A Three Cycle View of Design Science Research

Article *in* Scandinavian Journal of Information Systems · January 2007

CITATIONS
1,833

READS
31,699

1 author:

Alan Hevner
University of South Florida
251 PUBLICATIONS **27,549** CITATIONS

SEE PROFILE

A Three Cycle View of Design Science Research

Alan R. Hevner

Information Systems and Decision Sciences, University of South Florida, USA
ahevner@coba.usf.edu

Abstract. As a commentary to Juhani Iivari's insightful essay, I briefly analyze design science research as an embodiment of three closely related cycles of activities. The Relevance Cycle inputs requirements from the contextual environment into the research and introduces the research artifacts into environmental field testing. The Rigor Cycle provides grounding theories and methods along with domain experience and expertise from the foundations knowledge base into the research and adds the new knowledge generated by the research to the growing knowledge base. The central Design Cycle supports a tighter loop of research activity for the construction and evaluation of design artifacts and processes. The recognition of these three cycles in a research project clearly positions and differentiates design science from other research paradigms. The commentary concludes with a claim to the pragmatic nature of design science.

Keywords: design science, relevance cycle, rigor cycle, design cycle.

1 Design Science Research Cycles

Design science research is poised to take its rightful place as an equal companion to natural science research in the Information Systems (IS) field. As it is doing so, it is vital that we as a research community provide clear and consistent definitions, ontologies, boundaries, guidelines, and deliverables for the design and execution of high quality design science research projects. Understanding and communicating the design science research process is essential not only to support acceptance among IS professionals but also to establish the credibility of IS design science research among the larger body of design sci-

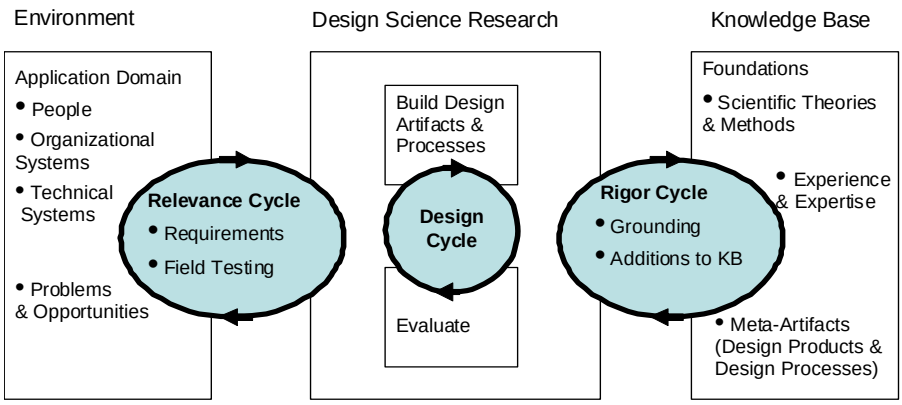

Figure 1. Design Science Research Cycles

ence researchers in the various engineering fields, architecture, the arts, and other design-oriented communities.

Juhani Iivari's essay (Iivari 2007) is an important and insightful contribution to a clearer understanding of the key properties of the design science research paradigm—ontology, epistemology, methods, and ethics. I find myself in basic agreement with the twelve *theses* that summarize the author's analysis of IS as a design science. In this commentary I relate several of the essay's theses to the existence of three design science research cycles. The goal is to enhance our understanding of what it means to do high quality design science research in IS.

Figure 1 borrows the IS research framework found in (Hevner et al. 2004) and overlays a focus on three inherent research cycles. The *Relevance Cycle* bridges the contextual environment of the research project with the design science activities. The *Rigor Cycle* connects the design science activities with the knowledge base of scientific foundations, experience, and expertise that informs the research project. The central *Design Cycle* iterates between the core activities of building and evaluating the design artifacts and processes of the research. I posit that these three cycles must be present and clearly identifiable in a design science research project. The following sections briefly expand on the definitions and meanings of each cycle.

2 The Relevance Cycle

Design science research is motivated by the desire to improve the environment by the introduction of new and innovative artifacts and the processes for build-

ing these artifacts (Simon 1996). An application domain consists of the people, organizational systems, and technical systems that interact to work toward a goal. Good design science research often begins by identifying and representing opportunities and problems in an actual application environment. In his essay, Juhani points out that some design science research is about potentiality; the identification of new opportunities to improve practice before any problem is recognized.

Thus, the relevance cycle initiates design science research with an application context that not only provides the requirements for the research (e.g., the opportunity/problem to be addressed) as inputs but also defines acceptance criteria for the ultimate evaluation of the research results. Does the design artifact improve the environment and how can this improvement be measured? The output from the design science research must be returned into the environment for study and evaluation in the application domain. The field study of the artifact can be executed by means of appropriate technology transfer methods such as action research (Cole et al. 2005; Jarvinen 2007).

The results of the field testing will determine whether additional iterations of the relevance cycle are needed in this design science research project. The new artifact may have deficiencies in functionality or in its inherent qualities (e.g., performance, usability) that may limit its utility in practice. Another result of field testing may be that the requirements input to the design science research were incorrect or incomplete with the resulting artifact satisfying the requirements but still inadequate to the opportunity or problem presented. Another iteration of the relevance cycle will commence with feedback from the environment from field testing and a restatement of the research requirements as discovered from actual experience.

