

## Management as a Design Science Mindful of Art and Surprise

A Conversation Between Anne Huff,  
David Tranfield, and Joan Ernst van Aken

*Huff:* Management is a relatively young profession and a young field of study. For some time, there has been an interest in “design” as a primary descriptor of management practice. Herbert Simon described management as a “design science” in *The Sciences of the Artificial*, first published in 1969 and reissued in a third edition in 1996, yet the specifics of design have not been clear to me, especially as the basis for action.

My interest in design was recently piqued by David Tranfield, professor of management at Cranfield School of Management, who then introduced me to the work of Joan (pronounced “Johan” for those of you not familiar with names from the Netherlands) van Aken, professor of organization and management at Eindhoven University of Technology. van Aken’s work was very interesting, but I wasn’t initially convinced that management conceived as design could incorporate two metaphors for management that I have been more inclined to use: an “artful” blend of resources and action and the “capacity to respond to surprise.”

The following conversation with David and Joan provided a convincing positive answer. We discuss the definition of design, its importance, the art of design, its capacity to deal with surprise, inevitable limitations, how theory is involved, and a vision of the future. I hope that readers will find the basic idea as significant as I do.

### THE NATURE OF MANAGEMENT DESIGN

*Huff:* Joan, I really liked your articles. Can you summarize the key aspects of management as a design science, from your perspective, to start our conversation?

*van Aken:* I am happy to do so. First, a distinction must be made between the role of design in management practice and the idea of regarding the academic discipline of management as a design science. Management practice has been defined as the art of getting things done by people (Mary Parker Follett). Managers often do that without much reflection or design, acting directly on the basis of their tacit knowledge, intuition, and creativity, honed by experience. However, looking before you jump, reflecting on your intentions, and so *designing* your interventions, strategies, structures, and systems before you actually do something, can help a lot in getting the right things done at the right time and at the right price.

If you see academic management research as a design science, its mission is to develop valid knowledge to support thoughtful, designing practitioners. More specifically, its mission is to develop valid knowledge to support organizational problem solving in the field. That support can be direct, instrumental, or more indirect—giving general enlightenment on the type of problem at hand.

Ever since Simon's seminal book *The Sciences of the Artificial*, we know that there are fundamental differences between "artificial science" and "normal science." Or I would rather say, between design sciences and explanatory sciences. The mission of an explanatory science, like the natural sciences and basic social sciences such as sociology, is to describe, explain, and predict: the well-known triplet. Research in an explanatory science is to solve *knowledge problems*; it is a quest for truth. The definition of "truth" varies, but students in an explanatory science are trained to become researchers to find the truth their science envisions.

On the other hand, the mission of research in a design science, for example engineering or medicine, is to develop valid knowledge to support the creation of solutions to *field problems* experienced by professionals in the discipline. It is a quest to improve human performance: a quest for utility, if you like. Most people who study a design science are not trained to become researchers but to become professionals.

Medical Schools and engineering schools are professional schools. Most people see the Business School as a professional school. However, research in Business Schools by and large is based on the paradigm of the explanatory sciences rather than on the paradigm of the design sciences. Herbert Simon saw management as a science of the artificial, as a design science. James Thompson, in his opening essay for *ASQ* when it was first launched, saw management as a design science, comparing it to engineering. Yet nothing of that can be found in present-day textbooks on business and management research. They define the field as a social science and are virtually indistinguishable in methodology from textbooks in other social sciences.

*Huff*: Shouldn't we regard management as a social science?

*Tranfield*: I say "of course." The tight coupling of management to the social sciences is not in doubt. Quite clearly, management has strong historical links within the social sciences, and yes, I see much of today's management research as social science research. I also argue, however, that clarifying the identity of management as an academic field may lead to repositioning it as a design science that complements more explanatory social sciences. This could offer a relatively unique and exciting opportunity for management research to perform a role similar to that of

medicine in the human and biological sciences or engineering in the physical sciences.

*van Aken*: The choice of paradigm is important, because it drives the type of research questions asked and the type of research products produced. In an explanatory science, one is interested in "what is"; in a design science one is interested in "what can be" to solve a problem or to improve performance. Questions with respect to "what is" lead to descriptive knowledge; questions with respect to "what can be" lead to prescriptive knowledge. If in management research we undertook more research on the basis of the design sciences paradigm, we would produce more prescriptive knowledge.

