MIS Quarterly

SPECIAL ISSUE

DESIGN SCIENCE IN THE INFORMATION SYSTEMS DISCIPLINE: AN INTRODUCTION TO THE SPECIAL ISSUE ON DESIGN SCIENCE RESEARCH

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Introduction

Design is fundamental to the information systems discipline. IS professionals are engaged in the design and implementation of information technology artifacts aimed at improving the performance of business organizations. Business managers commonly view performance through an economic lens, defining the overall goal as the maximization of firm value; that is, the long-term profit of the firm. These managers understandably ask questions such as: "Why do investments in IT artifacts often not result in an increase in firm value?" and "What IT artifacts will do so?" The first is a theory-based, causal-related question. The second is a design-based, problem-solving question. Each represents a critical class of research questions in the IS discipline.

Answering the first question requires an *understanding* of phenomena that occur at the intersection of organizations, people, and information technologies—the locus of the information systems discipline (Lee 1999). Researchers addressing it develop and justify theories that provide deep principled explanations of these phenomena. Such theories aim to explain what happened, why it happened, and possibly to predict what will happen within a given context. It is the focus of much of the research published in the IS literature.

While such theories may be strictly explanatory in nature, their relevancy and value are determined by the degree to which they enable managers to design work-systems that improve organizational performance (Alter 2003; Benbasat and Zmud 1999). This is the focus of the second question. Answering it is fundamentally a design task that requires, "shaping artifacts and events to create a more desirable future" (Boland 2002). Researchers addressing it build and evaluate IT artifacts that extend the boundaries of known applications of IT, addressing important problems heretofore not thought to be amenable to computational approaches (Hevner et al. 2004; Markus et al. 2002; Walls et al. 1992). This is the focus of design science research in information systems and of this special issue.

Design Science

In his seminal book, *The Sciences of the Artificial*, Simon (1996) observes that "Everyone designs who devises courses of action aimed at changing existing situations into preferred ones" (p. 130). Certainly the development, implementation, use, and management of information systems within organizational contexts are rooted in changing existing situations into preferred ones. Indeed, management itself can be viewed

s a design discipline (Boland 2002; Simon 1996). Managers within organizational contexts use information technology, among other resources, to define work systems through which organizational goals are accomplished (Alter 2003).

Simon posits a science of design rooted in (1) utility and statistical decision theory to define the "problem space" and (2) optimization and "satisficing" techniques to search it. The problem space represents "desired situations," "the present situation," and "differences between the desired and the present" (p. 141). Search techniques represent "*actions*…that are likely to remove particular differences between desired and present states" (p. 142). Hence, the representation of design problems and the generation and evaluation of design solutions are the major tasks in design science research.

Challenges for design science research in the IS discipline are to build and evaluate IT artifacts that enable managers and IT professionals to (1) describe desired organizational information processing capabilities and their relationship with present and desired organizational situations, and (2) develop actions that enable them to implement information processing capabilities that move the organization toward desired situations. Hence design science research is problem-focused. Initial research in a new problem area typically focuses on constructing "*sufficient*, and not *necessary*, actions for attaining goals" (p. 144). These are frequently in the form of prototype artifacts that demonstrate the feasibility of addressing the problem (Markus et al. 2001; Walls et al. 1992). Subsequent research aims at improving the effectiveness and efficiency of attaining goals or demonstrating the necessity of certain actions, thereby adding to our knowledge of goal attainment (Vaishnavi and Kuechler 2007). Simon described the latter as improving the factorization of differences yielding parallel search paths and as improving the allocation of resources applied to such paths.

Design science research is increasingly recognized as an equal companion to behavioral science research in the information systems field (Hevner 2007; Iivari 2007). Contributions of design science research are in the combined novelty and utility of constructed artifacts. These must be demonstrated in the presentation of design science research. Demonstrating that existing IT artifacts are or are not adequate for a specified problem is an important step in this process as is comparing the utility of existing IT artifacts within specific organizational contexts.

IT artifacts are broadly defined as constructs, models, methods, and instantiations (March and Smith 1995) created to enable the representation, analysis, understanding, and development of successful information systems within organizations. Constructs are vocabulary and conceptualizations that enable communication and description of problems (phenomena, possibly within a causal chain), solution components, constraints, and objectives for the designed artifact. Models use these constructs to represent a problem and its solution space. Methods are algorithms or guidelines that are used to search the solution space and enable the construction of instantiations—computer-based systems implemented within an organization. Each may constitute a contribution to research knowledge.

