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Tinkering, Tailoring and Bricolage: Implications for Theories of Design

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ABSTRACT

Current structural specifications for design theory and guidelines for Design Science fall short of creating theories that account for user tinkering, secondary design tailoring, and the interactions of supporting kernel theories. This paper offers an expansion of design theory conceptualization by incorporating aspects of design which occur in everyday technology use. Currently, design theory is focused solely on the artifact while obscuring the teleological *information processes* for which they are designed. We propose the addition of environments which can organize kernel theories and provide insight regarding interaction and influence of kernel theory in different use contexts. In addition, the modification of information artifacts and processes as users tinker with, and tailor systems is a necessary aspect of design theory specifications.

Keywords: Design Theory, Kernel Theory, Tailorable Technology, Tinkering, Information Environments, Bricolage

INTRODUCTION

The role and structure of theory in Design Research has recently come under greater scrutiny in the field of Information Systems (IS). The design and the embedding of technical artifacts in complex organizational, social, and task environments is fundamental to IS, and a deeper understanding of design theory has provoked significant research and discussion (for an overview see (Venable 2006)). As IS has searched for legitimacy and identity, it has focused on the technology artifact (Benbasat and Zmud 2003; Orlikowski and Iacono 2001) and artifact design has been shaped by guidelines for research to qualify as 'design science' (Hevner et al. 2004). In addition, the structural components of 'design theory' (March and Smith 1995) have been suggested, and design theory has been dissected into its anatomical parts (Gregor and Jones 2007). These efforts have promoted a belief in a dichotomous division of design theory into two paradigms which form a "complementary research cycle between design science and behavioral-science" (Hevner et al. 2004 p 76). At the same time, researchers have recognized that "technology and behavior are not dichotomous in an information system. They are, in fact, inseparable" (Hevner et al. 2004 p 77). This apparent contradiction, that design research is composed of cyclic motion between two potentially incommensurate paradigms in order to theorize about phenomena that are inseparable, raises interesting questions regarding what IS design theories should actually do. But the focus in literature on the structure of theory and what guidelines must be followed has obscured and underestimated the phenomena we are theorizing about.

What is shared in these papers is the development of theory about 'an artifact.' This is evidenced in statements that the purpose of design research is to develop "predictive theory about the utility (effectiveness, efficacy, etc.) of applying the technological solution" (Venable 2006 p 12) and to rigorously demonstrate "the utility, quality, and efficacy" (Hevner et al 2004 p 83) of the artifact. This reflects the "pervasive view that design science is about 'things' and the things or artifacts of interest in IS are technical systems" (McKay and Marshall 2005). The IS field has a number of prescriptive 'theories' for the design of specific classes of information systems, including those to support knowledge processes (Markus et al. 2002), systems for vigilant EIS (Walls et al. 1992), and systems for e-learning (Jones and Gregor 2006). Other researchers have broadened the design research domain to include software development theory, risk management, and organizational information services. Each of the design theories provides procedural knowledge of how to build information systems but none of these theories accounts for what system participants do when they are involved in the teleological goal of IS use and the *information processes* that surround such use.

We argue that when using an information system, it is not the participants' goal to work with information technology. Instead, the goal is to produce, collect, analyze, retrieve, store, or communicate *information* in an interactive and frequently ideographic process between the user, technology, and other people. As a result, our design theories must predict and explain the processes by which the user and technology produce and consume information. We expand the view of design research to include the entire constellation of components that combine to create situated *information processes* and not just a single, stable artifact. We suggest that the design and building of an artifact is only one-half of the design process, with the other half being the cognitive, subjective, and embodied interactions (Butler and Murphy 2007) participants have during information technology use and recreation.

