Scandinavian Journal of Information Systems

Volume 19 | Issue 2 Article 2

2007

Developing Knowledge Through IS Design Science Research

Sven A. Carlsson
Lund University, sven.carlsson@ics.lu.se

Developing Knowledge Through IS Design Science Research

For Whom, What Type of Knowledge, and How

Sven A. Carlsson

Informatics and Institute of Economic Research, School of Economics and Management, Lund University, Sweden
sven.carlsson@ics.lu.se

1 Introduction

I find Iivari's essay very timely and I read it with great interest and excitement. I was pleased to see that Iivari has risen to the challenges put forward by some IS scholars: analyses of ontologies, epistemologies, methodologies and ethics of design science. Said Purao: "…the scientific foundations underlying this critical area of the IS field—design research—have remained largely undeveloped.…Over the years, in spite of important writings about research (March and Smith 1995), philosophical underpinnings of this form of research have been largely unexplored. Without adequate scientific foundations, research in the technology of information systems (TIS) continues to be a lost child still searching for its scientific home" (Purao 2002).

The relevance problem of academic IS research is an old and thorny one. The academic IS community has responded to this problem in two different ways. Some scholars have argued that the problem is largely one of communication. The underlying assumption is that the academic IS literature does indeed contain much that is relevant to IS professionals and that if only it could be better presented, it would indeed be put to practical use more often.

© Scandinavian Journal of Information Systems, 2007, 19(2):75-86

Others have argued that much of the research output is of little relevance[1] and that the IS field must increase its Mode-2 knowledge production (Gibbons et al. 1994) and especially increase IS design science research (March and Smith 1995; Walls et al. 1992).[2] Iivari's view is that the main means for increasing IS research's relevance is to advance IS design science research. I agree with Iivari on this and I agree with most of Iivari's ideas and prescriptions. In this position paper I will discuss some, but far from all, of Iivari's ideas. I will also take some of Iivari's ideas and issues as starting points and try to show how these can be addressed.

In order to increase the relevance and bridge the gap between scholarly IS research and IS practice we need to have an understanding of the IS practice in terms of what type of knowledge can be useful to IS professionals. This is related to what kind and type of knowledge can and should IS design science research develop. Two major IS design science research schools have emerged (El Sawy 2006): 1) Information Systems Design Theory (Walls et al. 1992, 2004), and 2) Design Science Research (cf. Cao et al. (2006), Hevner et al. (2004), March and Smith (1995), and Nunamaker et al. (1990; 1991)). The schools share a focus on the IT artifact. My understanding is that Iivari also sees the IT artifact as the primary output of IS design science research, but he recognizes to a larger extent than the two schools the need for the development of, for example, ISD approaches, methods, and techniques.

My view on what type of knowledge IS design science research should develop differs in part from Iivari's view. My view is that information systems can be perceived as socio-technical systems. Given some of the current technological and business changes I think such a view is appropriate. For example, many organizations are no longer viewing ERP-projects as technical projects, but as major re-organization projects; and the increased use of commercial off-the-shelf (COTS) software and different forms of sourcing requires new relevant, and in part non-IT-artifact, knowledge to be developed. Reviewing lists of what IS/IT issues are most critical to organizations I find that most of these are managerial issues and not technological issues (Smith and McKeen 2006). Also, it can be argued that a broader view will become more fruitful as the use of IT moves from connection to immersion, and fusion (El Sawy 2003). In immersion IT-based IS are immersed as part of the business environment and can not be separated from work, processes, and the systemic properties of intra- and inter-organizational processes and relationships. In fusion IT-based IS are fused within the business environment such that business and IT-based IS form a unified fabric. Hence, IT-enabled work and processes are treated as one. And, a recent study suggests that business related IS-issues are becoming more and more critical (Zwieg et al. 2006). My view is that the IS-field should develop relevant design knowledge for this new 'land-

scape' and not just develop IT artifacts or IT artifacts design theory. More on this below.

The remainder of the paper will focus on what Iivari calls 'epistemology of design science' and 'methodology of design science'.

