Theorizing in Design Science Research: Inductive versus Deductive Approaches

Completed Research Paper

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Abstract

This paper explores which theorizing strategies can be employed in DSR to make a theoretical contribution by examining two illustrative case examples. First, we find that abduction, deduction, and induction all play a role in DSR. Second, we suggest that design theorists can choose among a range of theorizing strategies (i.e., inductive theorizing, deductive theorizing, and hybrid approaches) that differ in their degree to which they make use of abduction, deduction, and induction as well as their iterative sequencing over time in repeated theorizing cycles. Third, we reveal from the discussion of two prominent IS design theories that empirical and conceptual methods for theorizing play an important role in both the build and evaluate phases of the DSR cycle. Finally, we recommend theorists in future DSR projects that pursue the goal to develop design theory to think explicitly about their theorizing approach and select and use research methods accordingly.

Keywords: Design theory, theorizing strategies, deduction, induction, abduction

Introduction

An important contemporary issue for management and information systems scholars alike is improving and ensuring the practical relevance of our research while employing and maintaining a rigorous research approach to generate new theoretical insights and add to our understanding of a particular phenomenon (Straub and Ang 2011; Van de Ven 2007). In other words, our goal is to generate contributions with our research that are viewed as 'original' (i.e. incremental or even revelatory new insights) and provide 'utility', both practically and scientifically (Corley and Gioia 2011). An additional requirement in information systems research is that we study 'information systems' or 'information technology' in one way or another (Orlikowski and Iacono 2001). A research paradigm that has become very popular in our field recently – basically because it inherently addresses the two above mentioned challenges – is design science research (DSR) (Hevner et al. 2004; Kuechler and Vaishnavi 2008; Winter 2008). This type of research has been described as a form of 'engaged scholarship', referring broadly to research that addresses the theory-practice gap in the social and organizational sciences (Van de Ven 2007).[1] *What inspired the research of this paper was the identified gap in our understanding about theorizing in DSR*. In other words, we know little about how to build theory in DSR and while Van de Ven (2007) and other social science scholars do provide us with some valuable principles and guidelines, to the best of our knowledge we are among the first to systematically investigate the role of well-established methods for theorizing from the social sciences to DSR. We argue that a better understanding of theorizing in DSR is key for leveraging the theoretical and practical contributions of DSR projects and papers because it might yield more powerful design theories with both practical and scientific utility.

Valuable knowledge has been accumulated on the nature and anatomy (i.e. structure, components) of design theory in IS. Walls et al. (1992) were among the first to explore the characteristics of design theory which they defined as "*a prescriptive theory based on theoretical underpinnings which says how a design process can be carried out in a way which is both effective and feasible*" (p. 37). Gregor (2006) followed suit and presented a conceptualization of design theory that focuses on "*how to do something*", i.e. how to design and develop an artifact (p. 620). Gregor and Jones (2007) hone in more in detail on the anatomy of a design theory and identify eight separate components of design theories. The aforementioned conceptualizations of design theory have in common a dual focus on both design as a process and as a product (Walls et al. 1992, p. 43), leading to high barriers for scholars to generate design theory and making some to ask the question: "*is design theory possible?*" (Hooker 2004). Baskerville and Pries-Heje (2010) address this design theory feasibility issue and propose to think about 'design practice theory' (focusing on prescriptions how to design something) and 'explanatory design theory' (focusing on a general design solution to a class of problems that relates a set of general components to a set of general requirements) separately. Thus, the discussion of what constitutes a theoretical contribution in DSR and the nature of design theory in IS is currently very active and is producing new insights. It is also an important step towards developing a better understanding of how to contribute with DSR to the knowledge base (Hevner et al. 2004). However, we still have a lack of understanding about developing and constructing such theoretical contributions with DSR. In other words, while more and more knowledge is being accumulated about DSR methodology (e.g., Hevner et al. 2004) and design theory (e.g., Gregor and Jones 2007), little is yet known about how to theorize in the DSR process and develop such design theories. Exploring this question is the focus of this paper.

In this paper, the goal is to explore *theorizing* principles in DSR. We concur with Weick (1995) in that we need to think separately about what theory and what theorizing is. In DSR, great amount of knowledge has been accumulated about the nature of design theory, advancing our understanding about what constitutes a theoretical contribution in DSR. However, to the best of our knowledge only few have explored the question how to go about theorizing in DSR and how to combine the sometimes contradictory goals of solving a practical problem *and* building new theory. Hevner et al. (2004) stimulated this debate by making design science researchers think about the loop going back to the knowledge base rather than thinking only about building and evaluating IT artifacts and thereby solving

[1] The other types of engaged scholarship that are described by Van de Ven are Informed Research, Collaborative Research, and Action Research

practical problems (mostly with local solutions bound in time and space). Several innovative ideas have been presented to tackle the truth-utility paradox (March and Smith 1995) and make design science research compatible with the publishing culture and values and expectations of the international IS community. Prominent examples include the combination of principles from action research with DSR (Järvinen 2007; Sein et al. 2011) or the combination of grounded theory principles with DSR (Baskerville and Pries-Heje 1999; Gregory 2010). Others have explored more broadly how DSR may fit together with explanation seeking research (e.g., Holmström and Ketokivi 2009). However, existing approaches involve limitations when it comes to exploring more broadly the use of well-established *reasoning principles* such as induction, deduction, and abduction for building design theory. We argue that a better understanding of the use of these reasoning principles in DSR can enhance greatly our capabilities to develop novel IS design theories.

In addition, only few IS scholars have systematically investigated the role and use of well-established *theorizing strategies* from the social sciences in DSR. Theorizing strategies (e.g., deductive theorizing following the hypothetico-deductive model of social science) involve a combination and iterative sequence of the above mentioned reasoning principles and are thus situated at a more abstract level that depicts the overall theorizing strategy, rather than individual theorizing steps in which particular reasoning principles are employed. While prior IS research has started to explore the role and use of individual reasoning principles in DSR theorizing, we lack an understanding of the broader choices at the strategic level with regards to alternative ways of how to build a design theory. Venable (2006), Purao (2002), Goldkuhl (2004), Kuechler and Vaishnavi (2008), as well as Gregor (2009) are among the pioneers to explore the role and use of individual reasoning principles in DSR theorizing and each of these studies provides a good starting point for our investigation in this paper. For example, Gregor (2009) highlights the importance of induction and abduction in DSR theory building. However, in this paper we go a step further and systematically think about two well-established theorizing strategies from the social sciences – inductive theorizing and deductive theorizing (both involving a combination of all three reasoning principles but where the dominant logic is induction and deduction respectively) – and how they relate to or are applied in DSR. To the best of our knowledge we are the first to do this.