Our current conceptualization of 'design theory' is modeled after the natural sciences in which there are regular phenomena which are highly predictable in nature. Design theory therefore is constructed by attending to rationality, method, and programmatic design of an external artifact. One implication of this model is the perception that "people will encounter technology as something that is encountered just as it was designed, to be appropriated or incorporated into practice" (Dourish 2006 p 6). There are certainly classes of information systems for which this is largely true. Corporate ERP systems, enterprise accounting software, and medical reporting systems are examples of 'rigid' IS where there may be a desire that the users will use the system as designed and that users will all have similar experiences with the system. But at the other end of the spectrum are an increasing number of information systems and services which are intended to be tailored in the context of their use (Germonprez et al. 2007). These systems provide information environments where participants in the information process reflect on the context, tasks, and technologies and subsequently tailor the system or service set to suit their own metaphors and use patterns. Other users may tinker or play with the system components and functions with no specific task in mind. But prior experience with systems, and the affordances of the system themselves present transcendental possibilities in which the reflective user may create new uses or applications. Tailoring and tinkering are activities which overcome cognitive and normative barriers and allow users to see, appreciate and utilize all the potential applications already present (Ciborra 2002). The participants who tinker with and tailor systems in creating information processes are acting as secondary designers in the ongoing creation and recreation of information environments. Everyday informal modes of teleological use of systems involve tinkering, tailoring, and serendipitous outcomes from information systems (Germonprez et al. 2007; Ciborra 2002). This informal tailoring of systems, rather than a formal top-down design process, has led to numerous instances of strategically advantageous information systems, with the most noteworthy example being the Internet itself. Recent research has begun to address this phenomenon, including a theoretical approach to the design of tailorable technologies (Germonprez et al. (2007) which identified a dual-phase design process. Additionally, Gregor and Jones (2007) include mutability, "the ways in which [artifacts] emerge and evolve over time and how they become interdependent with socio-economic contexts and practices" (p 326) as a key unresolved issue for design.

In this paper, we examine the implications for design theory as we shift from theorizing about an artifact to theorizing about design as a holistic information process. We argue that design theory itself must account for the tinkering and secondary design that creates an evolutionary trajectory for contextually situated information processes. Additional questions are addressed regarding theorizing the roles and interactions of 'kernel theories' which comprise design theories. We suggest that the frameworks of Gregor and Jones (2007) and Hevner et al. (2004) have been applied by many researchers as a checklist for qualifying research as design theory and not as models of theoretical development. As a result, researchers are falling short in their development of strong design theory by not clearly addressing the fundamentals of theory development. Specifically, our key research questions are:

1) How can existing models (Gregor and Jones 2007; Hevner et al. 2004) be extended to theorize the design and in-practice use of information systems which compose the *information process*?

2) How can a composite design theory composed of multiple kernel theories integrate the justificatory knowledge it relies upon?

THE ROLE OF THEORY IN DESIGN THEORY

Gregor (2006) lists design theory as a distinct theory type that provides "principles of form and function, methods, and justificatory theoretical knowledge that are used in the development of IS" (p 628). It should be noted that most conceptualizations regard design theory as a composite theory composed, in part, of other kernel theories (justificatory knowledge) drawn from reference disciplines. Many authors have simplified the role of design theory and ascribe to it the role of prediction and explanation of known facts, and whose quality is measured via its usefulness. As a counter to this approach, we refer to Kuhn's (1977) characteristics of good theory as embodying "accuracy, consistency, scope, simplicity and fruitfulness" (1977 p 322). Of particular importance in this discussion are the characteristics of: scope, "a theory's consequences should extend far beyond the particular observations, laws, or sub-theories it was initially designed to explain"; and fruitfulness, or capable of revealing "new research findings: it should, that is, disclose new phenomena or previously unnoted relationships among those already known" (Kuhn 1977 p 322). Kuhn's work suggests that design theories that only prescribe building an artifact subjects these theories to a continuous state of trivial verification and are unable to "predict novel facts, facts which have been either undreamt of, or indeed have been contradicted by previous or rival programmes" (Lakatos 1973 p 24). As a result, we must consider the value of a design theory in its ability to predict novel facts and observations if design theories are not to degenerate to procedural, rather than theoretical, knowledge. Indeed the hallmark of scientific progress is not the verification of theory, rather "what really count are dramatic unexpected, stunning predictions…" (Lakatos 1973 p 25).