*Huff*: Some academics feel uncomfortable with developing prescriptive knowledge in management. They might see it as a return to the old days of the Business School as trade school or they might see prescriptive knowledge as rather unacademic.

*van Aken*: The association of prescriptive knowledge with a previous era is understandable. Before World War II, the focus of the Business School was indeed on prescriptive knowledge. But that was largely experience-based prescriptive knowledge, not prescriptive knowledge based on systematic, methodologically sound, rigorous research. In identifying management as a design science, prescriptive knowledge is research based, just as it is in medicine and in engineering. As for the "un-academic," many researchers do indeed believe that *all* science should be normal science or explanatory science. In such a limited view of science there is little room for design science research, with its interest in prescriptive knowledge to be used by professionals to solve field problems.

*Huff*: I know you have been more specific about the nature of prescriptive knowledge in your articles.

*van Aken*: Following Bunge, the general format of prescriptive knowledge is the so-called technological rule. A *technological rule* links an intervention or strategy or system in a certain setting with an outcome. Its logic is, if you want to achieve Y in setting Z, then do (something like) X. The core of the rule is X, a general *solution concept* for a class of problems. Technological rules incorporating solution concepts produced by systematic research are field tested and grounded. If the rule

is field tested, we know that it works in certain settings, and if it is grounded, we know why it works, what are the mechanisms that produce the outcomes. Alternative treatments for cholera or alternative electrical circuits for high-frequency amplifiers are examples of general solution concepts, which can be used to design specific solutions for specific cases. Likewise, alternative entry strategies for new markets or alternative layouts for the shop floor are examples of solution concepts in management.

### WHY THE MANAGEMENT FIELD SHOULD CONSIDER ITSELF A DESIGN SCIENCE

*Huff:* You have been a champion of this perspective, David, especially the idea of producing technological rules as key products of management research. Why do you think it is important to think about management as a design science?

*Tranfield:* It is important for emergent fields to establish identity within the sciences. Not only does this create a shared sense of nationhood and purpose for established members and aspirants, but specifying limits to ragged boundaries, establishing shared ideologies and values, as well as clarifying quality criteria, are all crucial in policy terms. In the late 1950s, driven by the Ford and Carnegie reports, management research set out to become more scientific in its approach and to legitimate itself within the social sciences. As a result of promoting this mission, the field fragmented and attracted scholars from adjacent social science disciplines.

In its attempts to become more scientific, the management field has privileged epistemological issues, and it has been right and proper that it should. But the resulting fragmentation now requires that parallel discussions take place concerning the ontological status of the field. If this does not happen, the field will remain in its current highly differentiated state, and the main danger is that, as Alvin Gouldner said of sociology, “a fragmented field is a weak field.”

Just as other design fields, such as engineering in the physical sciences and medicine in the biological sciences, have had to attend to identity by specifying boundaries, so management research also needs to ask, “what is the nature of the beast?” and provide a credible answer. What is it that distinguishes management research from say business economics, industrial sociology, occupational and organizational

psychology, etc.? I see the capacity to ask and answer difficult questions like these as a sign of a maturing field.

Our consideration of these issues in the British Academy of Management Research Policy Committee and Council in the 1990s led us to the conclusion that the distinctiveness of management research lie uniquely in its theory–practice link. Ken Starkey and I reported on these discussions in 1998. In such an applied field, the notion of design is paramount, because design denotes a concern not only for developing models to enhance the understanding of current activity but also going beyond current knowledge to develop future systems and structures not yet actualized. This means researchers will necessarily attend to key normative issues such as effectiveness, health, and change. The general engineering conception of design offers the possibility of encapsulating an academic and intellectual orientation that supports and is consonant with these issues and also sympathetic with the preoccupations of managers, who daily have to answer the question of “how should things be?”

*Huff:* I can see that design is important for managers, but why is it so important to regard management research in this way?

