core body of knowledge about design that is largely beyond contention. The
reader should be assured that although this book will use design in unconven-
tional ways and stretch it beyond the limits of the traditional design disciplines,
we will be building on a solid knowledge base that has been amassed over all
these years of design research. It is this strong foundation that gives us the self-
confidence to build bridges to other disciplines that have become interested in
design practices.

Not all design is good design
In pointing out the value of learning from “design practice,” we do not mean to
suggest that all design is good or that all designers are equally skilled in these
design practices. As in any profession, there is also superficiality and medi-
ocrity in design—and many designs that make up our human-made world are
hard to defend, even inexcusably awful. What we will be focusing on here is the
practice of a select group of top professionals in the field.

WHAT IS THE PLACE OF DESIGN IN THE GREATER SCHEME OF
THINGS? DESIGN AS A FORM OF REASONING
The case studies in chapter 2 show the strength and possibilities that a design-
erly approach can bring to a wide variety of problems. As we’ve seen, it is very
fruitful to look at problematic situations in a way that moves beyond conven-
tional problem-solving approaches, and to consider these problem situations
as if they were design problems. The designers and artists who were involved
in the YD/ and DOC projects somehow regarded these very complex problems
differently from the people who had tried to solve them before. But what, then,
is the core reasoning pattern they apply when they design? Is it really that dif-
ferent from conventional problem-solving?

This is a fundamental question which cannot be answered by giving exam-
pies alone. We need a bit of logic to help us attain a much deeper understanding
of the reasoning patterns behind design practice. We need to step back and sus-
pend the “rich” descriptions of design that make the case studies such a good
read, and take the question of design reasoning back to its very basics. Formal
logic can provide us with a simple group of core concepts that describes the
reasoning patterns behind design and other professions. This “poor” descrip-
tion of design helps us to understand whether design is different from other
fields, and provides us with fundamental insight about the value of introducing
design practices into other professional fields.
To penetrate to the core of design thinking, we look at the way fundamentally different kinds of reasoning are described in formal logic, in particular, the way Roozenburg and Eekels (1995) have taken the classic work of the pragmatist philosopher Peirce into design research. At the very simplest level, we can consider the world to exist of “elements,” such as people and things, and connections between these elements, captured in a “pattern of relationships” that we can observe through the interactions of these elements, and the “outcome” of a process in which the elements have interacted. This is very abstract—but as an example, we can look at the original problem situation of a complex case study like Kings Cross and see all the elements in the situation (the police, the various groups of youngsters, the clubs, the physical characteristics of the public space) interact with each other in certain patterns that define stable relationships—patterns of interaction which in this case are leading to an unwanted outcome, the problems of drunkenness and violence. This three-way distinction between “elements,” “patterns of relationships,” and “outcomes” gives us enough conceptual tools to analyze the four basic reasoning patterns that humans use in problem-solving, and to show that design reasoning is really very different from the other three. We will analyze these ways of reasoning by simply comparing different “settings” of the knowns and unknowns in the basic equation,

\[
\text{WHAT} + \text{HOW} \quad \text{leads to} \quad \text{OUTCOME}
\]

(elements) (pattern of relationships) (observed phenomenon)

The four basic ways of reasoning that we will compare are deduction, induction, (normal) abduction, and design abduction.

\textit{Deduction—solid reasoning from cause to effect}

At the start of a process of deduction, we know the “elements” in the situation, and we know “how” they will interact together. This knowledge allows us to reason toward an outcome. For instance, if we know that there are planets in the sky, and we are aware of the natural laws that govern their movement
within the solar system, we can predict where a planet will be at a certain time. The calculations to support this prediction are very complicated, but in the end reasoning deductively toward a prediction is not problematic. With our knowledge of the elements in the situation and the pattern of their relationships (as defined by the laws of gravity), we know enough to safely deduce the outcome. Our forecast can be verified by observations, confirming that we have considered all the players in the situation correctly and have a sound grasp of the pattern of relationships through which the sun and the planets in the solar system interact. Of all the reasoning patterns we humans have at our disposal, deduction is the only one that is rock-solid. In terms of our simple equation, the starting position for deductive thinking looks like this:

\[
\text{WHAT} + \text{HOW} \quad \text{leads to} \quad ???
\]