2 Developing Information Systems Design Knowledge

This section presents and discusses how to develop IS design knowledge through IS design science research. The underpinning philosophy is a specific form of realism, namely critical realism (Bhaskar 1978; 1998).[3] I start with discussing what types of IS design knowledge should be produced and for whom. The former is discussed by Iivari and I will expand some of his ideas. The latter is not explicitly discussed by Iivari, but it is critical to have a view of who is the target audience for the knowledge IS design science research produces. This is followed by a presentation of how IS design knowledge can be developed. Guiding me is Pettigrew's (1997) idea of the primary double hurdle: "IS design science research should meet the criteria of scholarly quality and practical (professional) relevance."

2.1 For Whom Should IS Design Science Research Produce Knowledge?

March argues that relevance, rigor and results are the trifecta of academic research and that they are defined by the constituency that comprises and supports the IS discipline. This IS constituency includes:

> IS academic researchers, organizations that develop and deploy information technologies (IT), organizations that produce and implement such technologies, IS managers within such organizations and, more and more commonly, general and upper level managers within such organizations. (March 2006, p. 338).

My view is that the primary constituent community for the output of IS design science research is IS professionals and managers responsible for IS/IT-supported and enabled processes and activities. This means primarily professionals who plan, manage and govern, design, build, implement, operate, maintain and evaluate different types of IS/IT initiatives and IS/IT. The design knowledge this community demands include: 1) knowledge for developing IT/IS-enabled solutions (including improving previous implemented solutions)

that primarily address organizational problems, and 2) knowledge for how to implement and integrate the solutions into the context (primarily organizational context). The developed IS design knowledge is to be applied by individuals who have received formal education, or a similar training, for example, in the IS field. An IS professional can be defined as a member of a fairly well-defined group who solves real-world IS problems with the help of skills, creativity and scientific and non-scientific IS design knowledge. (For simplicity I call the problems IS problems although it is more correct to say that someone has defined a problem where one, for one reason or another, has decided to try to solve the problem with an IS-initiative). Another important community is IS education, which means that the knowledge should be useful in different types of IS study programs and IS courses.

Although the primary constituent community works primarily in organizations driven by 'utility maximization' (often in terms of profit), it should be noted that critical realism has also a critical and emancipatory component (Bhaskar 2002). I certainly agree with Iivari when he claims that ethics is both critical and far from well addressed in the IS design science literature. The two major schools discussed above have a clear management perspective and certainly not an emancipatory or critical perspective. The emancipatory and critical issues are important, but here I note it and leave the issue for further exploration and development.

2.2 What Types of IS Design Knowledge Can IS Design Science Research Produce?

There is a lively debate in the IS community on what constitutes the 'IS core'. In the IS design science research literature this debate has been almost non-existing. It seems that most writings on IS design science research have views in line with Benbasat and Zmud's (2003) view that the core of the IS discipline and IS research should be the IT artifact. I find Iivari's presented archetypes of IT applications to have too much focus on the IT artifact per se, but I interpret his writings as he has a broader view. I find the 'pure' IT artifact view a too narrow view. McKay and Marshall (2005) argue that IS is a socio-technical discipline and that

> design science and the research that builds that body of knowledge must acknowledge that IS is fundamentally about human activity systems which are usually technologically enabled, implying that the context of *design* and *use* is critical, and that research paradigms, practices and activities must embrace such a worldview. (p. 5).

Venable (2006) argues that the core of IS design science research is 'solution technology invention', where

> Solution technologies that are relevant in the IS/IT field include IS development methods, techniques, and tools, IS planning methods, IS management methods, IS/IT security and risk management practices, algorithms for computer processing, such as database processing, and many others, all of which are designed purposefully to address human and organisational problems and all of which must be adapted or redesigned when addressing particular, situated problems. (p. 8)

In line with McKay and Marshall's and Venable's view I suggest that the aim of IS design science research is to develop practical knowledge for the design and realization of 'IS initiatives' or to be used in the improvement of the performance of existing IS—the latter is excluded by Hevner et al. (2004), but seems to be critical for practitioners; see, for example, Bendoly and Jacobs (2005) on strategic extension and use of ERP systems. By an IS initiative I mean the design and implementation of an intervention in a socio-technical system where IS (including IT artifacts) are critical means for achieving the desired outcomes of the intervention—hence, IS design science research should include organizations, people, IS, and IT artifacts.