*Tranfield:* The main reason that I champion the design perspective for management *and* management research is that it might help establish our identity academically within the social sciences as well as create a stronger relationship with practice by increasing the relevance of our research results. The relevance problem is an old one in the social sciences, and nowadays this issue is again receiving more attention—for example, in the 2001 special issue of the *Academy of Management Journal* on collaborative research and the 2001 special issue of the *British Journal of Management* on Mode 1 and Mode 2 knowledge production, for which you wrote a contribution yourself, Anne. Another example of concern about our purpose is the passionate plea for more teaching and research relevance in the recent *HBR* [*Harvard Business Review*] article by Bennis and O’Toole on “how business schools lost their way.” I think that driving academic management research on the basis of what Joan calls the paradigm of the design sciences—aiming to develop and produce field-tested and grounded technological rules—will contribute to healing the theory–practice split and help solve the relevance problem for our field.

*Huff:* Isn't it possible that a stronger link with practice will lead to contract research for companies and other organizations, which would create more rather than less fragmentation of the field? A related problem is raised by practitioners' concerns about short-term problems. Both could cause us to neglect more fundamental and general problems.

*Tranfield:* These are two real dangers we have to guard against. However, a closer link does not necessarily mean that practice will dictate our research agenda. There is no reason why this should be the case. A more inclusive approach would be to focus our research on issues that are both academically interesting and resonate with practice. In addition, my call for less fragmentation should not be interpreted as a modernistic call for uniformity in thinking. The present variety of perspectives on management issues is one of the strengths of our field.

My concern is for more communality in thinking about our identity and purpose. Why do we do research? Is it only to fuel the academic debate or should it eventually support "human flourishing" (to use the words of Peter Reason and Hilary Bradbury). In medicine, huge resources are spent on fundamental research at the level of the cell, not only because that research is expected to produce academically interesting results but also because it is expected to produce results that will eventually help medical practitioners cure diseases like cancer or AIDS. Likewise, our field could, and in my view should, develop a sense of purpose to the effect that many research results, directly or indirectly, have a positive impact.

### DESIGN SCIENCE AND THE ART OF MANAGEMENT

*Huff:* As you know, the basic vision is one I agree with. Still, the design perspective and its terminology have a technical ring to them. If not technical, design seems at least very rational. You know the criticism that Mintzberg and his colleagues made in *Strategy Safari* with respect to the design school in strategic management—they think it overly stresses a rational approach. Doesn't the design perspective as you define it similarly underestimate the importance of art in management?

*Tranfield:* It might from some points of view, for a design perspective does tend to take a rational view. However, management designs are always emergent,

and natural organizational dynamics ensure that in practice, designs are never realized as originally conceived. This is characteristic of design in the more technical fields like engineering as well. If we were considering building a bridge over a river, a civil engineer would ask a series of questions to inform his or her conceptual design such as How wide is the river? How fast is the flow? How deep is the water? What is the geology like? What are the temperature ranges, wind speeds? How heavy will the loads be, and how large the flow of traffic?

When the designer has the context and specifications formulated, then a conceptual design is produced, often by developing a particular vision from an existing portfolio of known and tested prototypes. For example, the designer may conclude, once a particular situation has been understood, that an appropriate form is more like a Brooklyn Bridge than a Golden Gate Bridge. Next, this concept would have to be detailed, and of course later, the actual building of the bridge would involve considerable crafting. The result would not be exactly like the Brooklyn Bridge, because no other situation exactly duplicates the conditions for which that bridge was designed.

It is in formulating context and specifications, and in applying design knowledge in the subsequent detailing and building, that "art" plays its part. However, even very artful departures from past practice, such as the bridge into Rotterdam that serves as an icon for the city, still rely on the known and tested.

*van Aken:* I agree that the development of design knowledge, which is codified knowledge, does indeed deal with the rational part of designing. As David says, one needs things like tacit knowledge, intuitive judgment, social competences, a deep understanding of the local context, and last but not least, a lot of creativity in applying design knowledge.

*Huff:* What is the source of this creativity?

*Tranfield:* I would say human agency, driven by the need to solve real-life problems. In our field, agency concerns managers acting in their roles as organizational architects. The influence of symbolic structures buried deep within the individual psyche in enacting this role is well documented in the psychodynamic contributions to management theory.

*van Aken:* My further thought is that developing design knowledge should be both ambitious and

modest. It should be ambitious in its drive for relevant research products but at the same time be modest in its expectations for contributing to the solution of real-life problems. One might compare it to a guide book for tourists. Such a book contains a lot of tested solutions, like attractive destinations, modes of transport, places to eat and sleep, but travelers are still “agents” trying to satisfy their preferences in the design of their journey, and they still have to react to the many surprises that occur en route. A guide book is not a prescription; it is just a set of tested options. Likewise, management research can produce a set of tested options for certain management problems. It is up to the practitioners to use these options, or combination of options, to design their interventions or systems. That is an art.

