Scandinavian Journal of Information Systems

Volume 30 | Issue 2 Article 8

12-31-2018

The Emergence of Design Science Research from Decision Theory

Richard L. L. Baskerville
baskerville@acm.org

© Scandinavian Journal of Information Systems, 2018, 30(2), 55–62

Reflection note

The Emergence of Design Science Research from Decision Theory

Richard Baskerville
Georgia State University, USA and Curtin University, Australia
baskerville@acm.org

Design science research has been well-established research as a paradigm within information systems (IS) for at least a decade (March & Storey 2008). It has had a powerful impact on the discipline. Its roots, however, were firmly anchored in decision theory long before IS refined our version of it. Even the name, 'design science research' was coined in a decision support journal (viz., March & Smith 1995). However, the most fundamental source of the decision-oriented influence on IS design science research has been Herbert A. Simon's classic work, *The Sciences of the Artificial* (1996), especially the chapter on "The Science of Design: Creating The Artificial".

Simon was a Nobel Prize winning researcher in decision-making. It is highly unlikely that any study of computers in management can achieve any depth without encountering Simon's work, or at least derivations of his thinking about the subject. His conceptualization of management decisions and human rationality are standard fare on the intellectual menu for MBA students worldwide. Perhaps Simon's most widely known ideas are his three-stage model of decision-making, the conditioning of such decisions by the bounded rationality of the decision-maker and, at least in IS circles, the sciences of the artificial. Of course, he was a prolific and long-lived scholar who made many significant contributions beyond these three, but these three have become significantly interconnected for the IS field, especially in our design science research.

Simon wrote extensively about models of decision-making. He introduced his three stage model as follows,

> Executives spend a large fraction of their time surveying the economic, technical, political, and social environment to identify new conditions that call for new actions. They probably spend an even larger fraction of their time, individually or with their associates, seeking to invent, design, and develop possible courses of action for handling situations where a decision is needed. They spend a small fraction of their time in choosing among alternative actions already developed to meet an identified problem and already analysed for their consequences. The three fractions, added together, account for most of what executives do.
>
> The first phase of the decision-making process —searching the environment for conditions calling for decision—I shall call *intelligence* activity (borrowing the military meaning of intelligence). The second phase —inventing, developing, and analysing possible courses of action—I shall call *design* activity. The third phase—selecting a particular course of action from those available—I shall call *choice* activity. (Simon 1960, p. 2 emphasis from original)

These three stages have a longer history than Simon's formulation: They are "closely related to the stages in problem solving first described by John Dewey: What is the problem? What are the alternatives? Which alternative is best?" (Simon 1960, p. 3) Further, the stages are not necessarily linear.

> The division of the decision-making process into such subprocesses as setting the agenda, representing the problem, finding alternatives, and selecting alternatives has sometimes been criticized as describing decision-making falsely as a 'linear' process, and thereby rigidifying it. Of course there is no implication in anything that we have said that these subprocesses must follow in a set order. Agenda-setting—and resetting—is a continual process, as is the search for new decision alternatives (e.g., new products), and the selection of alternatives as new occasions for decisions arise. An alternative discovered in one decision process may find its effective application at some much later time and in connection with a quite different decision. (Simon 1997, p. 145)

While it is not possible to do justice to this model in a few short pages, even the briefest of introductions must recognize that Simon conditioned his model with the bounded rationality available in the decision maker. Individuals and organizations are limited by their collective knowledge, their cognitive abilities, and their available resources.

Individuals will have limited knowledge, limited cognitive abilities, and limited computational power (Simon 1972). These boundaries on rationality in decision making effectively makes any determination of an optimal solution unlikely. Instead, decision makers must be satisfied with a solution that is probably suboptimal, but sufficiently satisfactory to be practical. Decisions will only satisfice; they satisfy the aspirations represented by the problem definition. When the decision results achieve the aspirations, there is satisfaction. When the aspirations exceed the decision results, there is dissatisfaction (cf. Simon 1996, p. 30).