The remainder of this paper is as follows. In the next sections, we first provide an overview over DSR methodology and discuss the role and nature of design theory in IS. This sets the context for our study and motivates the reader why we should think about theorizing strategies in DSR. Thereafter, we present two theorizing strategies that are well established in the social sciences: inductive theorizing and deductive theorizing. We then explore how these theorizing strategies are applied in DSR by presenting the analysis of two illustrative published cases that approached the theorizing process inductively and deductively, respectively. Finally, we provide suggestions for future theorizing in DSR.

Design Science Research

The foundations of DSR go back to the seminal work of Simon in 1969 (Simon 1996). In his work, he highlights the fundamental differences between natural science and the sciences of the artificial. Whereas natural science describes and observes natural objects and phenomena in order to understand reality, the sciences of the artificial have a focus on man-made artifacts that serve a human purpose. In IS research, the behavioral science paradigm has its roots in natural science as it aims to develop and justify theories within the context of information systems (Hevner et al. 2004). In contrast, design science has a focus on both the design process and the design product (i.e. the artifact) (Walls et al. 1992). March and Smith (1995) present two kinds of research activities to be conducted in a design science process: First, the building activity leads to an artifact that that should solve a problem and provide utility to its users. Second, the evaluation activity should provide evidence how effectively the artifact performs. Further, they highlight the importance of theorizing about artifacts and justification of resulting theories to understand which of the artifact's characteristics contribute to its ability to contribute to the problem's solution. While March and Smith (1995) state that theorizing and justification are based on natural science methods and do not represent research activities in design science, other contributions including Walls et al. (1992) and Markus et al. (2002) illustrate that theorizing represents a fundamental activity in design-oriented research.

The different kinds of artifacts to be developed in design science have been stressed by March and Smith (1995) who identify four different types of artifacts. According to them, design science research outputs comprise constructs, models, methods and instantiations. Constructs represent a vocabulary of a domain and provide the means to describe problems that have been identified by the researcher. To bring structure to the problems identified within this domain, models provide a basis to describe and explore the relationship between different constructs of interest. In order to focus on those issues being most relevant to address the problem, abstraction and simplification are indispensable here. Using existent constructs and models, methods such as algorithms define a sequence of steps to be taken in order perform a specific task. Finally, an instantiation represents the realizations of an artifact that demonstrates the feasibility and applicability of designed models and methods (March and Smith 1995). While Hevner et al. (2004) already stress the important role of a theory of design, other works including Hevner and Chatterjee (2010) extend our understanding of the IT artifact and point out that, besides constructs, models, methods and instantiations, DSR also aims at developing another type of artifact: better design theories.

Design Theory and Theorizing in DSR

Research on exploring the nature and anatomy of a design theory is gradually picking up in IS research. An important contribution towards these ends was published almost 20 years ago already by Walls et al. (1992) who developed a design theory for vigilant EIS and conceptualized a-priori about the core elements of a design theory as a basis for their design theory development (see Table 1).

Table 1. Components of an IS Design Theory according to Walls et al. (1992)

Design Product	
1. Meta-requirements	Describes the class of goals to which the theory applies
2. Meta-design	Describes a class of artifacts hypothesized to meet the meta-requirements
3. Kernel theories	Theories from natural or social sciences governing design requirements
4. Testable design product hypotheses	Used to test whether the meta-design satisfies the meta-requirements
Design Process	
1. Design method	A description of procedure(s) for artifact construction
2. Kernel theories	Theories from natural or social sciences governing design process itself
3. Testable design process hypotheses	Used to verify whether the design method results in an artifact are consistent with the meta-design

An important characteristic of this proposed conceptualization is that IS design theory involves both components related to design as a product as well as components related to design as a process. In other words, a complete IS design theory should not only explain how a certain class of goals/problems is solved with a class of artifacts, supported by the use of kernel theories and complemented by design product hypothesis. In addition, a complete IS design theory according to Walls et al. (1992) should explain the process of artifact construction within the defined class of goals and requirements, with the support of kernel theories and design process hypotheses for evaluation purposes.

Gregor and Jones (2007) extend the conceptualization by Walls et al. (1992) by offering a conceptualization and framework of IS design theory that according to them "*is more complete and contains important components that were absent in earlier work*" (p. 331). Table 2 summarizes their IS design theory specification framework.

Table 2. Components of an IS Design Theory according to Gregor and Jones (2007)	
Component	Description
Core components	
1) Purpose and scope (the causa finalis)	"What the system is for," the set of meta-requirements or goals that specifies the type of artifact to which the theory applies and in conjunction also defines the scope, or boundaries, of the theory.
2) Constructs (the *causa materialis*)	Representations of the entities of interest in the theory.
3) Principle of form and function (the *causa formalis*)	The abstract "blueprint" or architecture that describes an IS artifact, either product or method/intervention.
4) Artifact mutability	The changes in state of the artifact anticipated in the theory, that is, what degree of artifact change is encompassed by the theory.
5) Testable propositions	Truth statements about the design theory.
6) Justificatory knowledge	The underlying knowledge or theory from the natural or social or design sciences that gives a basis and explanation for the design (kernel theories).
Additional components	
7) Principles of implementation (the *causa efficiens*)	A description of processes for implementing the theory (either product or method) in specific contexts.
8) Expository instantiation	A physical implementation of the artifact that can assist in representing the theory both as an expository device and for purposes of testing.

This framework extends Walls et al. (1992) for example by including constructs and artifact mutability as core components and expository instantiation as additional component of an IS design theory. The other components build upon and partly refine the prior framework.

While Walls et al. (1992) and Gregor and Jones (2007) argue for including both product and process components in IS design theory, Baskerville and Pries-Heje (2010) think about 'design practice theory' – focusing on prescriptions how to design something – and 'explanatory design theory' – focusing on a general design solution to a class of problems that relates a set of general components to a set of general requirements – separately. They argue that past conceptualizations of design theory are too complex because they contain two very different sets of goals that focus on explaining/prescribing the design process *and* the design product simultaneously, making theory building in design science research a very challenging, if not even too difficult endeavor. While they reserve the development of a detailed framework for 'design practice theory' for future research, they elaborate in their article on the anatomy of an 'explanatory design theory' (see Figure 1). The authors make the argument that the main elements of an explanatory IS design theory are the general requirements and the general components that relate to these requirements. They state: "*This explanatory design theory is a general design solution to a class of problems that relates a set of general components to a set of general requirements. […] The definitions of general requirements and general components must be circular. Requirements specify (and explain) the reasons for components. Components are justified by requirements.*" (Baskerville and Pries-Heje 2010, p. 274). The presented framework for explanatory design theory focuses on explaining why a component is being constructed into an artifact, excluding the design practice component that explains how to construct the artifact (which is also included in prior conceptualizations of IS design theory, too).