*Tranfield:* I like your guide book metaphor. Such a guide book is based on a lot of field research but is continually tested and updated by its readers. In management, there is a huge amount of existing work, soundly undertaken, often containing significant implications for management practice. Yet this mountain of management knowledge rarely impacts management practice. Contemplating such a schism between science base and practice in medicine or engineering would be intolerable.

Other fields have been creative in uniting practice and research. For example, in medicine, the evidence-based approach using systematic review is having an enormous influence. I look at how this experience might be adapted to management in a recent article with David Denyer and Pali Smart in the *British Journal of Management*. We suggest that a way forward is to adopt an “evidence-informed” approach using systematic review, which would create “guide books” for specific management issues based on accumulated knowledge. In systematic review, one uses an inductive investigation, searching the literature base in a very transparent way in a particular topic area, making explicit the journals to be searched, the time frames over which they will be searched, the key words, the databases themselves, and the reasons for inclusion or exclusion of any items in the final database. This leads to a knowledge base from which we can draw conclusions concerning that which we know and that which we do not know and hence create a more reliable foundation for practice (and also, incidentally, for further research by academics).

*Huff:* I am sure systematic reviews can contribute to the creation of a valuable knowledge base, in part because I have seen the students you and David Denyer have been training in action. Still, the use of codified design knowledge in management is potentially problematic. I remember a recent article by Michael Beer, whose research is very relevant, explaining why management research products cannot be implemented.

*van Aken:* Many perceived problems with the use of prescriptive or design-oriented research products have to do with “immodest” or too optimistic expectations. “Prescriptive knowledge” is a bit of a misnomer. To think that academic research can produce actual prescriptions to management, like medical doctors give prescriptions to their patients, is immodest in my eyes.

What we can do is produce tested options, general solution concepts for interventions, or systems. There is only a long-linked relation between these options and eventual performance, though performance does indeed depend on the quality of the general solution concepts used. However, it also depends on the quality of the translation of the general to the specific by the practitioner, on the quality of implementation, on the quality and motivation of people doing the real work, and of course, on all kinds of external influences. So in management, a solution concept is not a prescription, ready to be implemented to get results. It seems to me that an important part of Michael Beer’s critique of research practicality is about overly optimistic expectations with respect to the direct applicability of academic research.

## DESIGNED CAPACITY TO RESPOND TO SURPRISE

*Huff:* We have talked quite a lot about the art of design. What about design’s capacity to respond to surprise? One way to address this issue has been described in the book *Managing the Unexpected* by and Karl Weick and Kathleen Sutcliffe. Is that a sound approach in your opinion?

*van Aken:* Their book certainly is a fascinating account of how “High Reliability Organizations,” like nuclear plants and aircraft carriers, develop structures, routines, and personnel development programs that enable them to respond to surprise. One could extract

solution concepts from their book for developing similar routines in other high-reliability organizations. However, as is always the case with solution concepts, the extent to which their findings can be transferred to other types of settings has to be tested.

*Huff:* Can you say anything at a more general level about how designs in management can be adapted to surprise?

*van Aken:* One way is to enable people to handle surprise. Designs for organizational structures and processes typically describe undisturbed process. But they should also include mechanisms to handle interference or other unexpected things happening. A well-known example is the red cord along the Toyota assembly line. Every worker has the right, even the duty, to stop the line by pulling the cord if some surprise threatens performance. And that act mobilizes in its turn (designed) actions to redress the situation.

*Huff:* I am not sure that including mechanisms in management designs to handle surprise can make them "surprise proof."

*van Aken:* I agree. Mechanisms like the Toyota cord by and large aim to handle "foreseen surprises." Real surprises have to be left to the people concerned.

*Huff:* And still design is important in management . . .

*van Aken:* Yes, still design is important. What you still can do by design is enable the people concerned to handle surprise with more preparation than if the topic had not been given forethought. This happens by giving users insight into the properties and dynamics of their systems and environment, by providing them with resources in the event of surprise, and by empowering them to act "outside the system" when necessary. The designed system should not be an "iron cage." People should understand its limitations and be empowered to leave it when surprise necessitates.

