# 0. Introduction

## 0.1 Making sense of design as a cognitive activity

### Design

During recent years, the scientific interest in design processes has grown rapidly. The working processes of designers have been well documented in a number of domains: alongside the classical design domain, architecture, there are also for example industrial design and graphic design, which today are established and recognized design disciplines. In addition, such fields as interaction design and information design are emerging and trying to establish their own identities.

From the studies of these various domains, the knowledge of authentic design processes is increasing. There is also an elementary understanding of *why* they work. However, this is still mostly a list of miscellaneous studies and their assorted insights; the work remains to find how each of the existing pieces can be put in relation to each other, as parts of a bigger picture.

At the same time, there already exists a "received" theoretical perspective on design. Known as *design methodology*, it is based on logic, rationality, abstraction, and rigorous principles. It portrays, or rather *prescribes*, design as an orderly, stringent procedure which systematically collects information, establishes objectives, and computes the design solution, following the principles of logical deduction and mathematical optimization techniques (cf. Alexander 1964, Asimow 1962, Jones 1970, Simon 1981). This view is still very much alive (as is evident in e.g. Dasgupta 1989), and there is good reason to believe that this won't change for a long time.

However, discontent with this approach is widespread and quite old, even though no substantive replacement has yet been proposed. Experience from design practice and from studies of authentic design processes has consistently been that not only don't designers work as design methodology says they should, it is also a well established fact that to do design in the prescribed manner *just doesn't work* (Alexander 1971, Broadbent 1973, Lawson 1980, etc.).

### Cognition

There is a similar situation in cognitive science. The conventional theories are highly sophisticated, most stringent in their form, and written in the language of computer science, mathematics, and formal logic. They were developed to explain the most advanced of intellec ctive reasoning, and so forth.

And also in this area, there is a growing body of work on making sense of authentic cognitive activities beyond psychological experiments and computer simulations. These activities are often of an everyday nature and so may appear mundane. Nevertheless, for those who look closely enough, they hold great sophistication underneath the surface, and they perform their functions very well. However, as also these authentic activities call for explanations that are substantially different from what the prevailing theories can provide, they too remain to be properly accounted for.

At the same time, the conventional, proposed cognitive mechanisms are becoming increasingly questioned, as their limited achievements have not been able to match the great claims that have been made on their behalf. Therefore the apparently mundane activities are increasingly being revaluated, as they in spite of their plain looks manage to perform the functions which the sophisticated models have failed on.

### The gap between the ideal and the actual

There are in both fields a received theoretical perspective, based on idealized views of rational behavior; chapter 1 serves to show how very closely related the two perspectives are. But the received theories are increasingly being called into question in both fields (cf. chapter 2). At the same time, there is an accumulating mass of evidence on design processes and cognitive performance under authentic circumstances. However, there is still an absence of a real theoretical alternative that can account for this growing body of knowledge.

The problem is in both fields a discrepancy between the received, theoretical views of how things ought to work, and how they have turned out to work in reality—a gap between the *ideal* and the *actual* which needs to be filled with a new explanation, a theory of human performance in these authentic activities. The aim of this book is to present such an explanation (chapters 3 to 6).

The promise of this topic lies in the many commonalities between the two fields, which hold the promise of a synergy. Not only in the gap that they share, but also in the building blocks that each field has





already produced. By combining these building blocks, one can gain leverage in building a single, joint explanation for both domains.

### From should to making sense

It seems that the shared gap has come out of a similar line of development in both disciplines: The "ideal" approach found certain kinds of solution formally elegant and powerful, therefore assuming that this was how things "had to be". And these *a priori* assumptions were made so confidently that there was hardly a need to ask if they worked, much less to test whether they did—and if they didn't at first, then they surely would if only given some refinement.

But some have found it increasingly hard to ignore the disparity between promises and what has so far been delivered. They have also recognized the procedures that people actually use, and the merits of these procedures in particular. There has therefore been a shift from laying down how things ought to be, toward an increasing estimation of authentic practice, and an interest in *making sense* of the sophistication that is inherent in the mundane.

And this is where the gap resides, in the vacuum between the existing, ideal theories, and the desire to make sense of authentic design activities and cognitive processes. In each field there are the beginnings of this; so far, the design side has come a little further along the way, but also there, the work of filling the gap between *should* and *making sense* is still very much in progress. To fill this gap that exists in both fields is the purpose of this book.