The contributions of new constructs, models, and methods are evaluated with respect to their ability to improve performance in the development and use of information systems. Instantiations or implementations demonstrate the feasibility of utilizing those information technology artifacts for a given task. They are evaluated with respect to their effectiveness and efficiency in the performance of the given task.

Thus, a design science research contribution requires (1) identification and clear description of a relevant organizational IT problem, (2) demonstration that no adequate solutions exist in the extant IT knowledge-base, (3) development and presentation of a novel IT artifact (constructs, models, methods or instantiations) that addresses the problem, (4) rigorous evaluation of the IT artifact enabling the assessment of its utility, (5) articulation of the value added to the IT knowledge-base and to practice, and (6) explanation of the implications for IT management and practice.

Five papers appear in this special issue. Each is exemplar of high-quality design science research. It is our sincere hope that their publication in this special issue will explicate and clarify the design science research paradigm and encourage its use among IS researchers.

The Journey: Decades in the Making ■

This special issue was approved in September 2005 by then *MIS Quarterly* editor-in-chief Carol Saunders. However, our interest in explicating design science as a viable research paradigm in information systems dates to our earliest research and service activities. We have been involved in both the information systems and computer science communities, seeking to understand how their contributions and paradigms can benefit each other and their respective constituencies (Denning 1997). In contrast to the heavily behavioral research focus that dominated the information systems journals and conferences, computer science research emphasized the development of information technology artifacts, with implementation and evaluation being crucial components

of the research paradigm. We were fortunate enough to discuss these paradigmatic differences with leading information systems researchers including Gordon Davis and Allen Lee. We also had opportunities to present our ideas about them at a number of conferences and symposia. The notion of design as a research paradigm resonated with information systems researchers, particularly those involved in the "technical" aspects of information systems.

With the formation of the Workshop on Information Technologies and Systems (WITS) in 1991, this part of the IS research community achieved significant recognition. A keynote at the 1992 WITS in Dallas resulted in the development and publication of "Design and Natural Science Research on Information Technology" (March and Smith, 1995). That paper, along with seminal articles by Nunamaker et al. (1991) and Walls et al. (1992), generated significant interest in the articulation of the design science research paradigm as it applies to the information systems discipline.

However, publication of design science research in information systems journals was still problematic. As a proponent of design science research, Jinsoo Park argued that the paucity of published design science research was detrimental to the information systems field. Subsequent discussions of information systems research methods with Allen Lee resulted in his commissioning "Design Science in Information Systems Research" (Hevner et al. 2004) when he became the editor-in-chief of *MIS Quarterly*. This paper has been widely cited and has crystallized much of the thinking about this paradigm. After its publication Allen encouraged us to propose a special issue of *MIS Quarterly* on design science research. We enthusiastically responded and developed a proposal that we presented to Carol Saunders. The Call for Papers stated that the special issue "specifically seeks research that creates and evaluates innovative IT artifacts (constructs, models, methods, or instantiations) that further knowledge applicable to the productive application of IT for managerial and organizational purposes" and explicitly indicated that the criteria for evaluating design science research articulated by Hevner et al. (2004) would be applied. A special review form was created that required the associate editors and reviewers to specifically identify and assess the problem addressed by the research, the IT artifact developed, and the procedure used to evaluate it.

Response to the call for papers was overwhelming. Over 60 submissions were received. After an initial screening, 49 were assigned to guest associate editors. Two were deemed inappropriate for the special issue, 17 were rejected by the associate editors without further review, and one was withdrawn. Most commonly, the rejected articles lacked either innovative solutions to important and unsolved information systems problems or failed to adequately evaluate the information technology artifact developed. The remaining 29 submissions were sent out for full review. The five articles included in the special issue emerged at the end of the first round as having strong potential for making significant design science contributions. Each, however, required major revisions and two additional rounds of review prior to acceptance. These revisions were invaluable in enabling the authors to develop their potential contributions into reality.

The Arrival: Five Exemplars

The five articles included in the special issue are summarized in the table on the next page. Each addresses a distinct and important design problem. Each develops and evaluates a novel information technology artifact. The problems are wide and varied as are the artifacts and evaluation methods.