IS design science research should develop practical design knowledge to be used to solve classes of IS problems. This means the development of abstract knowledge that can be used in designing and implementing IS initiatives. The knowledge is abstract in the sense that it is not a recipe for designing and implementing a specific IS initiative for a specific organization. A user, for example, an IS professional, of the abstract design knowledge has to 'transform' the knowledge to fit the specific problem situation and context. What types of IS design knowledge can and should IS design science research produce is related to Iivari's discussion on epistemology of design science and what he denotes 'prescriptive knowledge'. He says that this type of knowledge "…is the least well understood type of knowledge". Below I will present, discuss and illustrate what types of knowledge can be produced and how this knowledge can be produced.

Following Pelz (1978), I distinguish between conceptual and instrumental use of science and research output. The former involves using knowledge for general enlightenment on the subject in question and the latter involves acting on research results in specific and direct ways. Both types are relevant for the IS field, but design science research addresses primarily the development of design knowledge for instrumental use. My interpretation of Iivari's essay is that we share this view.

Using van Aken's (2004) classification I can distinguish three different types of designs an IS professional makes when designing and implementing an IS-initiative: 1) an object-design, which is the design of the IS intervention/(incl. the design of an IT-artifact)initiative, 2) a realization design, which is the plan for the implametation of IS intervention/initiative and 3) a process-design, which is the professional's own plan for the problem solving cycle and includes the methods and techniques to be used in object- and realization-design. IS design science research should produce knowledge that can be used by the professionals in the three types of designs. Given my broader perspective—IS intervention in a socio-technical system—than the schools discussed above, it can be argued, based on the IS implementation and IS failure literature, that realization-design knowledge is critical and should also be developed.

2.3 IS Design Knowledge as Design Propositions

In discussing epistemology of design science Iivari uses the construct 'prescriptive knowledge" and bases his discussion on the work of Walls et al., Bunge, and Niiniuoto. Below I try to expand Iivari's ideas on prescriptive knowledge by in part using the same references. Van Aken (2005; 2006) suggests that prescriptive design knowledge follows the logic of the 'technological rule' (Bunge 1967): "if you want to achieve Y in situation Z, then do (something like) X". However, as acknowledged by van Aken, "the term 'technological rule' may suggest to some a technical, rather mechanistic approach" (van Aken 2005, p. 30). A technological rule can be seen as a design proposition. I suggest that IS design science research should produce knowledge in the form of design propositions.[4] The core of a design proposition is the X, the general solution concept, which can be an action or a set of actions. The logical structure of a design proposition is as above, but the actual form can be an algorithm, a drawing or picture, a report or a whole book. An algorithmic design proposition can in principle guarantee a good (best) outcome, for example, a design proposition for normalizing a data base. A heuristic design proposition does not guarantee success, but it supports the development of a successful system or action. In IS design science research addressing non-technological issues the likely result will be in the form of heuristic design propositions. This is consistent with critical realism's view on causality and means that the indeterminate nature of a heuristic design proposition makes it impossible to prove its effects conclusively, but it can be tested in context, which in turn can lead to sufficient supporting evidence (Groff 2004; Hedström 2005).

A design proposition is general, which for IS design knowledge means that a proposition is a general prescription for a class of IS problems. Since a design proposition should be used by practitioners it should be applicable and actionable.[5] A field-tested and grounded design proposition has been tested empirically and is grounded in science. The latter means grounding in results and theories from the natural and behavioral sciences. Iivari says that the idea that IS design science should be rooted in theories was pioneered by Walls et al. (1992). Iivari stresses that the "term 'design theory' should be used only when it is based on a sound kernel theory." I agree with Iivari, but, unfortunately, Iivari does not address the critical question: what is a (sound) kernel theory? Over the years debates on what constitutes theory or not have been common.

I agree with Iivari that IS design science research can be carried out in a number of different ways, but I disagree with Iivari on that design science research has its roots in engineering. Given my view on the IS field and IS design science research means that IS design is both like and unlike material object design. This means that IS design science research in some cases can learn from engineering, but in other cases, especially when addressing non-technological IS issues, can learn more from management design science research.