For our purposes, we will leave aside the intelligence and choice stages and focus on the design stage. Design involves discovery, while choice involves comparisons:

> …classical decision theory has been concerned with choice among *given* alternatives; design is concerned with the discovery and elaboration of alternatives. … The evaluations and comparisons that take place during this design process are not, in general comparisons among complete designs. Evaluations take place, first of all, to guide the search [, to] provide the basis for decisions that the designs should be elaborated in one direction rather than another. (Simon 1972, p. 172).

Constrained by bounded rationality, designing courses of action is a discovery process. One searches for a course of action until one (or very few) is found that satisfies the aspirations. Never mind optimal, it is sufficient if the design works. This means that the search involves synthesis of possible solutions and the aspirations; it therefore involves a kind of *testing* or *matching* as to whether each or any of the possible solutions encountered provides a satisficing treatment of the aspirations:

> Designing courses of action introduces an important asymmetry between the "goal-like" constraints that guide synthesis and the constraints that test potential solutions. In general, the search will continue until one decision in the feasible set is found, or, at most, a very few alternatives. Which member of the set is discovered and selected may depend critically on the order of search, that is, on which requirements serve as generators and which as tests. (Simon 1960, p. 174)

This conceptualization of design as a search process carries forward into Simon's ideas about design in the sciences of the artificial. While IS design researchers often operate in general terms using *design principles* or *design theory*, Simon was more interested in *design logic* as a way to discover alternatives. This logic involves a means-ends analysis, which can be illustrated by the logic of the General Problem Solver (GPS):

> [The GPS] must be able to represent desired situations or desired objects as well as the present situation. It must be able also to represent differences between the desired and the present. [The GPS] must be able to represent actions that change objects or situations. To behave purposefully, [it] must be able to select from time to time those particular actions that are likely to remove the particular differences between desired and present states that the system detects. (Simon 1996, p. 122)

There is an incrementalism in Simon's design search process. Early design decisions set more abstract boundaries on later design decisions. In complex settings, these early decisions must be made in the presence of more incomplete information, hence the abstract nature. These early decisions must be elaborated, and the elaborations then evaluated against the design aspirations.

> In the design of complex objects—a bridge, say, or an airplane—the process has an even more involved search structure. Here, the early stages of search take place in highly simplified spaces that abstract most of the detail from the real-world problem, leaving only its most important elements in summarized form. When a plan, a schematized and aggregated design, has been elaborated in the planning space, the detail of the problem can be reintroduced, and the plan used as a guide in the search for a complete design. (Simon 1972, p. 172)

> Problem solving is often described as a search through a vast maze of possibilities, a maze that describes the environment. Successful problem solving involves searching the maze selectively and reducing it to manageable proportions. (Simon 1996, p. 54)

Like the model of decision-making, the logic of design is not a linear process. The selection for new design alternatives may arise in new occasions. An alternative discovered, but unused in an earlier design decision may be applied later (cf., Simon 1997, p. 145). Such non-linearity allows the opportunity to retrace to an early, more abstract design decision when it fails to yeild a satisfaction of aspirations as the design becomes less abstract (Simon 1972). When you are part way down a design path and things are not working, you can back up to a previous alternative selection and reconsider it.

> The search for new decision alternatives (e.g., new products), and the selection of alternatives as new occasions for decisions arise. An alternative discovered in one decision process may find its effective application at some much later time and in connection with a quite different decision. (Simon 1997, p. 145)

The main critiques of the science of design revolve around its "positivist, technical-rationality basis" although it "could form a fundamental, common ground of intellectual endeavour and communication across the arts, sciences and technology" (Cross 1982, p. 4). However, the strongest criticism is aimed at the developments of a design science independent of the sciences of the artificial:

> …the science of design is the study of design—something similar to what I have elsewhere defined as 'design methodology'; the study of the principles, practices and procedures of design. ... The study of design leaves open the interpretation of the nature of design. So let me suggest here that the science of design refers to that body of work which attempts to improve our understanding of design through 'scientific' (i.e., systematic, reliable) methods of investigation. And let us be clear that a 'science of design' is not the same as a 'design science'. … design science refers to an explicitly organised, rational and wholly systematic approach to design; not just the utilisation of scientific knowledge of artefacts, but design in some sense a scientific activity itself. (Cross 1982, p. 3-4)

It is difficult to separate the study of a practice in a professional school without the expectation that such studies will not infect the future practice in the profession. Much of Simon's work around decision-making and design is indeed intensely analytical and focused on rational and rather economic behavior. This viewpoint is decidedly academic. In practice, however, both decision-making and design inevitably have to have a creative element in practice.