Hence, the need for theory is still great, to explain and make sense of design as a cognitive process, but also to "give designers reason" for what they do, so that practice is no longer looked down on as imperfect and irrational, but is acknowledged for its merits. If so, practice may perhaps take advantage of an improved understanding of its underlying principles.

### Case in point: The renaissance of sketching

A good illustration of these developments is the devaluation and subsequent revaluation of sketching. When design research began, it was practically beyond discussion that what was then known as "design-by-drawing" was inadequate as a means for modern-day designers. This inadequacy was even considered the primary reason for developing new procedures of designing, which led to the birth of what would become design research:

> The writings of design theorists imply that the traditional method of design-by-drawing is too simple for the growing complexity of the man-made world. This belief is widely held and may not require any further justification. (Jones 1970, p. 27)

At this point, no distinction was made between working sketches and the final, carefully performed production drawings. Eventually there would be the occasional reference to the nature of sketching, such as those by Rittel (1972) and Graves (1977), although it was probably Schön (1983, 1987, 1988, 1992, Schön & Wiggins 1992) who started the revaluation in earnest, leading to the wide interest in sketching today (e.g. Goel 1995, Herbert 1993, Lawson 1980/1997).

The developments that have since taken place are reflected in the editions of Lawson's *How Designers Think*: The original edition is from 1980; the second from 1992 has a new chapter on designing with computers; in 1997, the third edition added a chapter on sketching with paper and pencil!

This is of course quite ironic, but it should also be seen in relation to the backlash that has occurred regarding computer-aided design, which like the new methods is still advocated as being indisputably superior to earlier procedures. When the limitations of computer tools became apparent, this contributed to the reappreciation of sketching. But the 180 degree reversal on sketching since the axiomatic rejection of "design-by-drawing" has also come from the turn away from the new design methods. The sophistication of paper and pencil became noticed only when the computer aids and new methods proved to lack the capacity that these decidedly low-tech tools had (cf. Black 1990). These developments are a prototypical example of science driven by ideals, and its shift into the sense-making approach. And central as it is, several aspects of sketching will be treated in detail in this book, from chapter 3 and forward.

### A general trend toward making sense

I perceive a general scientific trend in this kind of revaluation and in what I will call *making sense* of authentic human activities; a trend which has been slowly emerging for some time now, in diverse areas and fairly independently. Its shared aim is to understand these activities better: the performance by which people accomplish them, and the human abilities that enable them to do so. Especially, to understand *why* they are performed as they are, which is particularly important since the infallible theories have repeatedly proven incapable of what has been claimed of them. In contrast, people's outwardly simple means have repeatedly shown to work where the "ideal" methods have failed. They have often proven to be superior, if only understood on their own proper terms, not by some other inappropriate standard. Exactly this has been the case with sketching.

In design, another very good example is Guindon's account of so-called "opportunistic" design practices: from having previously been regarded as failures and deviations from correct behavior (e.g. Adelson & Soloway 1985), to being superior to the prescribed structured methods (1990a, etc.). Furthermore, there is a large number of highly useful design techniques that have been revalued in the same way, and of which sketching is only one. So-called "low-fidelity" prototypes (Rettig 1994) are one case in point; I will address a number of these techniques in chapter 6.

In other domains, probably the most important case is the reassessment of spoken language and conversation, which have long been viewed as a corrupted form of proper, written language; reified in the Chomskian competence vs. performance distinction. The epitome is perhaps the demonstration by Schegloff, Jefferson & Sacks (1977) of how "errors" in spoken language are better understood as "repair" than as signs of cognitive limitations, and thereby as an effective aspect of normal, equally effective conversation patterns, rather than as a poor derivative of written language.

Outside language, for example Hutchins (1980) has showed that the reasoning in Trobriand land negotiation is quite sensible even though it does not follow Western principles; later he did the same regarding Micronesian navigation techniques, which had previously been deemed as useless and based on native superstition and folklore (1983, 1995). A quotation reflecting the earlier view, and Hutchins' comment on it, reflect the two attitudes:

> Polynesians and Micronesians accomplished their voyages, not thanks to, but in spite of their navigational methods. We must admire them for their daring, their enterprise and their first rate seamanship. (Åkerblom 1968, p. 156)

Hutchins comments:

> I hope this chapter succeeds in laying such notions as Åkerblom's to rest. In fact, it seems more likely to me that we who have stud-

ied Pacific navigation have accomplished what understanding we have, not thanks to, but in spite of our own cultural belief systems. (Hutchins 1983, p. 224)

Elsewhere, Lave (1988) demonstrated the logic and rationality in everyday problem solving, in spite of its violating the principles of logic and rationality. Norman (e.g. 1988) made sense of people's actions in several incidents in aviation and automation, e.g. the Three Mile Island incident, attributing blame to flawed instrumentation, rather than to "human error" as is the standard procedure.