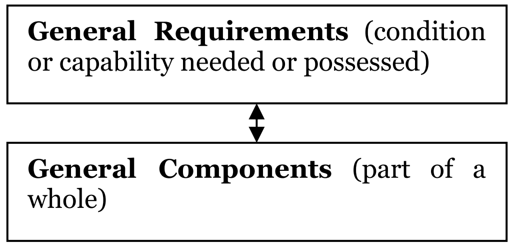

Figure 1. Explanatory Design Theory according to Baskerville and Pries-Heje (2010)

In summary, different specification frameworks for IS design theory exist in the literature each with a different focus and conceptualization. Certainly, the framework by Gregor and Jones (2007) is the most comprehensive, but it also poses great challenges for design science researchers to credibly make a theoretical contribution with their research. On the other hand, the framework offered by Baskerville and Pries-Heje (2010) is less comprehensive, but makes the quest of developing IS design theory more feasible and accessible to a larger group of design science researchers in our field. Besides the above analyzed differences, all of the above presented variants of design theory have one thing in common: they all focus on abstracting and generalizing, which is the core objective of any theorizing approach. Therefore, we argue that regardless of the variant of design theory that one is seeking to build, the theorizing strategies presented in this paper can be principally employed.

Apart from a solid foundation about the nature and anatomy of an IS design theory, what design science researchers also need is a deep understanding of reasoning principles and theorizing strategies that they can apply in the DSR cycle in order to develop unique IS design theories. The reason is that existing methodologies for DSR (e.g., Hevner et al. 2004; Kuechler and Vaishnavi 2008; Peffers et al. 2007) offer only limited advice for how to systematically apply reasoning principles such as induction, deduction, and abduction throughout the DSR cycle. Gregor (2009) argues for the need of more induction and abduction in DSR but does not investigate in detail how and in which sequence/with which emphasis they may be applied in DSR build and evaluate cycles. Purao (2002), Kuechler and Vaishnavi (2008), Venable (2006), Goldkuhl (2004), and others discuss theory development in DSR but not systematically analyze different basic strategies for theorizing – such as inductive theorizing and deductive theorizing – as pursued by prominent design theory exemplars in the IS literature (i.e. Markus et al. 2002; Walls et al. 1992). Thus, in the following we discuss what we know about theorizing in engaged scholarship that is based largely on prior experiences in the social and organizational sciences. We then explore theorizing in DSR by contrasting and comparing two selected approaches – inductive and deductive theorizing – as represented in the IS design theory literature.

Theorizing in the Social Sciences and Engaged Scholarship

Karl E. Weick triggered our thinking about theorizing in organization and management science by stating: "*Theory cannot be improved until we improve the theorizing process, and we cannot improve the theorizing process until we describe it more explicitly, operate it more self-consciously, and decouple it from validation more deliberately*" (Weick 1989, p.1). Theorizing consists of "*activities like abstracting, generalizing, relating, selecting, explaining, synthesizing, and idealizing*" (Weick 1995, p. 389). But how do we abstract, generalize, explain, and so on? These are ongoing questions as social scientists continuously seek to improve their theorizing to develop better theories and a more precise and accurate understanding of reality. Two well-established reasoning principles for theorizing are induction and deduction, as James D. Thompson stated back in 1956: "*The unique contribution of science lies in its combination of deductive and inductive methods for the development of reliable knowledge*" (Thompson 1956, p. 102). Inductive reasoning constructs or evaluates inductive arguments based on particular observations. In contrast, deductive reasoning constructs or evaluates deductive arguments based on premises or hypothesis. It is also well established nowadays that abductive reasoning plays an important role in any theorizing strategy (Locke et al. 2008). Abduction refers to creating a 'guess' to a concept theory that renders a surprising observation or unusual phenomenon in reality understandable (Peirce 1958). In his model of engaged scholarship, Van de Ven explains how abduction, deduction, and induction (three key reasoning principles) play a role in social science theorizing and how they relate to one another (Van de Ven 2007). Before doing that however, he states: "*Building a theory requires intimate familiarity with the problem domain. Problem formulation and theory building go hand in hand*" (Van de Ven 2007, p. 100). Therefore, in the following we first review principles for problem formulation before proceeding with a discussion of the three above mentioned reasoning principles as well as how to are combined in two different theorizing strategies, i.e. inductive theorizing and deductive theorizing.