*Induction—discovering patterns*

Matters begin to look slightly precarious in the next reasoning pattern, induction.

\[
\text{WHAT} + ??? \quad \text{leads to} \quad \text{OUTCOME}
\]

At the start of the reasoning process, we again know the “elements” in the situation, and—if we take the planets as an example—we know the outcome of
their interactions in the sense that we can observe their movement across the
night sky. But suppose we do not yet know the laws of gravity, the pattern of rela-
tionships that governs these movements.... Can we use our observations of the
movement of these planets to formulate such a law? We can't logically deduce
such a law from observations. But we can observe the movement of the planets,
and create meticulous descriptions. Those descriptions can inspire us to think
deeply about the underlying patterns that could cause this behavior. The formu-
lation of laws that explain this behavior is fundamentally a creative act, where
the pattern of relationships is dreamt up and proposed.

Induction is crucial in the progress of science: astronomers propose different
working mechanisms ("hypotheses") that could wholly or partially explain the
observed phenomena, and test them by using the hypothesis to predict future
outcomes, and check whether the hypothesis is true by matching it with observa-
tions. In the formulation of these predictions, we can again use the solid reason-
ing pattern of deduction: knowing the elements in a situation, and proposing a
pattern of relationships between these elements, we can do our deductive calcu-
lations and predict where a planet will be in the future. Then we can wait until
that moment arises, observe the planets again, and check whether the prediction
was correct or not. If the planet is indeed where the hypothesis said it would
be, we can cautiously say that the proposed pattern of relationships could be
true. If the planets are not where the hypothesis projected them, the astronomer
will have to come up with another possible theory of how these planets interact,
and again use the power of deduction to test the new proposal. The progress
of science comes from endless discussions between scientists who challenge
and prove false each other's hypotheses until there is agreement that a certain
proposed pattern of relationships is probably "true," because it matches current
observations.

Detectives work in much the same way, or at least they do in novels: there
is a group of "elements" (the suspects), and there is the undeniable fact of the
dead body (the outcome of an unknown process). To find out what happened, the
detective needs to create scenarios about how the murder might have happened,
and scrutinize them through deduction (would this scenario of interactions have
led to the murder, and the position of the body in the exact circumstances in
which it was found?). This is pure induction, a creative act—even though Sher-
lock Holmes adamantly denies this creativity, claiming that it is all "deduction,
my dear Watson." But by deduction alone, Sherlock Holmes would never have
arrived at the scenario which exposes the murderer. Like detectives, scientists
seem embarrassed being caught creatively guessing how something might work,
and tend to claim authority by presenting their work as purely deductive (Kuhn 1962; Latour 1987). But it really isn’t, and it fundamentally can’t be.

Deduction and induction are the two forms of reasoning that we have at our disposal to predict and explain real-world phenomena, and they have driven our understanding of the world immensely. But deduction and induction are not enough if we want to make something. If we want to create valuable new “things,” as in design and the other productive professions, the basic pattern of reasoning is called “abduction.” In abduction, we set out to create a new “what”—a new “element” for the problem situation—so that the interactions in the system lead to a desired outcome. Abduction comes in two forms. In both forms, we already know at the beginning of the process something about the outcome of the equation; that is, we have an idea about the value we aim to achieve with the creation of the outcome.

*Normal abduction—solid problem-solving, based on experience*

In normal abduction, we know the result, the value we want to achieve through the desired outcome, and also the “how,” a pattern of relationships that will help achieve the value we seek. The missing element is a “what” (an object, a service, a system), which still needs to be created. For example, faced with an undesirable situation of late-night violence in Kings Cross, we can choose to work within the established pattern of relationships for crime reduction, and send more police into the area in the early hours of the morning. Or we could—still within the same pattern—set up a training program for security personnel in which they learn to spot possible offenders more quickly. This is often what we do, create a solution within a fixed pattern of relationships. In this type of abduction, the degree of innovation will be limited because the problem-solving process doesn’t question the “how,” and therefore excludes the creation of
new scenarios. Normal abduction is the reasoning pattern behind conventional problem-solving—using the tried and tested patterns of relationships to reach a solution. And this should not be dismissed: often the patterns of relationships that have been developed over many years of problem-solving efforts are more than adequate to deal with the problem situation at hand. But sometimes this type of routine reasoning doesn’t lead to the desired value anymore, and we will have to think about the problem again. That brings us to the second type of productive reasoning, design abduction.