It is important to recall that maturity of theory is a dimension rather than a category, and can range from theory approximation to strong theory (Whetten 1989). Design theories may be unique in the sciences for their reliance on a specified list of structural components (Gregor and Jones 2007). The emphasis on guidelines and structural anatomy may provide a false sense of 'good theory' based on fulfilling a checklist, rather than the theory's ability to account for the phenomenon and to make novel predictions. Therefore we suggest that the guidelines of Hevner et al. (2004) and the proposed design theory structures of Walls et al. (1992) and Gregor and Jones (2007) should be extended in two important ways. First, researchers must understand that, except in trivial cases, design theories are not single, uniform theoretical structures that operate in a static, simple way. Gabriel (2002) and Ciborra (2002) describe *bricolage* as a way of describing modes of use characterized by tinkering, improvisation, and the resulting serendipitous, unexpected outcomes. Strong design theory must be able to account for this type of messy and ideographic secondary design activity underlying tailorable technologies.

Second, instead of focusing on the patterns of unexpected and the emergent phenomena implicit in the evolutionary trajectory of systems, many researchers have proposed that design theories rely on theoretical knowledge from multiple references sources. Although kernel theories provide a starting point, little consideration has been given to how, when, and where kernel theories are applicable. For example, does each kernel theory explain or predict a particular aspect of the design? How does one kernel theory interact with other kernel theories? In what context, for what system participants, and for what tasks do specific kernel theories become relevant to the design? Minger's (2001) exposition on the multidimensional world points to the difficulty in simply listing kernel theories for a design without considering the broader implications of the context from which kernel theories arose and are being applied. As a result, the core concepts of design theory presented by Gregor and Jones (2007) and Hevner et al. (2004) are in need of additional theoretical elements that can help support design theories in a more accurate, broadly scoped, consistent, and process-oriented way.

EXTENDING DESIGN THEORY I: TINKERING AND TAILORING

The IS discipline has been seeking definitive "theories" of design which help us build clear, unambiguous artifacts. Gregor (2006) suggests the goal of design theory is to give "explicit prescriptions (e.g. methods, techniques, principles of form and function) for constructing an artifact" (p 620). But the everyday engagement in an information process "shows unexpected consequences: events, behaviors, and features of systems and the people who use them fall outside the scope of the original specifications" (Ciborra 2002, p 44). System use patterns are irregular, often contradictory, untidy, and subject to approximation. Ciborra (2002) discussed the approximate and happenstance nature of systems in use, and likens successful systems to the "advanced, robust engineering, rustic design, and widespread virtuoso tinkering" that kept the MIR space station operating. In his view, the rational, method-driven design approach does not account for the ongoing everyday information processes. Current design science theory separates the design of the artifact from the teleological goal of the artifact (i.e. the use of the artifact in ongoing but changing information processes) while at the same time declaring that these two aspects are inseparable. It is impossible for a primary design effort to completely specify an information process *ex ante*.

Integrating theoretical components from the behavioral and design science paradigms as suggested by Hevner et al. (2004) is not a trivial task. First, Hevner et al. (2004) does not address this concern and simply states that these are the source paradigms for supporting theory. But they specifically state, "we do not include people or elements of organizations in our definition nor do we explicitly include the process by which such artifacts evolve" (p 82) and do not address the incommensurate nature of natural science and behavioral theories (Andersen et al. 2006; Kuhn 1962). At the same time, they contend that design theories "must explain how artifacts are created and adapted to their changing environments and underlying technologies" (p 82). This would imply the need for theoretical understanding of the everyday reflections and tailoring by system participants which produces the secondary designs and evolution of the information process. It is clear that the guidelines of Hevner et al. (2004) must be extended for a robust design theory to account for this phenomenon.