Problem Formulation

DSR can be viewed as a form of engaged scholarship (Åkesson et al. 2010; Mathiassen and Nielsen 2008; Van de Ven 2007). Van de Ven (2007) argues that for engaged scholarship problem formulation is important for grounding the subject or problem in reality, and directly affects the other activities of engaged scholarship, including theory building. From a theory building perspective, he argues that a deep understanding of the problem is a crucial prerequisite for developing relevant and powerful theories and criticizes the poorly crafted problem statements in the introduction of most social science journal articles. A research problem is defined as "*any problematic situation, phenomenon, issue, or topic that is chosen as the subject of an investigation*" (Van de Ven 2007, p. 73). The author depicts four interrelated activities for formulating a research problem: (1) recognizing and situating a problem (situating activity); (2) gathering information to ground the problem and its setting (grounding activity); (3) diagnosing the information to ascertain the characteristics or symptoms of the problem (diagnosing activity); and (4) deciding what actions or questions to pursue to resolve the research problem (resolving activity). *Situating a problem* involves clarifying the addressees of the research and whose perspectives are served. Thereby, the complexity of the problem domain is reduced by focusing in the problem formulation on the primary audience of the research and putting other secondary addressees of the research in the background. Furthermore, situation a problem involves specifying the level(s) of analysis (e.g., individual, group, organization, industry). Finally, the scope of the selected problem domain must be stated. *Grounding the problem* deals with exploring the nature, context, and what is known about the problem domain. This is done by gathering both particular 'case-specific' descriptions as well as more general answers to the problem domain to put the problem in the wider context or 'class of problems'. A variety of methods can be used to develop a deep understanding of the problem that helps grounding the problem. They include personal experiences, direct field observations, expert interviews, focal group meetings, and other primary data collection instruments (primarily useful for the particular descriptions). On the other hand a systematic literature review is also needed to ground the problem with regards to scope, prevalence, and context (the more general answers to the problem domain). For example, if the problem that is being addressed belongs to a class of problems, what has been said about this class of problems in general? *Diagnosing the problem* is a crucial activity that focuses on analyzing the raw data collected in the prior step and identifying deviations from normality that deserve scholarly attention as being novel and important. Thereby, the researcher constantly compares the observed with models or theories in order to distill the 'unexpected', 'surprise', or the 'anomaly' that then provides a strong motivation for which aspects of the problem to focus on in the research. *Resolving the problem* means deciding what actions or questions to pursue to resolve the research problem. Obviously there are resource constraints and the researcher needs to focus the limited resources on the key research question(s) and actions. Van de Ven also explains how formulating, reframing, and modifying research questions go hand in hand with the aforementioned problem formulation steps, highlighting the intertwinement of the four problem formulation activities: "*Honing in on the research question entails a clarification of the focus, level, and scope of the problem domain from the perspective of the research users. It should be grounded in the sense that the research question directly addresses a critical aspect of the problem as it was observed in reality. And the question should be important in identifying a critical gap, assumption, or anomaly that requires further theory building and testing*" (Van de Ven 2007, p. 88).

The Role of Abduction

Abduction refers to creating a 'guess' to a concept theory that renders a surprising observation or unusual phenomenon in reality understandable (Peirce 1958). In other words, it consists of making a 'surprising' observation or experience that is perceived to be incompatible with our present understanding and knowledge which triggers one to create a guess(or idea, hunch, hypothesis, explanatory proposition) with the intent of resolving the observed or experienced anomaly (Van de Ven 2007). The generated idea may be viewed as a 'freshly planted' conjecture (a proposition that is yet unproven but is believed to be true and has not been disproven) in response to an anomaly. Usually, this new conjecture contradicts, violates, or at least extends our existing understanding of the phenomenon which is why it holds the potential to 'grow' into a newly emerging theory. The term abduction (also referred to as 'retroduction') was coined by Charles S. Pierce and Norman R. Hanson (Hanson 1958; Peirce 1958). According to them, the abductive activity of creating a theory is based both on real-world observations that are inductively observed as well as theoretical viewpoints, premises, and conceptual patterns that are deductively inferred. Van de Ven goes even so far to say: "*Given the theory-laden nature of observations and data, we do not view the world with a 'blank slate'. We view reality from our theoretical viewpoint or perspective*" (Van de Ven 2007, p. 104). It is through the comparisons between the observed and the known that we are able to detect anomalies and start conceiving a new theory. Thus, abduction involves both inductive and deductive reasoning and their continuous revision in order to formulate an idea (Samuels 2000). The resulting idea (or guess, etc.) is necessarily and entirely tentative and thus needs to be empirically tested. Accordingly, deduction comes into play to consider what other possible empirical conclusions would be logically produced from the tentative theory, which may then be checked through empirical work involving inductive reasoning. Thus, the theorist goes through multiple cycles of formulating and testing a guess at explaining the phenomenon at study until an acceptable solution is found. Weick explains abductive reasoning as: "*clues give rise to speculations, conjectures, and assessments of plausibility rather than to a search among known rules to see which one might best fit the facts*" (Weick 2005, p. 433).

An important characteristic of abduction is that is generates better ideas *over time*. In other words, while the process of abduction starts with identifying an anomaly or surprise, the end goal is to generate a coherent resolution for this anomaly that is transferrable across the class of problems of which the single anomaly or 'breakdown' is part of. Agar (1986) explains it in the following way: "*a coherent resolution will (1) show why it is better than other resolutions that can be imagined; (2) tie a particular resolution in with a broader knowledge that constitutes a tradition; and (3) clarify and enlighten, eliciting an 'aha' reaction from members of different traditions. … A successful resolution will also do more than resolve a single breakdown. The coherence that results must apply in subsequent situations.*" (p. 22). Weick (1989) also concurs that theory building is an evolutionary process, including trial-and-error though experiments in variation, selection, and retention of plausible conjectures to solve a problem or make sense of a phenomenon. He adds that: "*The greater the number of diverse criteria applied to a conjecture, the higher the probability that those conjectures which are selected will result in good theory*" (Weick 1989, p. 523). In other words, multiple viewpoints and perspectives, both inductively and deductively inferred, help in building good theory. An important criterion for evaluating the quality of a conjecture is its plausibility. "*A conjecture is plausible when it appears to be reasonable, believable, credible, or seemingly worthy of approval or acceptance, even though it may or may or may not be true*" (Van de Ven 2007, p. 110). Finally, arriving at a 'coherent resolution' for the observed breakdown also involves working on the parsimony of the theory. An important technique in this regard is what Weick (1989) and others call 'emptying operation', referring to focusing the formulated theory on the generalizable components or concepts and putting the particular 'case-specific' formulations into the background. Dropping such words from the formulation of the conjectures that are specific to a particular context may support theorizing about subjects across many cases or a class or problems.