*Design abduction*—two unknowns lead to a process of creative exploration

In design abduction, the starting point is that we only know something about the nature of the outcome, the desired value we want to achieve. So the challenge is to figure out “what” new elements to create, while there is no known or chosen “how,” a “pattern of relationships” that we can trust to lead to the desired outcome. Thus we have to create or choose both a “how” and a “pattern of relationships.” As these are quite dependent on one another, they should be developed in parallel. This double creative step requires designers to devise proposals for both the “what” and the “how,” and test them in conjunction.

An example can help to clarify the difference between the two types of abduction: say that the outcome we want to achieve is an energy rush when coming to work in the morning. In normal abduction, we would also already know the “how,” say that this is to be achieved through coffee—and we might even have a proposed method of brewing coffee (dripping, squeezing, using steam) so we can start developing a “what,” engineering the machine to make the coffee for us. In design abduction, on the other hand, we would only know the goal (quick rush of energy before work) but not know how to achieve it. Hence, if we go for coffee, we would still need to choose a brewing method, create a design for a machine, and then judge whether this would do the trick.
(Is it quick enough? Is it economical? Is it environmentally OK?). If none of the coffee machines we can think of will satisfy the criteria, we might need to start considering other ways of creating the energy rush.

To sum up: this comparison establishes the design professions as thinking fundamentally differently from fields that are predominantly based on analysis (deduction, induction) and problem-solving (normal abduction). But this distinction is not as clear-cut as it may seem from this logical analysis. In the real world, design practices involve a mix of different kinds of thinking—including inductive and deductive reasoning and normal abduction—that are the fundamental building blocks of conventional problem-solving. But there is a real fundamental difference, too—the nature of design abduction that sets the design practice apart from those of other disciplines. The heart of the distinction between design and conventional problem-solving can be illustrated by comparing two problem situations (Hatchuel 2002). Picture a group of friends on a Saturday night. The first problem situation is that they are “looking for a good movie to see,” and the other scenario is that they set out to “have a good time.” Hatchuel argues that the first situation can be dealt with through conventional problem-solving, but that the second requires design abduction. He lists three important differences between these situations. The first difference is that the design abduction situation includes the expansion of a key concept by which the situation was initially framed (“a good time”). This reasoning process requires a design process instead of a one-off choice of which movie to go to, from a limited set of alternatives (the movies that are playing that evening). There is no dominant design for what a “good time” would be, so imagination is needed to arrive at a definition. A second difference is that the design situation requires the design and use of “learning devices” to reach a solution. These “learning devices” include (thought) experiments and simulation techniques, in this case imagining different scenarios for going out. Third, designing the understanding and creation of social interactions is part of the design process itself. The group of friends needs to develop a way to imagine a solution, to share this view with one another, to judge the solution, and to decide which way to go (and experience shows that this process is not always easy). The process that these friends are going through undoubtedly includes stretches of conventional problem-solving, but it also contains these other “design” elements.
WHAT MAKES DESIGN HARD? PROBLEMS AND PARADOXES

Many issues that we encounter in our daily lives and professional practices never reach the status of “a problem.” If the issue is quite simple and we have an obvious scenario in our repertoire to deal with it, we just get on with it and act. A “problem” occurs only when we either do not know how to progress or our chosen way of working gets us stuck. Then we have to stop and think, devise and critically consider options, perhaps be strategic and create multistep plans, do scenario planning, etc. Problems occur when something blocks our normal flow of how we deal with the issues in life. This “something,” the counterforce, is bound to have its own background and rationale—at the core of really “hard” problems is a paradox. The word “paradox” is used here rather loosely, in the sense of a complex statement that consists of two or more conflicting statements (Dorst 2006). All the statements that make up the paradox are (possibly) true or valid in their own right, but they cannot be combined for logical or pragmatic reasons. There are three ways forward. The first option is to choose one side of the paradox and let it take precedence over the other. There is also the option of compromise, where negotiation might lead to a decision that sits near the halfway point between opposing needs and views. The third way forward in these tough paradoxical situations, where there is a real clash of views, standpoints, or requirements, is to redefine the problem situation. Designers do this very well. In her book *Ethics in Engineering Practice and Research*, Caroline Whitbeck (1998) remarks, “The initial assumption (within moral philosophy) that a conflict is irresolvable is misguided, because it defeats any attempt to do what design engineers often do so well, namely, to satisfy potentially conflicting considerations simultaneously” (56).