In addition, the design process itself is important. A sound design process should lead to a sound design but also give people insight into links between the design problem and its designed solution, including possible alternatives and the reasons for not choosing them initially. Even more important, people involved in the design process need a sense of ownership with respect to the design and a

commitment to make it a success. Insight, empowerment, and commitment, then, are the driving forces for successful adaptation if and when the unexpected happens.

*Huff:* This sounds very much like the well-known adage in strategic management that both content (the plan, the design) and process are important.

*van Aken:* It does. In placid settings, management designs may face limited surprises, but in more turbulent settings, surprise is both common and important. In these cases, attention to both the design and the design process produces people able to react and adapt to surprise. Management design may not be that new as an idea, but it needs further articulation. Often, the idea of a design orientation is used in a fairly naive way.

*Huff:* Why do you use the word *naive*?

*van Aken:* Well, virtually all management textbooks for business schools implicitly use a design-approach, their message being: use this theory to design your actions, and you will be successful. They are illustrated by many examples of managers who *in hindsight* proved to be successful. Everybody knows that there may be some "implementation problems" in other situations, but a good design plus a good manager are thought to be sufficient. If not, then the design was not good or the manager wasn't.

If we really take design seriously as a field, textbooks would pay much more attention to art and surprise. They would acknowledge the fact that designs in management are seldom realized as designed and emphasize that the realization of a design always implies redesign by "users" who must design their own role into the overall system. Above all, textbooks that take design seriously would insist that a *good* design (i.e., a design made in a sound design process using state-of-the-art design knowledge) is not necessarily *successful* in every context. Books and instructors do not say enough about that.

Adaptation is always required. In research, this fact remains practically invisible; it is obscured by hindsight logic. But in testing solution concepts on the basis of intervention—that is to say, by using outcome or foresight logic rather than hindsight logic—management research could help users be very much aware of the critical role of adaptation. I would also add that using an explicit design orientation enables

one to learn about the use of design from other fields, particularly engineering, as we have discussed today. I think you were trying to do something like that in establishing research areas in the UK AIM project, Anne.

### LIMITATIONS OF A DESIGN APPROACH

*Huff:* I am glad you brought up the Advanced Institute for Management. An important purpose is to bring management researchers from many different disciplines together, including many not based in business schools. One of my tasks was to establish the basic subjects for that project, which has now attracted over 20 million pounds of government funding. I wanted topics that almost any management researcher could relate to, not only in the UK but in other countries because international fellows are involved.

The government agenda was to have an impact on national welfare, not just make a few researchers happy, so foresight definitely was desired. But most researchers tend to think of their research in very specific terms. That is good, in the sense that it facilitates connections with others who have similar interests. It is more problematic if a larger agenda is in view. My belief is that many researchers could relate their work to more macro topics with practical implications but rarely do. That is one of the reasons why we make fewer connections with practice or policy. All this is still being worked out in AIM. Perhaps you have thoughts about other contexts that require managers and researchers to go beyond current practice?

*Tranfield:* The critical thing about design is that it deals with systems that are not yet in operation, with artifacts that might but do not yet, exist. So you must be able to specify the desired future situation with some degree of precision. The more turbulent the context, the more difficult that becomes. In extreme cases, instead of tightly defining a future situation, it might be best to follow Quinn's logical incrementalism, using small-scale experimentation and going forward in small steps as the trajectory unfolds on the basis of lessons learned. But even in these cases, there is still a lot of designing to do, such as designing the direction in which you want to move, the experiments you want to make, and the evaluations you have to undertake in order to learn fast. Managers have always faced turbulent situations

and often have succeeded. We need to learn more systematically from these examples.

*van Aken:* I agree with David that the setting and nature of the design problem can put limits on the power of design. You might think in terms of a balance between designing—think before you jump—and nondesigning (i.e., improvisation). The first questions, then, are Can you design? Do you have the knowledge, the time, and the power to be able to design and realize?

In Stanley's day, there were no guide books for Africa, so there was little design knowledge available to help him search for Livingstone. In this case, he had to use improvisation with limited design, while nowadays, travelers in Africa can use more design and less improvisation. You seem to have been in the situation of an early traveler with AIM, and other attempts to have a broad impact face the same situation.