These are but a few examples of *making sense,* giving people good reason for doing what they do, when they don't do what science and engineering have dictated. After a century (at least) of measuring people by the standards of formal logic, mathematics, engineering, statistics, and so forth, we are slowly beginning to measure them on their own terms. Doing so includes the task of understanding what these terms *are*. If this approach rests on any assumption, then it is to grant people that they *do* make sense; the researcher's task is then to construe *what this sense is* that they make, not taking a certain approach for granted, whether it is because it has some desirable formal properties, or because no one considered any other option.

Perhaps the interpretation of foreign cultures was first to come up against this problem of finding the adequate standard of measure, or *yardstick* as I shall call it; only later would it be realized that the human being is not a member of the culture of formalistic, rigorous and stringent logical principles, and should not be measured within this cultural framework, but that we must first identify its own principles. It is probably no accident that the sense-making approach was pioneered by people from anthropology and related fields who entered into linguistics and cognitive science, as in the above examples.

## 0.2 Two views of cognition: Intellectual or practical?

As well as there being as there is a trend toward making sense of human activity, there is also a trend in how the sense-making turns out to portray human performance. In common-sense terms, this can be described as a transition from a view of cognition as basically *intellectual*, to one where it is instead conceived of as *practical* by nature. This trend can also be observed in models of design activity. The theoretical argument of this book can be said to revolve around the transition from an intellectual to a practical mode of cognitive explanation.





The traditional accounts have been based on an idealized norm for what cognitive performance should look like, heavily influenced by the intellectual ideal of high intelligence and abstract reasoning. In contrast, the sense-making accounts seem to unanimously paint a picture where such intelligence and abstract thinking play a quite different role. Instead, cognitive performance seems to rely on faculties that look quite mundane and primitive when seen through intellectual eyeglasses. Here it should be kept in mind, however, that also those feats thought to require and display abstract reasoning have been found to exhibit practical and purportedly primitive patterns.

### From ideal to intellectual to intramental

The "ideal" mind-set, and the view of cognition as basically intellectual, made up the very essence from which cognitive science was born. The precursors were located in formal logic and proof theory (e.g. the work of Turing), bounded rationality (Simon 1947), and so on. This early work was also intimately connected with the theoretical foundations of computer science (e.g. Chomsky 1957). When the mind was studied empirically, the chosen tasks were considered indicative of high intelligence, such as chess, logical deduction, mathematical problem solving, or tasks resembling IQ tests. An account straight from the horse's mouth can be found in the historical addendum in Newell & Simon (1972).

This strong bias naturally meant that theories also came to focus on the same kind of cerebral tasks. Thus, in this view, *intellectual* tasks and abilities—abstract thinking—were regarded as the prototypical kind of cognitive activity, i.e. which theory took as its first priority to explain. Accordingly, more mundane everyday activities, and the components of action and interaction with the world that they involve, were considered of secondary importance to cognition (and to cognitive theory). The rationale was that once the more difficult problems could be handled, then the simpler ones would easily follow—a sensible conjecture at the time.

From this focus, the influence of cerebral abilities on the theories that were developed became very strong, whereas cognitive abilities involving non-mental functions were strongly underrepresented. I will refer to these as theories of *intra-mental* cognition. With this I indicate the view of cognition as a process that is contained entirely within the mind, and which is performed by the mind alone, cognition being strictly isolated and separated from action, perception, and every aspect of the surrounding world, be it material, social or cultural. In this view, the study of cognition is often defined as the study of mental processes, and the two are thus considered equivalent.

In summary, there is a natural link from the ideal view of cognition, via the emphasis on intellectual activities, to the view of cognition as intramental. This position will be treated in detail in chapter 1.