This observation is borne out by the case studies in chapter 2—somehow, the designers and young artists managed to wriggle out of confounding problem situations that had, in some cases, already existed for a very long time, and created a position from which the problem situation could be steered toward a solution. This accomplishment is in stark contrast to a conventional problem-solving approach, where the problematic situation cannot be redefined because the way the solution must work (the “how,” its “pattern of relationships”) is already fixed. This is the serious limitation of the normal abduction used in conventional problem-solving. The conventional problem solver only has the options of giving one side of the paradox precedence over the other or creating a compromise between the two positions.

The challenge of dealing creatively with paradoxes is one of the aspects that makes design so fascinating and captivating. Unresolved paradoxes can
capture our attention to the extent that we cannot help thinking how to resolve them. Paradoxical problem situations inspire the creative imagination, much like the famous koans that are used in Japanese Zen training to provoke people to defy rationality and free their minds. While koans are beautiful and poetic, the challenge to come up with a sensible response can also be intolerable (Van de Wetering 1999). The mind-boggling nature of paradoxes and the difficulties they cause for our everyday thinking skills also make paradoxes a fascinating intellectual toy for linguists, logicians, and mathematicians (Hofstadter 1979). But that is not the way we want to talk about paradoxes in this book. Here we deal with real-world paradoxes that are caused by conflicting values and needs on the problem side, or by the incommensurability of design outcomes on the solution side.

In real-world situations, paradoxes are particularly formidable when the needs, interests, and “object worlds” (Bucciarelli 1994) are rationalized by different stakeholders. These perceived rationalities become a problem when a personal or institutional worldview is seen as the only one possible, making life hard for the problem solver, who is caught in the middle. Yet as Whitbeck has observed, designers can somehow deal with these knotty problems. In the Young Designers project on Integrated Living (case 5), the care organizations unquestioningly believed that part of their responsibility was to protect the mentally handicapped people in their charge. And they rationalized this “responsibility to protect” to include “complete control over their environment”—even if this meant isolating the mentally handicapped in their city residences. This result is, of course, completely at odds with the government objective of integrating these mentally handicapped into society. By being isolated, the mentally handicapped are further removed from companionship than ever (in the old days, they would at least have had each other to talk to) and are very far from being able to lead “normal” and “rich” lives in society. The paradox is complete. But one can see where some assumptions of the care organizations could be questioned, “cracked open,” and investigated. Does “care” really mean “protect,” and does “protection” really mean “control”? The government side of the paradox also needs to be unlocked: What are the assumptions that informed the ministry’s thinking, in particular the presumed need to integrate mentally handicapped people in society? Are these assumptions valid? And what are the ministry’s preconceptions about the role the care organizations would be playing in the new situation? Revealing the core paradoxes provides designers with an entry point for examining these assumptions.
In questioning the established patterns of relationships in a problem situation, design abduction creates both a new way of looking at the problem situation and a new way of acting within it. This comprehensive new approach to the problem situation is called a “frame” within design literature (see Schön 1983, and appendix 2). Expressed in terms of the concepts in our logical formula, a frame is the proposal through which, by applying a particular pattern of relationships, we can create a desired outcome. If we go back to the earlier example, the problem of creating an energy rush at the start of the work day, then the choice of a chemical stimulus (caffeine) as a way to feel energized is the frame, the approach to the problem. But this problem might be reframed by proposing that there are also social ways of being energized (by an inspiring conversation), or by delving deeper and saying that what we really are looking for is not so much the energy rush, but a level of concentration—in which case, meditation would be a way to achieve the clarity of mind that is otherwise achieved by drinking coffee.