Combining Induction, Deduction, and Abduction: Two Basic Strategies

Most scholars from the social sciences would probably agree that any type of theorizing involves to some degree induction, deduction, *and* abduction. The differences among theorizing methods and approaches can be explained by the sequence in which these three types of reasoning or inquiry are carried out and the dominance of any one of the three approaches. For example, Van den Ven (2007) in his model of engaged scholarship describes the theory building process in the organizational and social sciences as starting with abduction in which the researcher makes a surprising observation or experience that motivates him/her to create a hypothesis that might resolve the anomaly. He refers to this first step as 'conceiving a theory'. In the second step, the theorist then uses deductive reasoning to elaborate a theory by applying the hypothesis to a case. Called 'constructing a theory', principles of logical deductive reasoning are applied to articulate the 'anatomy' of a theory in terms of abstract concepts, the relationships between them, operational definitions, and stating the boundary conditions or assumptions of the theory. In addition, the theorist strongly builds upon existing conceptualizations and theories when elaborating the theory where possible (depending for example on the applicability of the underlying assumptions and values) and necessary (building upon existing knowledge to adhere to the cumulative research tradition). Newly added concepts and relationships must be justified and explained through logical reasoning. Finally, in the third step called 'justifying the theory', the theory is evaluated and tested using inductive reasoning, but by the time the theorist gets to this step, the creative and imaginative part of conceiving and constructing the theory has already been done. Van de Ven (2007) argues that multiple cycles of abduction, deduction, and induction are needed to develop good theory and in so far he makes a good argument that all three types of reasoning are needed to build a theory. However, the dominant logic in Van de Ven's model is deduction. This approach to theorizing in the social sciences (including information systems behavioral research) – referred to frequently as *deductive theorizing* – is probably the most widely used theorizing strategy in our fields. It is a 'top-down' approach to theory building and the theorist usually starts with existing knowledge that is typically codified in the extant literature. It involves "*going from generals to particulars; deriving conclusions based on premises through the use of a system of logic*" (Samuels 2000, p, 214). Theorizing in a deductive mode of reasoning is frequently done by identifying a problem in the literature (e.g., a tension, opposition, and/or contradiction among discrepant perspectives and explanations of the same phenomena) and then proposing a solution to that problem by developing a potentially superior explanation than previously offered in the form of hypotheses (Shepherd and Sutcliffe 2011). Van de Ven (2007) extends this view to the context of engaged scholarship and posits that theory building starts with problem formulation and abduction, assuring that a practically relevant and well-grounded problem is being addressed with the research. Either way, the central characteristic of deductive theorizing is that deductive reasoning plays a dominant role for constructing a theory while inductive reasoning comes into play afterwards for justifying or evaluating the theory. In summary, we find from our review of theorizing in the social sciences:

> *Deductive theorizing is a theorizing strategy that starts with abduction and then proceeds to deduction. Induction, deduction, and abduction all play a role in deductive theorizing. However, deduction and theoretical grounding in the construction of the theory are viewed as critical (giving this theorizing strategy its name).*

The relative importance and sequence of the three different theoretical reasoning principles is quite different in the other well established theorizing strategy from the social sciences – *inductive theorizing* – that we discuss next. This approach starts with abduction but then proceeds with induction. In other words, as in the case of the grounded theory method in its traditional form, the researcher starts with a 'blank slate' and lets the data speak for themselves in the first step of theorizing (Glaser and Strauss 1967). The grounded theory method is probably the most prominent form of theorizing that starts with abduction and induction. This 'bottom-up' approach to theorizing, involves "going from particulars to generals; deriving knowledge from empirical experience based upon a system of handling sense data" (Samuels 2000, p, 214). In this theory building approach, the theorist starts with raw data as opposed to existing knowledge. Data is allowed to 'speak for itself' so that a theory can emerge from the data (Clark 2005). Frequently, qualitative research methods are used for inductive theorizing because they support the inductive mode of reasoning in which the theorist starts with collecting and analyzing raw data and then subsequently discovers or generates emerging theory (Glaser and Strauss 1967). This is done in the behavioral sciences by coding data, classifying into concepts and densifying into categories, and then making the connections between the concepts and categories clear (Dey 1993). This approach to theorizing is viewed as 'bottom-up' because abstraction and generalizable theory stands at the end of the process, rather than the beginning. Abductive reasoning helps in the process to reach higher levels of abstraction (Reichertz 2007). The contribution to the extant literature and body of knowledge is determined at the end of the research process by comparing the emerging theory with existing theories and explaining to the reader how and why the emerging theory explains the studies phenomenon better than previous theories (Glaser 1978). An important feature of inductive reasoning is its potential to amplify our knowledge or understanding of a phenomenon by drawing conclusions that are more than a restatement of premises of existing theories (Salmon 1966). In other words, inductive reasoning is viewed to overcome the problem of deductive reasoning in which specific conclusions are based on the general premises of existing theories which limits the potential of building new theory (Ketokivi and Mantere 2010). On the other hand, the problems and limitations of induction are also well-known, including the challenge of reaching generalization and prediction based on the observation of particular events (Hume 1969). Another key advantage of inductive theorizing approaches such as the grounded theory method is that it produces theory that 'fits' reality as perceived by the studied stakeholders. In other words, the outcome of such research is usually very close to the lives of the researched and thus perceived to be highly relevant. In summary, we find from our review of theorizing in the social sciences:

> *Inductive theorizing is a theorizing strategy that starts with abduction and then proceeds to induction. Induction, deduction, and abduction all play a role in inductive theorizing. However, induction and empirical grounding in the construction of the theory are viewed as critical (giving this theorizing strategy its name).*

In summary, we find from our review of theorizing in the social sciences that formulating the problem and grounding it in both practice and theory is particularly important for any type of engaged scholarship. We suggest further that abduction plays an important role in any theorizing strategy, besides induction and deduction. Finally, we present two basic theory building strategies for engaged scholarship, including design science research, that all include inductive, deductive, and abductive forms of reasoning, but with different emphasis and sequence. We wish to emphasize that the two basic approaches presented in this paper – inductive and deductive theorizing – are two opposites on a continuous pole and that in practice, some theorists also decide for a hybrid approach. For example, in her guidelines for building theory from case study research, Eisenhardt (1989) builds upon techniques and principles from the grounded theory method (which in its original form would be a pure inductive theorizing strategy) while laying strong emphasis on theoretical grounding already in the beginning of the research process, a key characteristic of deductive theorizing strategies. We believe that future research needs to also think about such hybrid theorizing approaches in DSR, but in order to reduce the complexity we focus in this paper on the two described basic theorizing strategies and reserve the exploration of hybrid theorizing strategies in DSR for future research.

Contrasting Inductive and Deductive Approaches to Theorizing in DSR: A Comparison of Two Examples

In the following, we explore the usefulness of inductive and deductive theorizing strategies in IS DSR by comparing two prominent DSR papers that each developed an IS design theory, one with a deductive approach and the other with an inductive approach. We use these two examples to illustrate and support the arguments developed in this paper (Siggelkow 2007). In our case discussions about theorizing, we focus on the basic theorizing strategies including the reasoning principles induction, deduction, and abduction. We don't discuss 'problem formulation' in our case examples because there was a lack of information given in the reviewed papers, a limitation that Van de Ven (2007) also found in most journal papers that he reviewed for his engaged scholarship model (see beginning of chapter 3).

