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Opening up design science: The challenge of designing for reuse and joint development

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ABSTRACT

The purpose of this paper is to advance design science by developing a framework for research on reuse and the relationship between external IT artifacts and their users. A design science approach to IS research needs to grapple with the fact that a number of relevant, economically attractive, external IT artifacts cannot be designed from scratch nor meaningfully evaluated based on the current state of development, and so design science research will struggle with incomplete cycles of design, relevance, and rigor. We suggest a strategic research agenda that integrates the design of the relationship between an external IT artifact and the user by considering the impact artifacts exert on users. Three dimensions derived from adaptive structuration theory inform our framework on three levels of design granularity (middle management, top management, and entrepreneur): *agenda* considers the dynamic properties of technological objects, *adaptability* refers to the functional affordance of external artifacts in development, and *auspice* captures the symbolic expression and scope for interpretation. We derive implications for research design.

1. Introduction

Information systems (IS) pervade everyday organizational life. Managers and IS professionals build and evaluate IT artifacts, such as vocabulary, symbols, models, algorithms, procedures, and instantiations, tailored to organizational needs in order to solve problems that, until now, could not be addressed by information technology. The design science approach in IS established rigorous research guidelines that foster contributions to the problem-oriented, innovative, and effective creation, deployment, and evaluation of IT artifacts in organizations (Hevner et al., 2004; March and Storey, 2008; March and Smith, 1995). However, a growing number of IT artifacts are not only created outside the organization, they also extend beyond the organization in terms of both complexity and dynamics (Elbanna, 2010). As a result, any one designer's ability to fully understand and influence overall development remains limited. Working with systems and environments such as GNU Linux, Apache, or Mozilla, to name just a few of the largest and most popular open Source (OS) families of programs, managers and designers face the challenge of using external IT artifacts—existing artifacts developed outside their organization. This design activity that encompasses relating to external IT artifacts is only partially understood: as reuse across organizations (Ravichandran and Rothenberger, 2003; Haefliger et al., 2008) and as community relations entertained by firms (Shah, 2006; Dahlander, 2007).

The emerging literature on reuse of external IT artifacts considers search and adaptation efforts (Bonaccorsi et al., 2006; Majchrzak et al., 2006; West, 2003), whereas the literature on community relations emphasizes evaluation and sharing of IT artifacts (Henkel, 2006; Dahlander and Wallin, 2006; Dahlander, 2007; Stuermer et al., 2009). These design activities, while

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effective in tackling the challenge of dealing with external artifacts, partially ignore the systematic context difference between the external developers and the designers and users within the adopting organization. We currently lack a comprehensive framework that could inform design science research on the use of externally developed IT artifacts, in particular adaptation and evaluation. Crucially, use occurs in a different context from development and designers must be made aware of the effects external IT artifacts can have on use within the organization (Ciborra, 1998). Starting with the search for an IT artifact and problem formulation all the way through the adoption, development and internal evaluation, understanding the effects of use and context, that may limit "degrees of freedom" in design, has become a priority for IS researchers and practitioners. A strategic perspective reinforces the urgency because successful information systems (e.g. for knowledge management) rely on accessible and well integrated IT artifacts (Butler et al., 2008; Massey et al., 2002), and integration refers to the everyday context of use in an organization.

The purpose of this paper is to advance design science by developing a framework for research on reuse and the relationship between external IT artifacts and their users. We seek to advance avenues for future research on IS through the design science approach by formulating and grounding a set of research questions. In the next section, we briefly introduce the literature on the design of IT artifacts, and show the importance of a research thrust on designing and relating to externally designed IT artifacts. Next, we develop a framework of research questions to guide future work in this particular area. Before concluding, we discuss the implications of our framework for research design and for the role and focus of the design science researcher.

2. Design and relate: an overview of the literature

Design science was originally conceived within engineering and computer science and aimed at problem solving in these areas (Simon, 1996). Today, design science is pervasive in several academic disciplines that build artifacts, such as mechanical or medical engineering, biotechnology, construction engineering, and architecture. In IS, design science evolved into a coherent body of theory and research on design and action (Gregor, 2006). It opened vast opportunities for predicting and observing the interaction between researchers, designers, users, organizations, and the evolving artifact (Cross, 2007; Markus et al., 2002; Hevner et al., 2004; Banker and Kauffman, 2004; Gregor, 2006). Hevner and colleagues (2004) developed a foundational design science approach to IS research consisting of two activities, the initial development of artifacts and their subsequent justification and evaluation. They based their study on business needs originating with people, organizations, and technology, as well as theoretical foundations and research methods. More specifically, Hevner (2007) posited three cycles in design science: the relevance cycle that connects design science research and the problem environment through the specification of requirements and field testing; the design cycle that connects building and evaluating artifacts; and the rigor cycle that connects design science research and developing knowledge bases. Hevner et al. (2004) distilled the practical aspects of design science into seven pivotal IS guidelines: (1) create an artifact that addresses an organizational problem; (2) ensure the problem is relevant to business; (3) evaluate the utility of the design in view of the needs or problems it is created to address; (4) contribute to academic and practical knowledge through the new artifact, methods, or foundations; (5) use rigorous methods when creating and evaluating the artifact; (6) search for an effective artifact using available means to reach a desired end, within the (legal) constrains set by the problem environment; (7) communicate design outcomes to managers and academics.

As these guidelines show, one undisputed advantage of the design science approach is the intertwined nature of artifact design and the process of researching it. The distinctions between "research and design" or "observing and doing" become increasingly blurred, to the potential benefit of practice and academia alike. Design science helps researchers and managers engage in constructive dialogues: researchers to identify the most relevant and pressing research problems, and the academic IS discipline to contribute to practically useful knowledge, novel theories, and tested methodologies (Hevner, 2007). Fundamentally, design science frees the IS field of excessive technological determinism, or the simplistic view that technology is determined by rules or laws beyond human control (Hickman, 1998). It also helps IS researchers to add "truth value" to artifacts and recommendations by specifying their effectiveness and efficiency in specific situations (Iivari, 2007, pp. 46–47). An important assumption for design science to work, however, is that context along the dimensions of people, organization, and technology is known, potentially understood or, to some limited extent, controllable by the researcher, much like an attempt to identify and unilaterally control a complex set of variables in quasi-experiments. Inside firms, the design science approach to IS research still very much relies on a notion of a cyclical process that starts with problem formulation and ends with successful implementation (Hevner, 2007; March and Storey, 2008). As Hevner suggested (2007, p. 89), "Good design science research often begins by identifying and representing opportunities and problems in an actual application environment." Hevner then proceeds to clarify how the application context not only provides requirements for research, but also specifies acceptance criteria for the final evaluation of the research outcome. Under such conditions, design science is rational, rigorous, and useful. Yet, with the advent of external IT artifacts—where collaborative development across organizational boundaries engages widely distributed populations of designers and users and integrates a large variety of technologies—new forms and contingencies raise an important challenge to conventional design science in IS: the context defined along multiple dimensions becomes increasingly dynamic and problematic to identify, understand, and control unilaterally. Garud et al. (2008) alluded to this challenge when elaborating on the design approach taken by developers of collaborative efforts such as Wikipedia and GNU Linux. What the authors call "designing for incompleteness" is a cycle of evolving artifact designs that opens up questions and options for re-design.