3 Conclusion

The underlying ontological and epistemological view IS design science research is built on will ultimately affect how to do IS design science research and what types of outcomes (design knowledge) that can be produced. I agree with most of Iivari's ideas and theses. I have in this position paper tried to point out some weaknesses in Iivari's essay and noted some of the views were we disagree. I think we, in part, disagree on what types of knowledge IS design science research should produce and for whom (the latter is not explicitly stated by Iivari). Our disagreement might be an effect of that I see IS design research as having it's roots in not only in engineering. I have also tried to show how some of Iivari's ideas and theses can be approached. Iivari´s and my ideas are not the final word in the debate on IS design science research, but I am convinced that Iivari's ideas and theses can be used in IS design science research and lead to a stream of research that can develop high scholarly quality and practical (professional) IS design science knowledge.

Notes

1. It is interesting to note that already 30 years ago Susman and Evered (1978) noted that "as our research methods and techniques have become more sophisticated, they have also become less useful for solving the practical problems that members of organisations face". This view is echoed in recent debates, for example, in George and Bennett (2004) and Bennis and O'Toole (2004).
2. We have in the last years seen a growing interest in IS design science research and IS design theory/knowledge (Walls et al. 2004). For example, there is a fairly new ISWorld web-site on "Design Research in Information Systems" (Vaishnavi & Kuechler 2007); the United States National Science Foundation (NSF) issued a solicitation in 2004 with the goal "to stimulate research and education projects that build the Science of Design"; the First International Conference on *Design Science in Information Systems and Technology* (DESRIST 2006) was held in 2006 and was followed by DESRIST 2007; and *MIS Quarterly* had last year a call for papers on "Design Science Research".
3. Iivari's references, especially when discussing epistemology (referring to, for example, Bunge and Niiniluota), suggests that Iivari´s work is also based on realism (albeit a different form of realism).
4. The major output of IS design science research is design propositions. For behavioral IS research the major output is causal models.
5. We have discussed and shown how heuristic design propositions can be developed and tested (Hrastinski et al. 2007).

References

Benbasat, I., and Zmud, R.W., "The Identity Crisis within the IS Discipline: Defining and Communicating the Discipline's Core Properties," *MIS Quarterly*, (27:2), 2003, pp. 183-194.

Bendoly, E., and Jacobs F.R. (eds.), *Strategic ERP Extension and Use*, Stanford Business Books, Stanford, CA, 2005.

Bennis, W. G., and O'Toole, J., "How business schools lost their way," *Harvard Business Review*, (83:5), 2005, pp. 96-104.

Bhaskar, R., *A Realist Theory of Science*, Harvester Press, Sussex, 1978.

Bhaskar, R., *The Possibility of Naturalism*, third edition, Routledge, London, 1998.

Bhaskar, R., *From Science to Emancipation: Alienation and the Actuality of Enlightenment*, Sage, New Delhi, 2002.

Bunge, M., *Scientific Research II: The Search for Truth*, Springer Verlag, Berlin, 1967.

Cao, J., Crews, J.M., Lin, M., Deokar, A., Burgoon, J., and Nunamaker, J.F., "Interactions between System Evaluation and Theory Testing: A Demonstration of the Power of a Multifaceted Approach to Information Systems Research," *Journal of Management Information Systems*, (22:4), 2006, pp. 207–235.

Carlsson, S.A., "Towards an Information Systems Design Research Framework: A Critical Realist Perspective," in *Proceedings of the First International Conference on Design Science in Information Systems and Technology* (DESRIST 2006), Claremont, 2006, pp. 192-212.

El Sawy, O.A., "The 3 Faces of IS Identity: Connection, Immersion, and Fusion," *Communications of the AIS*, (12:39), 2003.

El Sawy, O.A., Personal communication, August 2006.

George, A.L., and Bennett, A., *Case Studies and Theory Development in the Social Sciences*, MIT Press, Cambridge, MA, 2004.

Gibbons, M., Limoges, C., Nowotny, H., Schwatzman, S., Scott, P., and Trow, M., *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*, Sage, London, 1994.