### Problems with the intramental view

The intramental focus would not have been a problem if only the resulting theories could also be made to account for other types of activity. However, whereas they have been able to account for intramental abilities and processes in a simple and natural manner, explanations of non-cerebral activities have been significantly more belabored and less convincing.

The exact reasons for the failure of intramental theories to account for factors outside the mind remain to be fully understood, but it seems (although this is still widely contested) that the focus on the isolated mind has resulted in a skewed conception of the tasks that were studied (related to the issue of ecological validity), which in turn came to give the theories deeply seated peculiarities that prevented such a satisfactory extension (cf. Hutchins 1995).

The most striking example of a not-so-convincing explanation is how the cognitive role of the physical world has been accounted for, by treating the world as an extension of long-term memory, while at the same time considering long-term memory as a part of the environment (Newell & Simon 1972, Simon 1981). But however bizarre this explanation appears, there seems to be no better alternative, given the foundational assumptions of these theories. Even more interesting is that the proponents of this view see no problem with this explanatory approach. In fact, this remains the official explanation to this day (see e.g. Goel 1995, Larkin 1989, Larkin & Simon 1986, Newell, Rosenbloom & Laird 1989, Vera & Simon 1993).

Historically, cognitive science began with theories of pure thought and intellectual activity, to which interaction with the environment was added later, e.g. in Newell & Simon's (1972) theory of problem solving, and the model of planning in the work of Miller, Galanter & Pribram (1960), but for which no proof of concept has ever been provided. I believe the question of what caused this failure to be an important one, which must be settled before we can put these theories and their hidden assumptions behind us, so as to make progress





and not make the same mistakes again. This is also necessary if we are ever to move beyond general criticism and vague claims that "one must also take social and cultural factors into account", etc. For example, it is quite widely recognized that Information Processing Theory (Newell & Simon 1972) has proven inadequate as a fundamental theory of cognition. However, the standard diagnosis is that its problems are located in the computer model of mind and the symbolic view of cognition. As will become evident, much of this book revolves around the question of exactly *what* caused the problems and rendered these theories deficient. As I will argue in detail, although these features are problematic, they are not the crucial defects.

The heart of my diagnosis, which I will present in chapters 1–3, is that *intramentality* is the culprit. Even among those who reject information processing theory, the view of cognition as *pure thinking*, which I consider to be the central problem, remains widely unchallenged in the belief that symbols and so on are the real problem.

I believe this is much because the intramental character hasn't been explicitly stated or advocated to the same extent. In comparison, Newell & Simon expressly described their theory as symbolic and computational, and these aspects have also been discussed by many others. The bottom line is that if only the usual suspects are charged and discharged, then the real culprit remains at large, continuing to cause the same trouble as before.

Accordingly, when I refer to "traditional" cognitive theories, or "conventional" cognitive science, etc., it is by the criterion of *intramentality* that I define these terms. This is a small but crucial shift from the current view where the defining characteristics of "traditional" cognitive science are held to be precisely the computer model of mind, symbols, and information processing theory. My shift in reference is of course based on the point that intramentality is the problem, and not these factors.

### From practical to interactive

In contrast to the intellectual perspective, there is an alternative approach where cognition is seen as fundamentally *practical* by nature. Accordingly, in this view practical activity is considered more fundamental to cognition, and so, the theory gives a higher priority to explaining practical activities and abilities.

### Some philosophical precedents

The contrast between the intellectual and practical positions is reflected in a number of prominent historical debates of 20th-century science and philosophy, the issues of which will at least implicitly reappear in what follows. Early among these, beside the pragmatists, are the respective views of Husserl (1900/1970), who based his work on the phenomenology of mathematics, and Heidegger (1927/1962), who countered him by arguing that non-reflective being is the fundamental mode of existence, and abstract thinking and reflection being the result of a disturbance, causing you to be "thrown" out of the basic mode of just doing (also cf. Dreyfus 1991).

Later there would be the contrasting views of knowledge as linguistic/propositional and explicit vs. knowledge as tacit/implicit and based in practical activity (Dewey 1925, 1933, Polanyi 1958, Schön 1983). These are also referred to as *knowing that* vs. *knowing how*; which are clearly the intellectual and practical views of knowledge, respectively. The antagonists personified in the early and late Wittgenstein should also be mentioned. Again, this list is by no means exhaustive. As part of the turn toward the practical dimension there is of course a revaluation of non-intellectual activities as being "worthy" of scientific attention; cf. the discussion of "making sense" above.