Ciborra (2002) describes examples in which tinkering and improvisation resulted in strategically important information systems. On a broad scale, one example is the "unplanned and unanticipated success of electronic mail. A local user hack caused a radical shift in the identity of ARPANET." (Ciborra 2002 p 43). More recent small-scale examples include mashups of Google maps and the tailoring of web portals. Collaborative technologies like wikis can be "appropriated and enacted by users in various intended and unintended ways" (Kane and Fichman 2008 p 3) and this mode of representation tailoring has been examined using process theory (Germonprez and Gal 2009). In this case, components of social representation theory were used for content analysis of wiki pages to identify anchoring, negotiation, and objectification (Vaast et al. 2006). These theory-derived components provided a useful mechanism through which to observe tailoring-in-use and the antecedents of tailoring processes.

In these cases, supporting theories are consumed as our understanding of the technology improves. In the case of tailorable technologies, there are an infinite set of divergent paths by which a technology may be tailored. As a result, the use context becomes increasingly ideographic and localized. To address this, design theory must account for different instantiations in localized contexts into which artifacts are placed by becoming less dogmatic and more sensitized to human-centered design.

EXTENDING DESIGN THEORY II: BRICOLAGE

Design theories frequently specify kernel theories or justificatory knowledge which "provides an explanation of why an artifact is constructed as it is and why it works" (Gregor and Jones 2007 p 328). Justificatory knowledge may come from natural science, behavioral science, social science, other designs, or evidence-based justification. Gregor and Jones (2007) argue that it is possible "to have a design theory with an incomplete understanding of the micro-theories on which it is based" (p 327). Here we suggest that there are two shortcomings. One is that the function of a theory is to increase explanation of the underlying mechanisms which produce a particular phenomenon. Although we could construct an artifact without understanding how it works, we contend that this would be atheroretic. It would be a practice or craft, not a theory.

Second, we have no guidance regarding how the kernel theories (justificatory knowledge) interact. Most examples of design theory provide a set of descriptions for building specific artifacts but have fallen short in illuminating how the kernel theories apply or how their influence may change in different contexts during actual use of the system. There are further unanswered questions regarding the degree of commensurability of kernel theories developed within differing contexts or ontological commitments. Finally, current invoking of kernel theories do not predict or explain the design processes that occur during the information process in which the participant is engaged despite the inability to separate the technological artifact and it's situated use. Drawing on Gabriel's (2002) metaphor, design theories are akin to recipes from which parts can be selected, combined, discarded, and altered to fit local contexts. Successful 'recipes' (secondary designs) are repeated and may be communicated among colleagues or work groups to become a *de facto* standard. From this perspective, kernel theories do not provide a uniform set of equally and uniformly contributing explanations. Rather they are a 'constellation' of predictive agents which explain/predict activities of the artifact, the primary designer, and the secondary designers in different contexts or for different tasks. To strengthen design theory, researchers must specify how and when kernel theories are applicable and how they interact. Accuracy, scope, and consistency of design theories are incumbent upon a deeper understanding of the role of kernel theories, rather than their simple invocation.

AN EXAMPLE: THE THEORY OF TAILORABLE TECHNOLOGY

We draw upon the Theory of Tailorable Technology Design (Germonprez et al. 2007) to provide an example of these two extensions. We characterize this theory as a mid-range theory with further development and testing required. However, the theory posits a dual phase design process, thus specifying the need understand the secondary phases of tailoring in localized contexts. Mapping the work of Germonprez et al. (2007) to the design theory specifications (Gregor and Jones 2007) shows considerable overlap. However, Germonprez et al. (2007) extend the model as seen in Figure 1.

Anatomy of Design Theory (Gregor and Jones, 2007)	**Theory of Tailorable Technology Design (Germonprez et al., 2007)**
1. Purpose and Scope	Systems that are intended to be modified in the context of use
2. Constructs	Definition of construct of tailoring
3. Principles of Form and Function	Eight design principles
4. Artifact Mutability	Variable degree of generality based on selection of design principles
5. Testable propositions	None provided
6. Justificatory knowledge	Overlapping concepts from prior literature
7. Principles of implementation	None provided
8. Expository instantiation	Web portal case
	Additional Theoretical Aspects Provided
	Kernel theory relationships: Active and reflective environments
	Tinkering, improvisation, design through use in practice

Figure 1. Mapping of Theory of Tailorable Technology (Germonprez et al. 2007) to Design Theory Anatomy (Gregor and Jones 2007)