> Yet, a very large part of the managerial effort in any organization is devoted to discovering possible alternatives of action. To take some obvious examples, there is search for new products, for new marketing methods, for new manufacturing methods, even for new organization structures. All of this search activity is aimed at enabling the organization to go beyond actions that are already known and understood and to choose novel ones. (Simon 1997, p. 145)

> A deep source of communication difficulty between the discipline-oriented and the practice-oriented members of a professional school faculty stems from the difference between science and art, between analysis and synthesis, between explanation and design. The pure scientist wishes to explain phenomena in nature; the practitioner wishes to devise actions or processes or physical structures that serve some specified purpose.
>
> Analysis leading to explanation is generally thought to be itself susceptible of analysis and systemization, hence to be teachable. Synthesis aimed at design is generally thought to be intuitive, judgmental, not fully explicit, hence an art. Medicine, engineering, management, teaching are arts. (Simon 1997, p. 373)

This early acknowledgement of the art in engineering and management (and thus IS) does not contradict Simon's highly analytical discourse on design, nor is it even a concession. It incorporates the generative element of synthesis as a logical means for achieving an effective design. He rejects as "mischievous" the castigation that "utility is the only touchstone of relevance" in professional schools (Simon 1997, p. 366). Even a decision or a design logic can be intellectually and aesthetically challenging. The result of developments like a science of design should be "teachable doctrine".

> The artificial world is centered precisely on this interface between the inner and outer environments; it is concerned with attaining goals by adapting the former to the latter. The proper study of those who are concerned with the artificial is the way in which that adaptation of means to environments is brought about and central to that is the process of design itself. The professional schools can reassume their professional responsibilities just to the degree that they discover and teach a science of design, a body of intellectually tough, analytic, partly formalizable, partly empirical, teachable doctrine about the design process. (Simon 1996, p. 113)

So we cannot assume that the science of design is only intended as a descriptive study of how design unfolds. As teachable doctrine, it is also intended as a way for professionals to go about designing. It is a way that is partly science, partly art. Ultimately it is part of a consistent scheme for deciding and designing, one that invokes logic, analysis, science and method wherever possible. At the same time, it is one that also invokes synthesis and the aesthetics of generative productions wherever possible.

Yes, in some sense, the science of design is a scientific approach to design: utilitarian, analytically tough and formal. In this sense, it is hard to distinguish from notions of a design science. But in Simon's writings, this is only one of its senses. In another sense the science of design is aesthetically synthetic and artistically generated. Descended from decision theory, and like decision theory, it is partly science, partly art. Likewise design science research in IS: scientific when it can be, creative when it must be.

References

Cross, N., (1982). Designerly ways of knowing. *Design Studies,* (3:4): 221-227.

March, S. T., and Smith, G. F., (1995). Design and natural science research on information technology. *Decision Support Systems,* (15:4): 251-266.

March, S. T., and Storey, V. C., (2008). Design science in the information systems discipline: an introduction to the special issue on design science research. *Management Information Systems Quarterly,* (32:4): 6.

Simon, H. A., (1960). *The new science of management decision*. Harper & Brothers, New York, NY.

Simon, H. A., (1972). Theories of bounded rationality. In: *Decision and Organization: A volume in honor of Jacob Marschak*, C. B. McGuire and R. Radner (eds.), North-Holland Publishing Company, Amsterdam, pp. 161-176.

Simon, H. A., (1996). *The Sciences of the Artificial* (3rd ed.). MIT Press, Cambridge, Mass.

Simon, H. A. (1997). *Administrative behavior: A study of decision-making processes in administrative organizations* (4th ed.): Simon and Schuster.