### The evolutionary perspective

Beside the ability to explain cognition better, the choice of giving theoretical priority to non-intellectual cognitive abilities is often motivated with evolutionary arguments: the skills that are uniquely human have developed from the more fundamental capacities that we share with other species. A second tenet is that these "lower" capacities are more powerful, and play a more important role, than intuition tells us, even in those tasks that we instinctively tend to consider simply as "thinking".

This goes counter to the intellectualist take on evolution, which holds that humans, unlike lower species, have a monolithic mental module defined in their genes, which gives us all the intramental abilities that make humans special: language, propositional attitudes, problem solving, and so on (cf. Anderson 1983, Donald 1991). The problem with this view is of course that it places a magnificent burden on evolution, in requiring this mammoth structure to have appeared out of nowhere in humans, with no intermediate evolutionary forms, which is otherwise virtually unheard of in evolutionary biology.

The practical view can cut the "uniquely human" stuff into smaller chunks, seven or so, and distribute parts of the explanatory burden from genes and intramental faculties onto material and immaterial human culture, yielding these abilities *in co-evolution with* species-inherent genetic progress. The result is an account that is much easier to swallow, not only in evolutionary terms, but also in terms of how cognition could attain the human capacities.

### The practical view of cognition

In a scientific context, the difference between these positions mainly concerns what theoretical explanations should look like. In the intellectual view, theory should be based on the explanation of thinking and abstract skills of the kind mentioned above, whereas in the practical view, cognitive theory is built around practical skills and authentic activities. These serve as the basis for explaining intellectual abilities as well, which are also seen as essentially practical, albeit refined, skills which remain dependent on action and the physical world for their operation (think pen and paper—also cf. e.g. Agre & Chapman 1987, Hutchins 1995). Also, they are at least partly of cultural origin, and to some extent acquired rather than innate. Hence, here it is instead *intellectual* abilities that are considered as "specialty cognition" and that are explained in terms of practical skills, instead of the other way around. This is what it means for either kind to be considered fundamental.

## Redefining cognition

A major share of this book is devoted to presenting a cognitive theory based on this point of view; I can here merely give a hint of what it will look like, and I will do this in terms of a contrast with conventional, intramental theory. Speaking in general terms, the theory amounts to not defining cognition as narrowly as just thinking. As a result of the historical emphasis on a narrow view, we have come to a point where today many find it hard to imagine how cognition could include something other than strictly mental activities, and what this would then signify; this is an issue that I will also discuss in later chapters.

## The extended ontology of cognition

The extended view can be described along two dimensions: one extends cognition to involve other *entities* than the mind, the other spans a wider set of *activities* than merely intramental processes. The first, material dimension is the more tangible one. Here I will claim

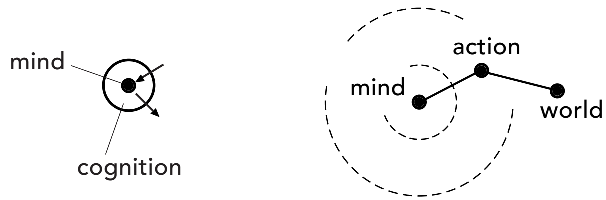


**Figure 0.1** Simplified schemas of the traditional, sharply delimited view of cognition as an intramental process, and the wider and less distinctly circumscribed view of cognition adopted here.

that not only the mind but also action and the physical world have roles in cognition. Schematically, interaction realizes the link between mind and environment in the cognitive process. The two views of cognition can be represented diagrammatically:

## The activity dimension

However, this extended "ontology" of cognition is not as significant as the less tangible dimension of *activity*. The most consequential statement of this book is that cognition shouldn't be regarded as thinking (a mental process), but as an activity of *inquiry* (derived from, but not a faithful replica of, Dewey's theory of inquiry, e.g. 1929, 1938, 1949, also cf. Schön 1983, 1987). The most important idea is that there are various activities that are not intramental but which nevertheless have a partially or predominantly cognitive function—or more correctly, that *most* activities have such a cognitive function, as well as having the physical effects which we normally associate with action.