Lack of cohesive knowledge is not the only concern. In turbulent settings, as David said, you'll tend to use less design than in more placid settings. You may lack the time both to design and then to realize; your design may be already obsolete by the time it is realized. The power to have your designs realized is a critical part of design. Designs without the power to realize them are fairly useless. For instance, in politically complex and ambiguous decision making—garbage can settings—you may want "to play it by ear," to improvise rather than to design a complete course of action beforehand.

This means that "should I design?" is an important design question. Sometimes it may be better to give only general directions and leave the designing of detailed actions to the people doing the actual work, both for motivational reasons and because they may be better able to react to local circumstances and surprises than top management. Wrapp's provocative *HBR* article, "Good Managers Don't Make Policy Decisions," provides an excellent discussion of this issue. He points out that one should not create a policy straightjacket but should leave room for local adaptations.

*Huff:* Let's focus on knowledge as a limiting factor. Do you want to say through your guide book metaphor that design is a useful idea only insofar as a technological rule has been specified and tested?

*Van Aken:* Well, designing without much available design knowledge demands more creativity and

needs, in its realization, more improvisation. In the field of product innovation, one makes a distinction between incremental design and radical design. Designing the next version of a TV set is incremental design, much design knowledge being available; designing the first compact disk set was radical design, much less design knowledge being available. Likewise in management, there is both incremental and radical design, depending on the amount of available valid design knowledge and, of course, on your ambitions with respect to the innovativeness of your design.

*Tranfield:* Radical design certainly involves more than just rational analysis, but it also includes the rational. This was really brought home to me by learning about the designing of the famous monocoque bicycle, ridden by Chris Boardman, Gold Medal winner in the 1992 Olympic Games 4,000-meter pursuit. It is a fine example of radical design developed by the designer, Mike Burrows over some 10 years, a process studied by Linda Candy and Ernest Edmonds from Loughborough University.

Candy and Edmonds dismissed the received wisdom that Burrows was “just” a truly gifted individual who conceived and delivered a radical departure from current ideas in some spontaneous and independent way. Their analysis revealed eight discrete stages in the bike’s development, beginning with early, playful, “funny” bikes, eventually leading to a very innovative design, using leading edge materials. They also showed the importance of Burrow’s networking competencies; his use of a holistic perspective; his creative redefinition of the design problem; his use of analogies with products, which had nothing to do with bikes; his ability to break with convention; his capacity for sketching techniques and gestation; and so on. In contrast to the accepted wisdom that radical design is the result only of brilliant individual inspiration, the reality turned out to be much more complex, involving specific personal attitudes and organizational routines. It seems that many of the characteristics found in this case might help managers operating as designers in their own roles as organizational architects and engineers. There is a lot to be learned about the design of sound *processes* that generate radical outputs.

*Huff:* Now we are back to inspiration and its role in design. But I want to raise one more context in which the design approach does not seem very helpful, at

least today. The Mode 1/Mode 2 discussion contrasts purely academic knowledge production with knowledge production for solving real-life field problems. Developing technological rules seems to me to be an example of Mode 2 knowledge production. But I feel Business Schools also need to develop the capacity to produce “Mode 3” knowledge, which considers the human and social antecedents of organizational action and action’s possibly unethical consequences. Nongovernmental organizations, for example, get little help from us as they try to address serious social problems.

*van Aken:* Yes, the wider context of organizational action, with its complexities, uncertainties, ambiguities, and the varied interests of diverse stakeholders certainly is an important field of study and a perspective from which it is extremely difficult to develop codified design knowledge. NGOs do design effective actions, as Greenpeace did in opposing sinking the Brent Spar in the ocean by Shell. In this wider context, there is as yet little codified design knowledge to link interventions with outcomes. For instance, one outcome, which was almost certainly unanticipated by Greenpeace, is that Shell now positions itself as an environment-conscious company. So there is a lot of Mode 3 knowledge production to work on.

### THEORY’S PLACE IN DESIGN SCIENCE

*Huff:* I’m very glad you agree about the importance of a social agenda—and look forward to more codified knowledge in this important area. Are you pointing to the possibility of something like formal theory? What is the role of theory in a design science?