Inductive Theorizing in DSR: The Example of EKP Design Theory

Markus et al. (2002) inductively developed a new IS design theory for a class of user requirements they call emergent knowledge processes (EKPs). An example is new product development in which repeated trial-and-error experiences are made in an iterative and recursive manner to find and evaluate a working solution. Such EKPs cannot be fully structured a-priori, i.e. they are emergent. They are also characterized by highly unpredictable user types and work contexts. Finally, they also have very challenging requirements for information and knowledge types and practices. Markus et al. (2002) define an EKP as "*an organizational activity pattern characterized by (1) an emergent process of deliberations with no best structure or sequence, (2) an actor set that is unpredictable in terms of job roles or prior knowledge, and (3) knowledge requirements for general and specific distributed expertise*". The development of EKP design theory started inductively back in 1991 through a multi-year, industry-focused, ten-million dollar research program partly funded by the National Center for Manufacturing Services and involving the participation of four big companies (Hewlett-Packard, General Motors, Digital Equipment Corporation, and Texas Instruments) (Majchrzak and Gasser 2000). In other words, the development of EKP design theory was conducted in a bottom-up-approach, focusing initially (from 1991 to 1995) on the observation of a practical problem and the development of prototypes to solve a special type of unstructured decision support problem that the four involved companies were facing at that time. Over time, with another interim step starting in 1996 in which the generated problem solution for the four companies was started to be extended into a more general tool (i.e. TOP-Modeler) to be applicable to more cases, the insights generated inductively from the industry-academic collaboration were gradually developed towards a design theory for emergent knowledge processes (Markus et al. 2002). The bottom-up approach to theorizing in this case becomes clear through the following statement: "*we present our design theory for EKPs in the context of the case that prompted us to develop it*" (Markus et al. 2002, p. 186). Furthermore, the authors acknowledge that their theorizing to develop the EKP design theory was done during or to some extent also after the TOP Modeler project. They state on page 187: "*the evidence suggests that TOP Modeler was successful in supporting organization design. Therefore, the story of TOP Modeler is a worthy exemplar for purposes of design theorizing about emergent knowledge processes*".

After the initial inductive step of making observations in the field, particularly in the four involved companies, comparing these observations with what is known in the literature (e.g., about decision support systems), and formulating the problem, the research team advanced to abduction. Thus, they started to develop possible solutions to the problem, formulate conjectures, and think about design solutions. Thereby, the use of existing kernel theory to solve the problem was quite limited as reflected in this statement: "*At the outset of the TOP Modeler project, we did not use EKP kernel theory, since we had not yet developed the EKP concept*" (Markus et al. 2002, p. 188). In other words, the applicability of existing theories to deductively solve the problem and develop a design theory was quite limited as the research team was addressing a quite novel class of problems. However, they initially tried to make use of existing literature on decision making and decision support systems (Keen and Scott Morton 1978) to formulate conjectures and ideas for their design theory. What followed was a constant iteration between induction and abduction, similar to how theorizing works in a grounded theory study where constant comparisons and theoretical sampling guide the theory development process (Bryant and Charmaz 2007). Importantly, existing theory must not be 'forced' onto the data (Glaser 1992). Aligning well with this spirit, the authors of EKP design theory state: "*Over time, however, we learned that the IS design theory of semi-structured decision-making processes was inapplicable to the organization design process*" (Markus et al. 2002, p. 188).

The detailed description in the paper of how each design principle of EKP design theory evolved over time provides indications for which theorizing strategy was lastly chosen and which methods were used. Numerous statements suggest that much of the theorizing for EKP design theory was actually derived inductively from the empirical investigations: "*Interviews with representatives from the four sponsoring companies revealed that…*" (p. 188); "*The interviews further revelead that…*" (p. 189); "the interviews indicated that…" (p. 190); "*These interviews led us to think of our system as needing to be self-deploying among a population of reluctant, event hostile, naïve users of every conceivable stripe*" (p. 190). Besides qualitative interviews, ethnographic field observations also played a role: "*While the rule-based representation worked for experts, observation showed it did not match non-experts' representations or organization design knowledge*" (p. 194); "*This observation suggested to us that lay users represent their knowledge as tradeoffs for action, rather than the if-then rules of experts*" (p. 194). An important insight is that induction (supported for example through qualitative interviews and observations in this case) played a dual and complementary role both in the develop/build and justify/evaluate cycles of the DSR process (Hevner et al. 2004). In other words, inductively generated insights triggered abductive reasoning and improved IT artifacts which were then evaluated with inductive methods which again triggered new ideas for improving the IT artifacts: "*in our radical iteration approach, users evaluated functional prototypes by working with the system through real "use cases" of organization design analysis, rather than hypothetical ones…we continued iterating far more times than is customary with prototyping. During an 18-month period, over 70 functional prototypes were generated.*" (p. 195). A further important observation in terms of theorizing concerns the role of empirical research methods (e.g., ethnographic field observations) to get a more nuanced understanding of requirements and better ideas for solution components. The authors of EKP design theory state: "*In sum, we learned that, when designing for emergent knowledge processes, asking people to review nonfunctional prototypes or participate in conference room pilots or "organizational games" is not sufficient to guide development,* *because these techniques involve hypothetical contexts.*" (p. 195). In so far, theorizing for design theory in this case examples resembles a lot how inductive theorizing is typically done in social science research, with the difference that the development of an abstract design theory goes hand in hand with the technical development of a case-specific problem-solution (in this case the TOP Modeler system).

Similar to single-case studies in inductive qualitative social science, the authors of EKP design theory also discuss the potential limitations of their approach: "*as our design theorizing was stimulated by our experience with a single revelatory case, we need to address the generality of our contribution*" (p. 207). The final design theory is depicted in Figure 7 on page 206 (Markus et al. 2002). Even though this is not elaborated in detail by the authors in the paper, an in-depth reading of the paper suggests that most of the design theories elements (the generated meta-requirements and meta-components) were derived inductively from the single case study. A comparison of design theories based on prior literature and their case study supports this finding (see Tables 1 and 2 in the paper). Accordingly, the study by Markus et al. (2002) is an illustrative example of how theorizing in DSR may follow an inductive approach.