In such activities, action and physical materials are necessary parts, which make these activities possible rather than being the crucial elements in themselves. To make a crude analogy, what makes a pocket calculator more powerful for arithmetic than a pencil is not that it is based on silicon rather than graphite, or that you press plastic buttons instead of moving a piece of wood; these are merely the means which realize the *function* of the calculator. It is this function which is more advanced (for arithmetic). Conversely, it is not graphite that makes pencils superior to computer-aided design for the conceptual stages of design work.





## Viewing cognition in terms of function, not ontology

Above all, I advocate that cognition should be defined in terms of function rather than ontology or physical location. In precedence to the extended view in the figure above, cognition should be regarded as the adaptive abilities with which it equips us, rather than as the things that go on in our heads.

This also implies that the entities that are part of cognitive explanations will *vary* with the specific functions that we are explaining. For example, I will be concerned with functions in which the explanations need to include single individuals, more or less, and their activities and working materials, whereas others may study functions that involve, say, multiple actors and artifacts working in concert, as Hutchins has done (1990, 1995). Conceiving of cognition in terms of function rather than ontology means a theoretical shift from realism to instrumentalism that in my view has been long overdue (but which should not be confused with the kind of functionalism that has been popular in cognitive psychology, cf. Clancey 1997). However, this is much harder to represent in a diagram than the three entities of mind, world, and action.

The main fallacy is committed when the unit of analysis chosen entails that cognitive functions are wrongly attributed to the mind instead of other entities (cf. Hutchins 1995, chapter 9). This will give us a theory which mistakenly equips us with superfluous modules because their genuine location isn't eligible for cognitive explanations. This is done for example when something is placed in long-term memory because the environment cannot be made part of the cognitive system. This will yield a view of cognition and the mind which is fundamentally mistaken. The aim is thus not to eliminate the mind from cognitive explanations, but also among other things to yield a better model also of the mind and its function. Such a model is however beyond the scope of this book.

The contrast between the two perspectives and their respective theories makes up the axis around which this book revolves. My argument will concern, on the one hand, the problematic aspects of the conventional view, and an effort to make clear the roots of its problems; and on the other hand, my alternative account, which addresses these problems.

Here, design provides cognitive science with a rich, authentic domain on which to build such a cognitive theory; correspondingly, the cognitive perspective can with such a theory provide design research with an explanation of authentic design processes. This is the synergy which I have tried to engender on the following pages.

## 0.3 Outline of chapters

The general organizing principle of the book is to move from the existing, ideal-oriented theories successively toward my alternative model and then into its finer points. I first present the conventional theories and dissect them to expose the anatomy of their defects. This is done in chapter 1; the failures are introduced in chapter 2, and the discussion of the conventional theories is concluded at the end of chapter 3. However, before that I begin building my alternative explanation in chapter 3, with the rest of the book going deeper into these issues in chapters 4 to 6, with a brief last chapter that looks back in conclusion at the overall argument, and addresses the wider implications of this.

#### 1. The masterplan

The main topic of the first chapter is a "dissection" and critique of the existing, conventional theories, mainly of cognitive science but also of design research, the result of which lays the foundation for my alternative that is to follow. In chapter ch1 I present the conventional theories in order to disclose their tacit key principles, but also to show that they are in fact *the same principles* in the theories of both cognition and design. As I demonstrate there, these theories and a number of others of the "ideal" lineage are all based on the same underlying model of ideal rationality and ideally rational action. Chapter 1 serves to make this model explicit, and to expose its constituting principles and inherent problems.

#### 2. The general failure of design methods

This analysis then provides the basis for showing *that* these theories fail, in chapter 2, and then *why* they fail, in the last part of chapter 3. The upshot is that the failure of the "ideal" theories is inherent in the underlying model from chapter 1; and that the problematic principles cause the same failures to occur whenever these theories are put to work for their intended purposes.

In the rather brief chapter 2, the purpose is firstly to establish the general and complete failure of design methodology. Since this has been thoroughly documented by design theorists, I only make this point briefly, with reference to their original works. The second purpose is to show that this failure can be traced down to the original geometrical proofs and the domain of formal logic in general. This also goes to show that the failure can be traced to the underlying model of rational action. As the exposition and critique of this model in chapter 1 is rather thorough, much of chapter 2 consists in demonstrating that the principles of the underlying model of rationality indeed are the reasons for its problems.