*van Aken:* We have to go back to the distinction between explanatory and design sciences. As the labels suggest, theory in explanatory sciences should explain, theory in design sciences should support designing (i.e., it should help find solutions for field problems). The typical tool in an explanatory science is the causal model, providing knowledge to understand “what is.” In a design science, the typical tool is the technological rule, providing knowledge on how to approach the realization of certain outcomes.

That is not to say that in a design science you only develop prescriptive knowledge but that prescriptive knowledge is an essential part of theory in the discipline. For instance, in mechanical engineering,



you have prescriptive knowledge about how and when to use the various forms of laser welding, but at the same time you need a lot of descriptive knowledge on material properties and the physical phenomena accompanying the welding process in order to use that prescriptive knowledge properly. Physicists are not interested in producing that kind of rather specific knowledge, so the discipline of mechanical engineering has to produce that descriptive knowledge itself. Likewise, even if management research were repositioned as a design science, we will still need a lot of descriptive knowledge next to prescriptive knowledge.

*Huff:* So prescriptive and descriptive theoretic generalizations are needed in a design science. Let's be even more specific. Does theory development in a design science differ from theory development in an explanatory science in your view?

*van Aken:* There are several similarities. Both descriptive models and technological rules use causal logic, and induction is important in establishing it. The differences between normal science and design science include the choice of dependent variables. Design science is typically aiming toward improved performance on one or more criteria; explanatory science tends to be interested in a more diverse set of issues. Second, in a design-science approach, one should be able to manipulate independent variables; in an explanatory science approach, this is not a requirement.

The most important difference between the two may lie in the difference between hindsight and foresight, a point that we discussed earlier. Explanatory research is always hindsight research, trying to explain something that has already happened. Success is attributed to some causes after the fact. Hindsight research can lead to hypotheses on interventions leading to future outcomes, but this is rarely, if ever, the objective. The proof of design foresight is the field test, and this will be central to any theory developed. Design science will focus on foresight logic to design what does not yet exist, though of course it will draw on hindsight ideas when they seem applicable.

## EVALUATING THE RESULTS OF DESIGN

*Huff:* How do you then evaluate the results of design science research? What are your criteria?

*Tranfield:* Pettigrew's idea of dual hurdles for management research, summarized under the general categories of academic rigor and practitioner/policy relevance, provide a good start. As an academic, my view is that our conclusions, conceptual models, methodologies, and prescriptions should be based on the most rigorous investigation that we are able to achieve. There is no excuse for poor-quality empirical research or sloppy theorizing. These should inform our modeling of current circumstances and our understanding of future possibilities and constraints.

For many management academics, adopting the assumptions of the explanatory sciences has mitigated against contributing to the development of a context-sensitive science. However, if the legitimate products of management research were expanded to include technological rules, then a key evaluation criterion involves practitioner/policy relevance. This engages the engineers' tests of: Will it work in practice? What are the contextual limitations? What is the class of problem that this design addresses? In what circumstances and under what conditions does the design have validity? Technological rules provide archetypal solutions to archetypal problems. They provide insights for answering the questions that the interventionist or clinician asks. So my twin tests would be: First, are the ideas soundly formulated and well researched? Second, do they work in practice and what are the limiting conditions?

*Huff:* What are the primary impediments to simultaneously clearing these hurdles?

*Tranfield:* The first thing is that we haven't really articulated what is meant by a "design perspective" or engaged in a widespread discussion of its relative merits and challenges. This is why Joan's work is so important. He defines on the one hand what a design perspective is (preoccupation with "how things should be," with a key product being the development of field tested and grounded "technological rules") and on the other hand what it isn't (a "formal science" producing logically consistent sets of propositions or an "explanatory science" specifying formal laws).

In short, the first impediment is that we have not understood the role of the design sciences and their research products. Nor have we agreed on the implications of a clear definition. That seems to me to lie at the very heart of the problem.

Second, those who want to approach management as a design science have not had the necessary intellectual tools and concepts. In this conversation, we have given a lot of attention to these issues, but this is only a start, and there is a need for further theoretical and conceptual development concerning the general notion of design and its potential application to management research.