Groff, R., *Critical Realism, Post-positivism and the Possibility of Knowledge*, Routledge, London 2004.

Hedström, P., *Dissecting the Social: On the Principles of Analytical Sociology*, Cambridge University Press, Cambridge, 2005.

Hevner, A.R., March, S.T., Park, J., and Ram, S., "Design Science in Information Systems Research," *MIS Quarterly*, (28:1), 2004, pp. 75-105.

Hrastinski, S., Carlsson, S.A., and Keller, C., "Towards a Design Theory for Synchronous Computer-mediated communication in E-Learning Environments," in *Proceedings of the Second International Conference on Design Science in Information Systems and Technology* (DESRIST 2007), Pasadena, 2007.

March, S.T., "Designing Design Science," in *Information Systems: The State of the Field*, J.L. King and K. Lyytinen (eds.), John Wiley & Sons, Chichester, 2006, pp. 338-344.

March, S.T., and Smith, G., "Design and Natural Science Research on Information Technology," *Decision Support Systems*, (15:4), 1995, pp. 251-266.

McKay, J., and Marshall, P., "A Review of Design Science in Information Systems," in Proceedings of the 16th Australasian Conference on Information Systems, Sydney, 29 November–2 December, 2005.

Nunamaker, J.F., Chen, M., and Purdin T.D.M., "System Development in Information Systems Research," *Journal of Management Information Systems*, (7:3), 1990-1991, pp. 99-106.

Pelz, D.S., "Some Expanded Perspectives on the Use of Social Science in Public Policy," in *Major Social Issues: A Multidisciplinary View*, M. Yinger and S.J. Cutler (eds.), Free Press, New York, 1978, pp. 346–57.

Pettigrew, A., "The Double Hurdles of Management Research," in *Advancement in Organisational Behaviour: Essays in Honor of Derek S. Pugh*, T. Clarke (ed.), Dartmouth Press, London, 1997, pp. 277–96.

Purao, S., "Design research in technology and information systems: truth or dare," unpublished paper, School of Information Sciences and Technology, The Pennsylvania State University, University Park, State College, PA, 2002.

Simon, H.A., *The Sciences of the Artificial*, third edition, MIT Press, Cambridge, MA, 1996.

Smith H.A., and McKeen J.D., "IT in 2010: The Next Frontier," *MIS Quarterly Executive*, (5:3), 2006, pp. 125-136.

Susman, G.I., and Evered, R.D., "An Assessment of the Scientific Merits of Action Research," *Administrative Science Quarterly*, 23, 1978, pp. 582-603.

Vaishnavi, V.; and Kuechler, W., "Design Research in Information Systems," http://www.isworld.org/Researchdesign/drisISworld.htm, Accessed 10 March 2007.

Van Aken, J.E., "Management Research Based on the Paradigm of Design Sciences: The Quest for Field-tested and Grounded Technological Rules," *Journal of Management Studies*, (41:2), 2004, pp. 219-246.

Van Aken, J.E., "Management Research as a Design Science: Articulating the Research Products of Mode 2 Knowledge Production in Management," *British Journal of Management*, 16, 2005, pp. 19-36.

Van Aken, J.E., "The Nature of Organizing Design: Both Like and Unlike Material Object Design," Working Paper 06.13, Eindhoven Centre for Innovation Studies, Technische Universiteit Eindhoven, The Netherlands, 2006.

Venable, J.R., "The Role of Theory and Theorising in Design Science Research," in Proceedings of the First International Conference on Design Science in Information Systems and Technology (DESRIST 2006), Clarement, 2006, pp. 1-18.

Walls, J.G., Widmeyer, G.R., and El Sawy, O.A., "Building an Information Systems Design Theory for Vigilant EIS," *Information Systems Research*, (3:1), 1992, pp. 36-59.

Walls, J.G., Widmeyer, G.R., and El Sawy, O.A., "Assessing Information System Design Theory in Perspective: How Useful was our 1992 Initial Rendition?," *Journal of Information Technology Theory and Application*, (6:2), 2004, pp. 43-58.

Zwieg, P. et al., "The Information Technology Workforce: Trends and Implications 2005-2008," Society for Information Management IT Workforce White Paper, 2006.