#### 3. Design and cognition as inquiry

After that, chapter 3 goes on to analyze actual design work, and introduces the fundamentals of my alternative theory in order to capture and explain this. It begins with the contrast between on the one hand the "ideal" view of the problem (or requirements specification) being given already before design begins, and on the other hand that in actual design projects, the task of problem definition amounts to the largest, most difficult, and most important part of the design task.

My alternative draws on the pragmatist view of knowledge, and in particular the theory of inquiry, originating in the work of Dewey (e.g. 1929, 1938, 1949) and then updated and made known in relation to design by Schön (e.g. 1983, 1987). The core idea is that inquiry is an aggregate process with several component functions, *one* of which is action. Hence, in this view cognition consists in inquiry, including all these component functions. It thereby amounts to a composite, physical and concrete activity; this in contrast to the view of cognition as pure thinking, as in the conventional model presented in chapter 1.

At the end of chapter 3, I put the separation of the conventional view in contrast to the compound nature of inquiry, showing that design (and cognition in general) cannot consist in pure thinking, as conventional theory requires. This is why the rational model of action, and the descendant theories of e.g. cognition and design, all fail: abstract thought alone cannot perform the cognitive task required of a designer. The main introduction in this chapter is the elements of the theory of inquiry; in particular, I introduce the notion of a second, “inquiring” or cognitive purpose of action, which will then make up a key element of the theory, and a central concept in the rest of the book.

**4. The cognitive roles of action and world**

The remaining chapters are concerned with developing my alternative theory and the concepts introduced in chapter 3. The underlying idea in these chapters is of a cognition which comes to include both action and world, with their having cognitive functions and being parts of the cognitive process. Here, sketching is taken as a prototypical physical design activity that is to be explained in this way. The chapter also addresses the question what the roles of these two are; how they *can* have cognitive roles, even, as this extended view of cognition is somewhat counterintuitive.

The explanation I present for the cognitive role of action and world I have tentatively given the name *interactive cognition*. The strategy for this presentation is similar to that of chapter 1: beginning on the surface with the most basic and general issues and then going successively deeper into the finer details. This begins in chapter 4 with a first sketch of what the theory means through an analogy with written and spoken language, where these correspond respectively to intramental and interactive cognition.

**5. Interactive cognition**

Chapter 5 then goes on to the particulars of the theory. It is framed as an explanation of *why* design activity follows an interactive structure. This is because it *brings important advantages* over working as intramental theory says; since in a sense, interactive cognition works better than an intramental kind would. As in the rest of the book, the theoretical motivation is made on general cognitive grounds, and is not restricted to the domain of design.

This why-argument is presented as four steps, where each represents a certain type of advantage brought by involving (inter)action in the cognitive process; also these steps go from general to successively more narrow and particular. Each consecutive step is made possible by the previous ones, and brings the advantages to a new level; For instance, the first step concerns the advantages brought by addressing the *actual* world instead of dealing with a mental representation—a surrogate—of the world; and the second step adds to that the ability to employ *action* for cognitive purposes, where this corresponds to the inquiring or cognitive function of action.

**6. Making the world a part of cognition**

Chapter 6 turns from interactive cognition in itself to the role of the world in this scheme; in doing so, I introduce the notion of a second, inquiring function also of physical materials (i.e. the world). Here I analyze a number of well documented and widely used design techniques that heretofore lack a proper explanation, for instance of why they are so useful; particularly so since they go counter to existing theories. Although the techniques are quite diverse on the surface (e.g. prototypes, scenarios, simulation, storyboards, participatory design), chapter 6 will demonstrate that they can all be explained as serving to *make the world a part of cognition*. Along with this argument, I also analyze what aspects and properties of the world they re-create, and what their contribution to cognition is, and in particular, the *relation* between their properties and cognitive contribution. This then serves as a closer examination of just what the cognitive role of the world consists in.

**7. Intermission**

In the concluding chapter, I elaborate on the theoretical implications of the techniques from chapter 6: They even go beyond simply using the world in cognition, since they all go to a certain length to *create* working materials that can be given cognitive roles. This means that designers go to some length to even *avoid* having to work intramentally, as the usual theories claim they should do.

This is quite a strong argument against cognition being fundamentally intramental, and thus in support of my extended view of cognition (and design) as inquiry. I thereby briefly address some potential counterarguments from the intramental camp. Hence, I conclude the book by returning to the bigger issues and the debate on whether cognition is fundamentally intellectual or practical. It will however hardly be the last word in this matter.