We call the act of proposing such a hypothetical pattern of relationships “framing.” Framing is the key to design abduction. The most logical way to approach a paradoxical problem situation is to work backward, as it were: starting from the only “known” in the equation, the desired value, and then adopting or developing a frame that is new to the problem situation. This framing step is intellectually similar to induction: after all, we have seen that in inductive thinking a pattern of relationships is also proposed and tested. Once a credible, promising, or at least interesting frame is proposed, the designer can shift to normal abduction, designing the element that will allow the equation to be completed. Only complete equations with “elements,” “pattern of
relationships,” and “desired outcomes” in place can be critically investigated, using the powers of observation and deduction to see if the “elements” and “frame” combined actually create the desired outcome.

In our Kings Cross example, strengthening the law enforcement approach didn’t result in a desired outcome. But the metaphor of the “music festival” introduced a whole new set of relationship patterns (about access, crowd management, the creation of a benign atmosphere, etc.) that could be applied to the Kings Cross situation, and led to the introduction of new elements in this public area (such as signage, Kings Cross guides, public toilets). We can only learn whether the metaphor of the “music festival” is fruitful by implementing these new elements that flow from this frame, and observing whether the desired outcome of a more peaceable and less violence-prone nightlife in the area is achieved. Until it is thus tested, the proposed frame is just a possible way forward.

Earlier research into design practices (appendix 2) has shown that designers indeed spend a lot of time reasoning from desired outcomes via frames to possible design solutions, and go back again to reframing the problem when they suspect the design solution is inadequate. This reasoning pattern leads to the above-mentioned phenomenon of designers playing around with ideas, tossing up possibilities (proposals) for frames, relationships, and solutions in what may look like a childishly playful hit-and-miss process. Yet in doing so, design practitioners try out and think through many possibilities, building up an intuition about what frames might work in the problematic situation before they pursue one in greater depth. We have seen in the case studies of chapter 2 that designers naturally think beyond the current context (often much to the surprise of the other stakeholders, as in the “integrated living” case study). Designers realize that a real-life paradox is completely contradictory only in a certain, predefined context. Strategies to move forward from a paradoxical situation are based on the investigation of this context, exploring the assumptions that underlie the paradox.

This is a process of thinking around the paradox rather than confronting it head-on. The solution is not within the core paradox itself (which is stuck in closed definitions), but in the broad area of values and themes in the context surrounding the paradox. The richer this context, the more chance that fruitful avenues can be found to move forward. Thus, the very same properties of problem situations that are so challenging to conventional problem-solving—the open, complex, networked, and dynamic nature of contemporary problems that
was mentioned in chapter 1—actually provide a rich field of opportunities for people with a designerly bent of mind. They need this richness to create a new approach from which solutions are possible.

In creating a frame, or a novel standpoint from which a problem can be solved, a design practitioner will say: let’s suppose we use this particular pattern of relationships (in Kings Cross, the pattern was a “music festival”) and see if we can achieve the outcomes we are aiming for. As Einstein once said, “A problem can never be solved from the context in which it arose.” Apart from the obvious circularity of this statement (if the issue could be solved in its original context, it would probably never have registered as a problem), there is some wisdom here as the statement highlights the need for a problem solver to look at the context in which the problem was formulated. By looking at a broader context, the designers in these cases could frame the issues before them in a way that made the problem situation amenable to solution.

AN ANATOMY OF DESIGN PRACTICES

Design is a very broad field. In this book we are just looking for those elements of design practice that are potentially useful for dealing with open, complex, networked, and dynamic problem situations. Before selecting salient practices, we need a brief anatomy of design. Below, the core categories of design activities (figure 3.1) and the levels in design thinking (figure 3.2) are used to lay out the huge variety of design practices.

First of all, design practices are shaped around five general activities, starting with (1) **the formulation**, or identification, of the issues in a problem arena, which are then often framed in a new manner. (2) **The representation** of problems and solutions (in words, sketches, and sophisticated visualization techniques) allows the designer to develop his or her ideas in conversation with these representations. Designers tend to use multiple representations in parallel, where each representation highlights certain salient features of the solution that is under development. (3) **The moves**, or design steps taken, in manipulating the problem and creating solutions can be entirely original, part of the designer’s repertoire, or in line with common design practices. (4) To keep a design project on track, there is an almost continuous **evaluation** going on. Early on in the project, this evaluation necessarily has an informal and