Deductive Theorizing in DSR: The Example of VIS Design Theory

Walls et al. (1992) present a deductive approach to theorizing in DSR and develop a design theory for vigilant EIS (Executive Information Systems). EIS refers to a class of systems that supports executive strategic decision-making through functionalities such as exception reporting, on-line access to external information utilities, data integration from spreadsheets, databases, and text, and more. The authors formulate the problem that existing theories and EIS do not support strategic decision-making in turbulent environments and that executives in organizations are increasingly struggling with making better decisions under strict time constraints. Thus, they derive the need to develop a design theory for vigilant EIS, where vigilance is defined as "*the ability of an information system to help the executive remain alertly watchful for weak signals and discontinuities in the organizational environment symptomatic of emerging strategic threats and opportunities*" (Walls et al. 1992, p. 37). The authors approached their theory building activities in a top-down deductive approach. They state right from the beginning in their paper: "*Research on managerial information scanning and emerging issue tracking as well as theories of open loop control are synthesized to generate vigilant information system design theory propositions*" (p. 36). Later on, they undermine their deductive theorizing approach by adding: "*Figure 3 depicts our view of how descriptive empirical research on issue tracking and normative theories of open loop control form the basis of an IS design theory for vigilant IS (VIS)*" (p. 48).

The first set of meta-requirements for the design theory are derived from research on emerging issue tracking. Issues are defined as events, development, and trends which may affect the organization, sometimes in a strategic manner (Dutton and Webster 1988). Thus, the authors deduce that a VIS should support issue representation and based on a prior longitudinal study that showed that issues can be made operational via the concepts of templates, triggers, and twitches (El Sawy and Pauchant 1988), argue that these issue representation techniques need to incorporated into a VIS design. Next, based on prior literature suggesting that issues are dynamic entities which evolve over time through different stages – discovery, emergence, maturity, and fading – (King 1984), the authors conclude that a VIS should support the issue management life cycle. The authors go on to argue for the need of problem squeezing heuristics in the VIS design based on the aforementioned literature as well as logical deductive reasoning.

The second set of meta-requirements are derived from theories of open-loop control (Widmeyer 1991). Open-loop (as opposed to closed-loop) control refers to a directive or policy that may be ambiguous or open to multiple interpretations. The idea is that alternative sources of learning and control signals make the feedback loop from managers to executives more robust, faster, and more responsive. Based on open-loop control theory, the authors of VIS design theory argue that problem templates that are provided to the manager by the executive (as a basis for the manager to provide systematic feedback) must be consistent with the corporate culture and vision in order to ensure vision-/culture-consistent courses of action of managers. This should support the implementation of open-loop control and better feedback from the managers to the executives.

Based on the defined meta-requirements that are deduced from prior literature and theories, the design theorists go on to derive the meta-components directly from these requirements. The general components of the resulting VIS design theory are summarized by Baskerville and Pries-Heje (2010, p. 279) and include templates (containing data structures, operations, automatic history, and passing), critical indicators (the system should have information links to critical indicators), twitch heuristics (a twitch is a template modification caused by a trigger), organization values, directives (with automatic directive-value checking), and proposed action monitoring.

In summary, theorizing for VIS design theory by Walls et al. (1992) was done in a top-down deductive fashion with meta-requirements and meta-components derived from existing literature and theories. The authors were able to synthesize different literature streams and theories and apply the insights to the construction of a new design theory that supports vigilant strategic decision-making in organizations. What can be learned from this case is that drawing on different types of kernel theories for deductive theorizing can support the theory building process in DSR. The authors also state in their paper: "*design theories are composite theories which encompass kernel theories from natural science, social science and mathematics*" (Walls et al. 1992, p. 41). Thus, theorizing in DSR with a deductive approach can be enhanced by drawing upon kernel theories of different classes and from different fields. What is also important to recognize is that while deductive reasoning is clearly the dominant form of reasoning in the deductive theorizing strategy as represented by Walls et al. (1992), abductive reasoning certainly also plays an important role in this strategy, as also explained by Van de Ven (2007). Abductive reasoning in the deductive theorizing strategy comes from a critical analysis of the literature, combined with empirical experience, a crucial theorizing step in the deductive strategy that sits outside the final paper that is published. In other words, the broader evolutionary history of literature review, gap identification and search for resolutions that precedes any DSR study is omitted in the final reporting of the theory in a design paper.

Discussion, Implications, and Future Research

The core idea of this paper was to enhance our understanding of theorizing in DSR by exploring the applicability and use of well-established reasoning principles and particularly theorizing strategies from the social sciences and engaged scholarship. The two presented illustrative case examples of prominent design theories in our field (i.e. EKP and VIS design theory) support the argument developed in this paper that two basic theorizing strategies – inductive theorizing and deductive theorizing – are applicable and actually used in design science theorizing practice. Thus, this paper contributes considerably to our understanding of theorizing in DSR as we are the first to systematically explore these two well-established theorizing strategies in this context.

A related contribution of this paper at a more abstract level is proposing the usefulness and need of three core reasoning principles – abduction, deduction, and induction – in DSR, where the emphasis given on each one and the sequencing depends upon the theorizing strategy (e.g., inductive versus deductive strategy). There are a few studies that acknowledge the need for reasoning principles in DSR. For example, Gregor (2009) emphasizes the need for more inductive and abductive reasoning in DSR, based on the argument that more novel and relevant IS design theories can be generated that way as with classical deductive approaches. She uses the example of technology acceptance model (TAM) research to undermine her argument that there are known problems with deductive theorizing approaches in IS. Some scholars have explored reasoning principles in DSR by attaching abductive and deductive reasoning to individual steps in the DSR process (see Figure 3 in (Kuechler and Vaishnavi 2008) and (Purao 2002)). The role of induction is not discussed and the assignment of reasoning principles to some DSR steps contradicts studies of theorizing in engaged scholarship (e.g., deductive reasoning is attached to the evaluation/justification phase in DSR while Van de Ven propose that inductive reasoning is most important for evaluation/justification of theories). Other prior studies discuss theory building in DSR without paying close attention to core reasoning principles and/or theorizing strategies. In this paper, we propose a more differentiated view.

First, we argue that *abduction, deduction, and induction all play a role in DSR*. In this regard, we concur with Van de Ven who explains that multiple cycles and iterations between these three reasoning principles are needed for good theory development in the engaged scholarship model in which DSR is one example (Van de Ven 2007). This paper is the first to explore the use of all three reasoning principles in DSR by using two prominent IS design theory exemplars as illustrative cases. Thus, we extend the guidelines offered by Kuechler and Vaishnavi (2008), Venable (2006), Purao (2002), Goldkuhl (2004), Gregor (2009), and others on building theory in DSR.