The Future: Where Do We Go from Here?

The publication of this special issue is intended to demonstrate and accelerate the momentum of design science research in the information systems discipline. The diverse papers included in it reflect a number of challenging problems facing information systems researchers and practitioners. We hope they provide insight into the paradigm and stimulate its use within the discipline.

We are encouraged by a number of recent developments in this regard. The National Science Foundation has funded over 50 projects in its recently completed Science of Design program. Contributions of these projects include both explication of the design science paradigm and artifact development. A complete list of funded projects can be found at http://www.research.gov (select the Research Spending and Results link, then the Advanced Search link, and enter "Science of Design" in the Program field). The Design Science Research in Information Systems and Technology Conference (DESRIST) is in its third year and serves as a forum for the presentation and discussion of design science research and best practices. The International Conference on Information Systems (ICIS) dedicates a research track to design science research. Finally, the Association for Information Systems (AIS) has a Web site dedicated to design science research (http://home.aisnet.org (select the Design Science choice in the Research section).

Problem	IT Artifact (Solution)	Evaluation Method
Article: "The Design Theory Nexus" Authors: Jan Pries-Heje and Richard Baskerville Guest Associate Editor: Matti Rossi		
Managers are frequently faced with ill-structured and multi-criteria decision-making situations. Systems intended to support managers in such situations are *ad hoc*, costly to develop, and frequently not used or not used effectively.	Constructs and methods that offer a unique problem-solving approach for developing decision systems for ill-structured and multi-criteria decision-making situations.	Field studies using subjective evaluations of (1) satisfaction with the decision systems produced and (2) intentions to implement decisions made using them.
Article: "Process Grammar as a Tool for Business Process Design" Authors: Jintae Lee, George M. Wyner, Brian T. Pentland Guest Associate Editor: Michael Prietula		
Business process design is problematic because of the large number of design alternatives that must be considered. Managers must be assured that they have considered a sufficient range of alternatives.	Grammar-based method to generate and manage business process design alternatives and software prototype (instantiation) that supports the method.	Prototype that demonstrates feasibility of the approach and a comparison of alternatives generated.
Article: "Making Sense of Technology Trends in the Information Technology Landscape: A Design Science Approach " Authors: Gediminas Adomavicius, Jesse C. Bockstedt, Alok Gupta, and Robert J. Kauffman Guest Associate Editor: Sandeep Purao		
Managers must consider the potential impacts of future technology developments when making technology adoption decisions.	Constructs and methods used to develop an ecosystem model of technology evolution.	In-depth interviews with IT industry experts and comparison of the ecosystem mode with existing techniques for technology forecasting.
Article: "CyberGate: A System and Design Framework for Text Analysis of Computer Mediated Communication" Authors: Ahmed Abbasi and Hsinchun Chen Associate Editor: Roger Chiang		
Computer mediated communication systems lack capabilities to adequately analyze, evaluate, summarize, and present the textual content of messages	A design framework for text analysis systems instantiated in CyberGate, a software system.	Field experiments; text categorization experiments.
Article: "Using Cognitive Principles to Guide Classification in Information Systems Modeling" Authors: Jeffrey Parsons and Yair Wand Guest Associate Editor: Ramesh Venkataraman		
Analysts have difficulty developing consistent, meaningful, and high-quality data representations.	Model of good classification structures; rules to guide identification of classes in conceptual modeling**.**	Formal proofs and an empirical study using a panel of conceptual modeling experts.

This special issue is intended to augment these discussions, and lead to further rigorous work in the design science area. We invite your feedback and suggestions for how to improve both the articulation of the design science research paradigm and its application in the information systems discipline.

Acknowledgments

We wish to thank the past and present editors-in-chief of *MIS Quarterly*, Allen Lee, Carol Saunders (and the *MISQ* editorial board), and Detmar Straub for their support of this special issue. Special thanks to Alan Hevner, Sandeep Purao, Allen Lee, and Carol Saunders who provided both encouragement and valuable feedback. We are grateful to the associate editors (listed by name below), to the reviewers (too numerous to name), and to all of the authors who submitted papers to the special issue. We are especially indebted to the guest associate editors who handled the papers that were ultimately accepted for publication. They and the reviewers offered valuable critique and suggestions throughout the review and revision process. This special issue would not have been possible without their efforts.

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