The first addition is the inclusion of the theoretically informed active and reflective environments in the technology. These environments are meta-theoretical constructs which organize the sets of potential user interactions with the artifact, and furthermore explain and predict the manner in which the design principles (kernel theories) are applied and interact. For example, the user will have periods during which she reflects on her goals, courses of action, and patterns of use. The theory delineates principles of task setting, recognizable components, conventions, representation, and metaphor that explain/predict the user's reflections, not the user's outcomes. When the user selects a course of action and activity, the kernel theory principles in the active environment (i.e., tools, methods, functional characteristics, or user representation) may provide the explanatory mechanisms. As the user-as-designer cycles between reflective and active phases, different grouping of kernel theories will be more or less explanatory. Further research using the theory will reveal patterns of reflection and activity in different contexts, for different cognitive perspectives (Fomin and de Vaujany 2008), and for different levels of experience.

The principles in the reflective and active environments in the design theory allow for multiple perspectives on design, use, and outcomes, and account for the predicted tinkering, as well as situated tailoring. It specifies that participants reflect on principles embodied in the technical artifact (objective) which align with their social world (collaboration, communication), and their own use-patterns and metaphors (subjective). In this way, the theory can explain different instantiations, different secondary design trajectories, and different interpretations by participants. The theory has not over-specified a technical artifact. Rather it has theorized a class of information processes that includes the artifact, the participant, and the situated task environment.

We see potential fruitfulness in the Theory of Tailorable Technology Design in its ability to predict novel observations. In one case, the identification of the class of tailorable technologies illuminates the contrast class of technologies which are designed to be rigid or 'non-tailorable.' This distinction itself provides interesting research questions about the contexts in which non-tailorable systems may be desired and which design principles would compose the a "design of rigid IS theory." In addition, the theory predicts that the ideographic, secondary designs may be adopted by a wider community and become a *de facto* standard and the subject of further primary design efforts. Anecdotally we see this happening within social network communities where tailored structures and contents are widely distributed and have migrated from the public community into enterprise-level information systems. The theory provides a starting point for research into this process.

Through the incorporation of users' activities into design theory through reflection and tailoring, the theory predicts contextually localized instantiations of tailorable technologies. This yields a subtle, yet important consideration. The predictive nature of the design theory is not focused on the performance outcomes of the technology, but on the processes by which information systems evolve and on their trajectories. It has limited our ability to measure uniform outcomes in exchange for suggesting that divergent and localized uses of technology are predictions themselves that may be explored through application of existing principles.

Understanding the role and interaction of kernel theories then becomes increasingly important as users create processes by which technologies are localized. Like the Theory of Tailorable Technology Design, the choice of kernel theories should recognize the roles that users play in designing and building their own technology environments. As an example, social representations theory may play an important role in understanding how tailorable technology is used. It provides theoretical components that are mindful of users and their capacity to shape their world (Vaast et al., 2006).

CONCLUSION

It is clear that if design theory is to account for observed phenomena and attain the ability to make novel predictions, design science theory requires a new consideration of "IT artefact" (in the terms of Orlikowski and Iacono (2001)). Design theory must account for the secondary design and interaction by participants as a crucial element in the way information systems are designed. In addition, the integration of behavioural and design sciences requires an account of the interaction of component kernel theories and how their influence dominates or recedes in different contexts.

If we, as researchers, wish to assume a more defining role in the new class of information systems, our focus needs to shift from the management of outcomes measures and towards identification of use patterns. In considering the role of design theory, researchers are tending to be accountable only for the characteristics of the technology, not for the design of the teleological goals of the technology. We, as design researchers, no longer prescribe the full class of technologies in the marketplace. Where we once designed the characteristics behind such technologies as GSS, GDSS, or expert systems, we are now in a position of explaining, *a posteriori*, the world around us. Furthermore, where technologies were once stand-alone systems, they are now a constant morphing of new technologies and information. They are not stable, they are not predictable, and they are not solitary artifacts. Our construction of design theory must account for these observations or lose credibility as theory.