Second, we suggest that *design theorists can choose among a range of theorizing strategies* (i.e., inductive theorizing, deductive theorizing, and hybrid approaches to be discussed in future research) that differ in their degree to which they make use of abduction, deduction, and induction as well as their iterative sequencing over time in repeated theorizing cycles. For pragmatic reasons of scoping and focusing, in this paper we honed down in detail on the two opposite poles of what we view as a theorizing continuum between inductive and deductive theorizing strategies. In the inductive (deductive) theorizing strategy, inductive (deductive) reasoning plays the dominant role. However, good engaged scholarship and DSR also requires or could rely upon the other reasoning principles. We wish to emphasize that *in DSR practice, abduction, deduction, and induction may be combined in very different ways*, yielding oftentimes hybrid theorizing approaches, just as in qualitative theory building research (e.g., Eisenhardt 1989). Design theorists should acknowledge and leverage this flexibility to enhance their creativity and imagination in conceiving, constructing, and evaluating original IS design theories.

Third, we reveal from the discussion of two prominent IS design theories (Markus et al. 2002; Walls et al. 1992) that *empirical and conceptual methods for theorizing play an important role in both the build and evaluate phases of the DSR cycle* (e.g., qualitative interviews, focus group discussion, and ethnographic observations in the case of EKP design theory construction and evaluation). We thereby extend the guidelines offered by Hevner et al. (2004) and others who have proposed that such methods are mainly used in the evaluation phase (see the list of methods in Figure 2 in that paper). In particular, we argue that such methods for theorizing might also play an important role in the build cycle, too, especially in an inductive theorizing approach which usually starts with the systematic collection of some empirical data and observation to trigger abductive reasoning and conceiving or constructing a theory. In this regard, Gregor (2009) would probably agree with us who emphasized the need for more inductive and abductive reasoning in design theorizing.

Finally, we recommend theorists in future DSR projects that pursue the goal to develop design theory to *think explicitly about their theorizing approach and take strategic and well-informed decisions*. Our understanding about the nature and anatomy of a design theory has advanced considerably recently (e.g., Baskerville and Pries-Heje 2010; Gregor and Jones 2007; Walls et al. 1992) and guidelines for methods use and to some extent theorizing in DSR (e.g., Hevner et al. 2004; Kuechler and Vaishnavi 2008; Sein et al. 2011) are also picking up. This study has shown further how well-established theorizing strategies and methods from the social sciences can be applied in DSR. Together, this provides design theorists with a tool set that helps them to make informed decisions about their theorizing and research approach. Design theorists must be clear about the implications of opting for the one or other theorizing strategy. For example, an inductive approach to theorizing requires the use of interpretive methods of data collection and analysis as reflected in the study of Markus et al. (2002). Accordingly, methods selection and use must be well aligned with the theorizing approach that is selected.

Future Research Directions

Future research might *explore the use of more hybrid theorizing approaches* in DSR. For reasons of scoping and focusing, in this paper we focused on discussing and contrasting inductive theorizing with deductive theorizing approaches in IS design theory building research. However, we believe that hybrid approaches that combine inductive with deductive strategies (e.g., Eisenhardt 1989; Shepherd and Sutcliffe 2011) may also be worthwhile exploring in the context of DSR. Future research might also *discuss inductive theorizing and deductive theorizing individually and more in-depth* than could be done in this paper in which the goal was to provide a broad overview over these two basis approaches and a general introduction to the use of three core theorizing principles in DSR. Such an in-depth discussion of a single theorizing approach in DSR would also go into more detail with regards to the use of empirical and conceptual research methods as they relate to the selected theorizing strategy as well as discuss the epistemological foundations, among other things. Another avenue for future research would be to *map the discussed reasoning principles induction, deduction, and abduction to existing DSR methodologies* and guidelines. Vaishnavi and Kuechler (2008) building upon Purao (2002) and others have made a first step in this direction but the mapping of theorizing principles to individual steps or phases in the DSR cycle is not consistent with Van de Ven's model of engaged scholarship and the proposed mapping could also be extended by including alternative theorizing strategies and sequences/emphases on the three different theorizing principles. In addition, *future researchers should consider whether a one-to-one mapping of individual theorizing principles to individual steps/phases in the DSR process/cycle is desirable at all because it might limit our creativity and flexibility to develop unique IS design theories*. This question, too, needs to be explored in future research.

Conclusion

With this paper, we contribute to our understanding of developing design theory and generating novel theoretical insights through DSR. We do this by exploring the use of well-established theorizing strategies from the social sciences and engaged scholarship in the DSR process/cycle. While much has been said about the nature and anatomy of a design theory (e.g., Baskerville and Pries-Heje 2010; Gregor and Jones 2007; Walls et al. 1992), we have much less understanding about how to actually go about theorizing and developing such theories. This is also reflected in the poor representation of design theories in our top scholarly journals as compared to other types of theories (Gregor 2006). With this paper, we address this important gap in our understanding and contribute to the DSR literature in two different ways: (1) by illustrating and explaining the potential value of applying social science *principles* for reasoning and theorizing throughout the entire DSR cycle, and (2) proposing and suggesting alternative *strategies* for theorizing – inductive theorizing and deductive theorizing – in the build and evaluate phases of the DSR cycle. Furthermore, we also suggest for future DSR publications to make explicit which theorizing strategy and associated research methods were applied and where in the DSR cycle.

The implications for future DSR are potentially important and multifold. First and foremost, we equip design science researchers with approaches to theorizing that – when applied rigorously and appropriately – yield the potential to leverage a DSR project to generate more powerful design theories. Our recommendations come timely as can be seen in the resurgent debate over design theories (Baskerville and Pries-Heje 2010) as well as publishing DSR results (Baskerville et al. 2011). We strongly believe that our findings and recommendations can not only help design science researchers develop better design theories but may also reduce the barrier for getting their work published in our leading journals. Theories and methods for theorizing are an integral part of behavioral science researcher's mindsets and by building upon well-established theorizing practices, design science researchers can increase the acceptance level of DSR as a rigorous research approach alongside behavioral science research. This will ultimately also help us build a vibrant 'professional learning community' (Simon 1976; Van de Ven 2002) in which engaged scholarship is encouraged, rigor and relevance are combined, and types of engaged scholarship such as design science (Åkesson et al. 2010; Mathiassen and Nielsen 2008) are well established in our community. Aligning with the spirit of visionary leaders in our fields (e.g., Simon 1976; Van de Ven and Johnson 2006), let us reach out to both theory and practice and build powerful design theories that have an impact on our scientific *and* practitioner fields!

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