3 The Rigor Cycle

Design science draws from a vast knowledge base of scientific theories and engineering methods that provides the foundations for rigorous design science research. As importantly, the knowledge base also contains two types of additional knowledge:

- The experiences and expertise that define the state-of-the-art in the application domain of the research.
- The existing artifacts and processes (or meta-artifacts as put forth by Juhani in Thesis 5) found in the application domain.

The rigor cycle provides past knowledge to the research project to ensure its innovation. It is contingent on the researchers to thoroughly research and reference the knowledge base in order to guarantee that the designs produced are research contributions and not routine designs based upon the application of well-known processes (Hevner et al. 2004). As Juhani notes, "It is the rigor of constructing IT artifacts that distinguishes Information Systems as design science from the practice of building IT artifacts."

Research rigor in design science is predicated on the researcher's skilled selection and application of the appropriate theories and methods for constructing and evaluating the artifact. A key question that Juhani addresses is whether a 'design theory' is an essential aspect of design science rigor. My opinion aligns with Juhani's contention that it is often a stretch to find kernel theories for the creative activities of design research. While theories can serve as sources of creative ideas, to insist that all design research must be grounded on descriptive theories is unrealistic and even harmful to the field when good design science papers are rejected in top journals due to lack of a grounding theory. I much prefer the direction of identifying several different sources of ideas for the grounding of design science research to include rich opportunities/problems (from the relevance cycle), existing artifacts, analogies/metaphors, and theories (Juhani 2007). I would expand this list of design inspiration to include additional sources of creative insights (Csikszentmihalyi 1996).

Additions to the knowledge base as results of design science research will include any extensions to the original theories and methods made during the research, the new meta-artifacts (design products and processes), and all experiences gained from performing the research and field testing the artifact in the application environment. Research contributions to the knowledge base are key to selling the research to the academic audience just as useful contributions to the environment are the key selling points to the practitioner audience.

4 The Design Cycle

The internal design cycle is the heart of any design science research project. This cycle of research activities iterates more rapidly between the construction of an artifact, its evaluation, and subsequent feedback to refine the design further. Simon (1996) describes the nature of this cycle as generating design alternatives and evaluating the alternatives against requirements until a satisfactory design is achieved. As discussed above, the requirements are input from the relevance cycle and the design and evaluation theories and methods

are drawn from the rigor cycle. However, the design cycle is where the hard work of design science research is done. I believe that it is important to understand the dependencies of the design cycle on the other two cycles while appreciating its relative independence during the actual execution of the research.

During the performance of the design cycle it is important to maintain a balance between the efforts spent in constructing and evaluating the evolving design artifact. Both activities must be convincingly based in relevance and rigor. Having a strong grounded argument for the construction of the artifact, as discussed above, is insufficient if the subsequent evaluation is weak. As Juhani states in his essay, "The essence of Information Systems as design science lies in the scientific evaluation of artifacts." Along with Juhani, I agree that artifacts must be rigorously and thoroughly tested in laboratory and experimental situations before releasing the artifact into field testing along the relevance cycle. This calls for multiple iterations of the design cycle in design science research before contributions are output into the relevance cycle and the rigor cycle.

5 Design as a Pragmatic Science

Let me conclude this brief commentary with a claim for the pragmatic nature of design science. Juhani states that prior research papers (Hevner et al. 2004; March and Smith 1995) associate design science with a pragmatic philosophy. Pragmatism is a school of thought that considers practical consequences or real effects to be vital components of both meaning and truth. Along these lines I contend that design science research is essentially pragmatic in nature due to its emphasis on relevance; making a clear contribution into the application environment. However, practical utility alone does not define good design science research. It is the synergy between relevance and rigor and the contributions along both the relevance cycle and the rigor cycle that define good design science research.

In my current assignment at the U.S. National Science Foundation (NSF) I work with research proposals in the directorate of Computer and Information Science and Engineering. A majority of these research projects use a design science research paradigm. Since its beginnings in 1953, the NSF has struggled with distinctions between basic science and applied science in its awarding of research funds[1] to academic researchers. Does the practical utility of a result necessarily make the research project applied science? Can a research project effectively balance goals of fundamental scientific understanding with

considerations of the usefulness of the resulting artifacts? These are importance issues for us in Information Systems to address as we strive to better understand how to perform rigorous and relevant design science research and how to attract external funding to our research.

Notes

1. I highly recommend Stokes (1997) for an in-depth discussion of the history and current implications of the debates over the funding of basic and applied research at NSF and in the U.S. government.

References

Csikszentmihalyi, M., *Creativity: Flow and Psychology of Discovery and Invention*, HarperCollins, New York, 1996.

Cole, R., Purao, S., Rossi, M. and Sein, M.K., "Being Proactive: Where Action Research Meets Design Research," *Proceedings of the Twenty-Sixth International Conference on Information Systems*, Las Vegas, 2005, pp. 325-336.

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.

Iivari, J., "A Paradigmatic Analysis of Information Systems as a Design Science, *Scandinavian Journal of Information Systems*, 19(2), 2007.

Jarvinen, P., "Action Research is Similar to Design Science, *Quality & Quantity*, 41, Springer, 2007, pp. 37-54.

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

Simon, H., *The Sciences of Artificial*, 3rd Edition, MIT Press, Cambridge, MA, 1996.

Stokes, D., *Pasteur's Quadrant: Basic Science and Technological Innovation*, Brookings Institution Press, Washington D.C., 1997.