We propose that design researchers need to frame the initial design activities of these interactionist cognitive-technical systems in different rhetorical terms and construct theories which account for participants' interactions in a life world created with these emerging technologies. Thus we reduce the dichotomy between 'designing the artifact' and 'using the artifact'. Our design theories should account for the actual information process enacted between participant and information technology.

We can view this paper in light of two perspectives: metaphorical and interactionist. Kendall and Kendall (1993 abstract) state that metaphors "are the cognitive lenses we use to make sense of all situations" and the metaphors we use in design are critical in that they allow new perspectives to be seen. Thus an important step in developing an extended view of design theory is to empower researchers to see the world differently by changing the rhetoric that shapes perception. Metaphor may be used to perceive a situation in a new way and to provoke invention of future artefacts, and metaphors from our experience are used to understand new environments (Madsen 1989). As design inherently produces new environments, the metaphors by which designers and participants understand the systems are crucial. Interactionist metaphors such as *conversation*, "includes the essential elements of situated directedness and ongoing dialectical movement (to and fro) as an exemplar of cognition and action" (Introna and Whittaker 2002 p 166) and may inform design by providing a deeper understanding of the relationship between participants and technology. This is apt metaphor for tinkering as the user is simultaneously *acting upon* and *acting with* system components, engaging, distancing, and reengaging, and communicating with components, other users and IS designers/providers.

An interactionist perspective emphasizes the coupling and creation of meaning with the world, and the sharing of that meaning with other participants. Tailorable technologies (such as Web 2.0, RSS, Wikis, cloud-tags, Twitter, etc.) can provide inherent communication/collaboration in direct channels with other participants. But the interaction with the technology must supply feedback to the participant during use regarding what it *has done* and *might do*. As the horizon of possibilities emerges, the participant must have clear signals about how to realize the desired structural coupling. This can be done through referencing a set of design principles including existing tools, recognizable conventions and components, and metaphors (Germonprez et. al. 2007). This also changes the rhetoric from *design* to *disseminate*. Users are engaged in identification of goals and actions and the dissemination of the resultant activities through the action of creation. This subtly changes the design metaphor from product design to language/action (Winograd 1988) which opens a new domain of applicable kernel theory.

Our received design science view shapes the perception of information systems as fixed, completed artifacts which can be optimized. The research goal is to design, model, and evaluate systems in relation to a set of predetermined goals and operators. In contrast, the interactionist perspective suggests that the secondary design states cannot be fully predicted, modelled, or optimized by external measures. It recognizes that systems "will often be used in ways that were not anticipated in their design" (Winograd and Flores 1986 p 53). Design includes the generation of possibilities which are subject to interpretation and action-as-conversation in appropriate contexts in which the system and the horizons of the domain of possibilities can change. By re-creating systems in accordance with their own tasks, tools, use-patterns, and metaphors, participants maintain a skilful conversation with the systems, other participants, and themselves.

Information systems have a design trajectory that is driven by functional fit, with different users proposing different ideas about what things “go together in the world” (Hovorka 2005). Adaptable, mutable, easily recombinatorial processes can mutate and evolve to fill functional niches for a wider set of participants. Teleology differentiates this reflective process from biological evolution where mutations are random. As technologies are recombined they may fit new unanticipated functional domains and fill niche domains of use. (e.g. mashups, Twitter). The secondary design phase can be a powerful force for IS evolution as “it can create new ways of being that did not previously exist and a framework for action that would not have previously made sense” (Winograd and Flores 1986 p 177). As these emerging technologies proliferate, and participants select, interact, disseminate, and disengage their technologies, it is important to understand these processes in the larger scope of the participants’ entire information lifeworld.

The perspective presented in this paper invites reflective evaluation along the lines suggested by Introna and Whittaker (2002). Reflection has long been an issue surrounding systems that engage and encourage the user to look, touch, and work with parts in the creation of a larger whole – in other words, to tinker. The reflective component is critical if we are to interact with and ultimately tailor component parts. To move from design of mere artefacts to design theory for contextually oriented, unique, and innovative information technologies system requires a broadening and deepening of our design theories.

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