think in Action* (New York: Basic Books, 1983). Schön even suggested that, since research is an activity of practitioners, triggered by features of the practice situation, and immediately linked to action, there is no need to undertake research outside the immediate context of practice. Exceptions to this rule include four kinds of research that may enhance practitioners' capacity for reflection-in-action: frame analysis, repertoire building, research on fundamental methods of enquiry and overarching theories, and research on the process of reflection-in-action.

5   Alan Chalmers, *Science and Its Fabrication* (Milton Keynes, UK: Open University Press, 1990).

6   Nigel Cross, "Designerly Ways of Knowing: Design Discipline versus Design Science," *Design Issues* 17:3 (2001): 49–55.

7   Horst W. Rittel and Melvin Webber, "Dilemmas in a General Theory of Planning," *Policy Sciences* 4 (1973):155–169.

8   Johannes Eekels and Norbert F. M. Roozenburg, "A Methodological Comparison of the Structures of Scientific Research and Engineering Design: Their Similarities and Differences" *Design Studies* 12:4 (2003): 197–203.

9   The philosophy of science reflects on issues such as the variety and coherence of the sciences, the different methods of knowledge acquisition, the relationship of (scientific) knowledge to the daily practice, on the one hand, and philosophical assumptions on the other. In contrast, the philosophy of mind deals with fundamental questions about the nature of the human mind in the foundations of philosophy, cognitive science, and psychology: What is consciousness, and how can it be caused by brain processes? How does it function causally in our behavior? How do we represent reality to ourselves in our mental processes? What is the nature of perception, memory, knowledge, and action? How exactly do our mental processes underlie society and our construction of social institutions?

10   John Searle, *Intentionality: An Essay in the Philosophy of Mind* (Cambridge: Cambridge University Press, 1983).

11   Ibid., chapter 1.1.

12   John Searle, *The Rediscovery of Mind* (Cambridge, MA: MIT Press, 1992), 175 ff.

13  John Searle, *Expression and Meaning: Studies in the Theory of Speech Acts* (Cambridge: Cambridge University Press, 1979); and Searle, *Intentionality: An Essay in the Philosophy of Mind*, chapter 1.2. In some exceptional cases, the traffic between mind and world is not one-way. The expression: "You are fired!" for instance, creates a state of affairs by representing that state of affairs as existing. Such speech acts or intentional states are said to have *both* directions of fit.

14  Veikko Rantala, "Environmental Experience: Beyond Aesthetic Subjectivism and Objectivism," *The Thingmount Working Paper Series on the Philosophy of Conservation, TWP* 99–104 (Lancaster, UK: Lancaster University, 1994), 6.

15  Ruth Millikan, *White Queen's Psychology and Other Essays for Alice* (Cambridge, MA: MIT Press, 1996), 66–75; and Michael Smith, *The Moral Problem* (Oxford: Blackwell, 1994), chapter 1. There may be room for negotiation, however, since you can develop adaptive desires for your basement; but this is another story. See Jon Elster, *Sour Grapes: Studies in the Subversion of Rationality* (Cambridge: Cambridge University Press, 1983), chapter 4.

16  Richard Buchanan, "The Study of Design: Doctoral Education and Research in a New Field of Inquiry" in *Doctoral Education in Design,* Richard Buchanan et al., eds. (Pittsburgh: The School of Design, Carnegie Mellon University, 1998), 1–29.

17  John Searle, *Rationality in Action* (Cambridge, MA: MIT Press, 2001).

18  Already since Max Weber, a classic theme in the social and human sciences is that, precisely because they have subjective phenomena as their object, the subjective view cannot be eliminated since it is part of what science is about in these cases. To explain Oedipus's deed, for instance, you need to look at Oedipus's mind. From a detached perspective, he just married his mother, yet the story can be explained only if you know that he desired to marry Jocasta, and did not know she was his mother. So scientific objectivity here presupposes grasping subjectivity, and that does not mean that the scientific aim is compromised. Just the contrary, it would be poor science (poor psychology, poor history, poor anthropology, etc.) to contend that Oedipus married his mother, period, since this is not what happened in fact.

19  Buchanan, "The Study of Design: Doctoral Education and Research in a New Field of Inquiry," 1–29.

20  Rittel and Webber, "Dilemmas in a General Theory of Planning," 155–169.

21  Buchanan, "The Study of Design: Doctoral Education and Research in a New Field of Inquiry," 1–29.

22  Morris Asimow, *Introduction to Design* (Englewood Cliffs, NJ: Prentice-Hall, 1962).

23  Geoffrey Broadbent, *Design in Architecture: Architecture and the Human Sciences* (London: David Fulton Publishing, 1988 (1973); and Herman Neuckermans, "The Relevance of Systematic Methods for Architectural Design," *DMG-DRS Journal* 9:2 (1975): 140–144.

24  Bruce Archer, "Systematic Method for Designers" in *Development in Design Methodology* Nigel Cross, ed. (Chichester, UK: John Wiley & Sons, 1984), 57–82.

25  John S. Gero, "Design Prototypes: A Knowledge Representation Schema for Design," *AI Magazine* 11:4 (1990): 26–36; and John S. Gero and Udo Kannengiesser, "The Situated Function-Behaviour-Structure Framework" in *Artificial Intelligence in Design'02,* John S. Gero, ed. (Dordrecht: Kluwer, 2002), 89–104.

26  Gero, "Design Prototypes: A Knowledge Representation Schema for Design," 26–36.

27  In this respect, the documentation stage differs from earlier stages in the design process, where architects produce documents first of all to communicate with themselves and other members of the design team. By sketching and drawing, designers see what they think, and what they see makes them think. Because the drawing reveals more than was invested in its making, it becomes an active agent in producing ideas. (See Nelly Marda, "Visual Design Thinking," *STOA Architectural Review of EAAE 2* (1997): 42–53). It provides new perceptual cues, and supports not only verification but also extraction of design characteristics (Balakrishnan Chandrasekaran, "Multimodal Perceptual Representations and Problem Solving" in *Visual and Spatial Reasoning in Design* John S. Gero and Barbara Tversky, eds. (Sydney: Key Centre of Design Computing and Cognition, University of Sydney, 1999), 3–14. Moreover, throughout the design process, sketches and drawings have been observed to change from being treated frozen, and hence unavailable for change; to fluid, open, and dynamic. See Jennifer K. Whyte, Boris Ewensteint, Michael Hales, and Joe Tidd, "Visual Practices and the Objects Used in Design," *Building Research & Information* 35:1 (2007): 18–27.

28  Searle always tends to use very simple metaphors. In this case, he imagines the mind as floating above the world, and thus symbolizes a world-to-mind direction of fit by an upward arrow (↑) and a mind-to-world direction of fit by a downward one (↓).

29  Bryan Lawson, *Design in Mind* (London: Butterworth Architecture, 1994).

30  Ann Heylighen and Herman Neuckermans, "Design(ing) Knowledge in Architecture" in *Recherche et Architecture/Research and Architecture* Stéphane Hanrot, ed. (Leuven: EAAE, 2000), 231–241; and Ann Heylighen and Herman Neuckermans, "Are Architects Natural Case-Based Designers? Experts Speaking," *The Design Journal* 5:2 (2002): 8–22.

31  Lawson, *Design in Mind*.