Even if we had an agreed definition and the necessary theoretical formulations, there is a third problem—namely, the many social and policy impediments that inhibit widespread adoption. To begin with, there is an obvious structural impediment: Our academies, our schools, and our learned journals have failed to privilege a design perspective. For example, in the UK, research performance is measured by a UK-wide Research Assessment Exercise (RAE). In the RAE, research quality across all universities in all subjects is assessed, but over the years, this exercise is widely regarded as failing to reward the taking of a design-based view. Whilst this might be regarded as merely a policy impediment within the UK, my view is that it reflects what has been a policy limitation evident to a greater or lesser degree in many countries.

Fourth, I believe that because the management field has attracted researchers from a wide range of disciplines, if we are honest, we often have intellectual and academic allegiances elsewhere, at least to some significant extent. Whilst on the one hand, the notion of putting in place management as design science might be thought of as liberating; if it is to work effectively, there would have to be widespread critical self-reflection on the part of individual researchers who would have to ask themselves the extent to which they wish to be part of such an endeavor.

In answering your question, Anne, I think that taken together, these four comprise a challenging agenda for management as design.

*Huff:* That is a succinct but difficult agenda. Do you see similar issues from a practice perspective, Joan? I know that your experience at Philips has energized your interest in developing a design perspective.

*van Aken:* Indeed, my experience in management and in management consulting—both inside and outside Philips before joining academia more than ten years ago—has fuelled my ambition to produce valid knowledge that can be used by practitioners to solve real-life problems. I have seen that managers are extremely eager to know what “industry practice” is, what other managers have done in similar circumstances, and

what the outcomes of such actions were. They listen to management consultants. And they read—or at least buy—a lot of management books, somewhat condescendingly called “Heathrow literature” by academics. But all of these actions reveal a huge market for valid design knowledge in management.

An important impediment is that managers are not convinced that mainstream academic management research provides such knowledge, one reason being that most academic research is focused on analyzing problems rather than developing and testing solutions. Another issue is the language and cultural barrier between academia and practice. Still, another is that practitioners want fast-working solutions to their specific problems. With respect to the last point, consultants are often in a better position to contribute than academics. I still feel that with more emphasis on a design orientation, academic management research should be able to grab a sizable share of the huge market for management knowledge.

*Huff:* David, I suspect that your work on manufacturing is behind your interest in this area.

*Tranfield:* This is true to a degree but not entirely. I am not trained as an engineer, although it is true that I have undertaken much of my research in manufacturing management. Manufacturing engineers, just like managers, are very attracted to the notion of “what works, for whom, in which circumstances,” which is not a bad colloquialism for a “technological rule.” My own academic heritage is in sociotechnical systems, and I suspect it was being a student of Ken Bamforth’s at the University of Leeds in 1970 that influenced my views. More recently, I have seen many other fields progress at a fast pace by asking the tough questions posed in this discussion, re-evaluating their identity and knowledge base in the process. Medicine is an obvious example, but social policy, education, criminal justice, and community development are all social sciences making progress in this way in the UK.

## FUTURE SCENARIOS

*Huff:* That is an expansive view of the future. Joan, what do you see as the way forward?

*van Aken:* In the first half of the last century, the field of management was considered to be a practice-based craft. The “scientization” of our field in the second half of the century, starting in the U.S. and

subsequently extending to the rest of the developed world, has brought us rigor and much needed academic respectability. I feel that only now has the time become ripe boldly to move on. The prime mechanisms for change include debates at our academic conferences on the relevance problem but also practical examples of the application of management knowledge that demonstrate the possible contribution of a design view.

Several presidents of the American Academy of Management, including of course yourself, Anne, have given attention to the relevance issue. Now it is important to organize and facilitate the relevance debate more vigorously. A special contribution may come from editors of academic journals, who might not only ask authors for management implications of descriptive research but also for actual field testing and further development of those management implications. I am happy to see that this is already beginning to happen. Symposia and full tracks on design science have been held at recent AoM, EURAM, and EGOS conferences. *ASQ* devoted a special issue to the relevance problem of academic management research. Special issues of *Organization Studies* and the *Journal of Applied Behavioral Science* have recently appeared. It is important to keep the momentum going.

*Huff:* A vision of increasing momentum is an excellent conclusion. Thank you both very much. You've helped me see that art is required to make and realize designs in management and management research. You have shown how design can deal with the many things that cannot be anticipated. The work the two of you are doing is an important contribution to thinking about how we can mature as a field. I hope the group you represent continues to grow.

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