WRITING MY NEXT DESIGN SCIENCE RESEARCH MASTERPIECE: BUT HOW DO I MAKE A THEORETICAL CONTRIBUTION TO DSR?

Samir Chatterjee, PhD
Center for Information Systems & Technology
Claremont Graduate University
Claremont, CA, USA
samir.chatterjee@cgu.edu

Abstract

Design science research is a valid research methodology today in IS. Its goal is to solve wicked problems and show that IT artifacts created to solve the problem has efficacy and utility. However developing design theories or making theoretical contributions (theory as artifact) is still a challenge. This thoughtful essay is meant to provide deep insights into the interplay between theory and design and provides some answers into two big questions: 1) where should we theorize in DSR and 2) how do we holistically approach theory development in the sciences of the artificial.

Keywords: Design Science Research, Theory Building, Sciences of the Artificial, Knowledge contribution, IT artifacts.

1 Introduction

It is difficult to overstate the importance of theory to the scientific endeavor. A unique distinction between academia and industry/practitioners is often in the realm of knowledge creation. One could argue that science is knowledge represented as a collection of "theories" derived using the scientific method. Theory allows scientists to understand and predict outcomes of interest, even if only probabilistically (Colquitt & Phelan, 2007). Theory also allows scientists to describe and explain a process or sequence of events (DiMaggio, 1995). Bacharach (1989) suggested that "theory prevents scholars from being dazzled by the complexity of the empirical world by providing a linguistic tool for organizing it (Dubin 1976)".

Design is a central activity of information systems researchers and IS practitioners are the ultimate beneficiaries and evaluators of research in the information systems field (Denning 1997). Organizations and individuals acquire and implement information systems to make themselves more productive, that is, to change existing inefficiencies into preferred ones (Vaishnavi & Kuechler 2008). Simon (1996) describes design as the "thin interface" between inner and outer environments. He argues that "a science of artificial phenomena (i.e., design) is always in imminent danger of dissolving and vanishing" as researchers focus on the natural laws of the inner or outer environments; to the exclusion of the interface that gives them meaning (Simon 1996).

Within the information systems discipline, the inner environment is the hardware, network and operating system, commonly referred to as the computer system infrastructure. The outer environment is the people, organizations, and societies served by the information system. The information system itself is a combination of software and data structures (technological components) and the policies and procedures prescribing its development, implementation, management, and use (behavioral components) (Nunamaker & Briggs, 2011).

Much of the research in the top IS journals is behavioral research (Nunamaker & Briggs, 2011). Behavioral research focuses on the human element of IS (outer world according to Simon), for example, system acceptance and usage, emotion in IS, and information overload; its prevailing modes of inquiry are theoretical and experimental research. But researchers such as Nunamaker et al. (1991), Hevner et al. (2004), Hevner & Chatterjee (2010) have conceptualized and formalized Design Science Research (DSR) into a useful approach that is gaining wide acceptance. DSR focuses on the rest of the information system: IT-artifacts including hardware, software, procedures and data. The objects of inquiry for Design Science are: (a) design products, (b) design processes, and (c) designed systems (Briggs & Schwabe 2011). Design Science proposes that there is much to be learned by applying scientific knowledge to designing and deploying new information systems. Key contributions to the IS literature have come from design science research streams, for example, research on modeling of systems dynamics (Abdel-Hamid & Madnick 1989), group support systems (Nunamaker et al. 1991), security (Chen et al. 2003), healthcare informatics (Chatterjee et al., 2013) and electronic commerce systems (Bapna et al. 2003).

Recently, the founding fathers of the IS field reflected on its future (Nunamaker & Briggs, 2011). They stated:

> *"While we continue to track the emergence and use of new technologies, we must expand our vision to inventing new systems that address information needs not covered by current systems. We must not only be observers and historians of technology, we must make technological contributions."*

The above call to action has been well embraced by the IS research community. More and more papers are being published that uses DSR methodology to invent and build new systems. However a plaguing challenge confronts DSR researchers. When they try to publish their work in top IS journals, they are often rejected stating the lack of any new theory development or weak theoretical contribution. In this paper, we try to make a cogent argument about theory contribution in design research. This discourse is not the final answer but rather food for thought for authors, reviewers and editors of our journals to better understand how to make a strong theory contribution in DSR.

2 Brief history of the evolution of DSR

Information Systems is a relatively young discipline and it has only recently been recognized that DSR is a distinct, yet legitimate, research paradigm (Gregor & Hevner, 2013). It is important to acknowledge that DSR did not start in IS. But the founding father of the field was Dr. Herbert E. Simon. In 1966, as a professor in the Economics department at Carnegie Mellon University's Business School, Simon was frustrated to see his colleagues giving theory an "elevated status". He argued that most of management field including accounting and economics dealt with design not theory. To help researchers understand this more, he wrote the phenomenal book "Sciences of the Artificial" (Simon 1996). That book perhaps had the greatest impact within the engineering community who embraced what they did as a form of science.

Relevant work in IS DSR started to appear as "systemeering" (Iivari, 1983), a "constructive approach" (Iivari 2007) and "system development" or an "engineering approach" (Nunamaker et al. 1991). Yet mainstream recognition of DSR in information systems is acknowledged to have occurred with the 2004 Hevner et al. publication in MIS Quarterly (Kuechler & Vaishnavi, 2008), which drew inspiration from Simon.

From 1970-1991, it is safe to say the bulk of the research that was published in IS journals followed the behavioral paradigm. It was only 5% or less that could be labeled DSR. Around 1991, Walls et al (1992), published a seminal paper titled "ISDT". This was the first known reference to design theory in IS literature. It is interesting to mention that the authors have shared with many people in the community that the real objective to writing that paper was about Executive Information System (EIS) design. However it was the terms ISDT and kernel theories that got picked up as the more salient contribution. In 1995, March and Smith (1995) published their seminal article which for the first time elucidated the notion of IT artifacts and the fact that DSR process involved two cycles: "build" and "evaluate". Even though ISDT and March & Smith articles laid the grounds for DSR research, not much happened until 2004 when the Hevner article appeared in MIS Quarterly.

Since then, four other notable events have happened that has catapulted the interest in DSR.

- A focused conference called DESRIST started in 2006 to promote dialogues around DSR
- Two important books on DSR, Vaishnavi & Kuechler (2008) and Hevner & Chatterjee (2010) have since been published.
- Österle et al. (2010), in their "Memorandum on design-oriented information systems research" and Buhl et al. (2012) have clearly voiced the German and Scandanavian IS academics views on the acceptance of DSR scholarly work by journals and conferences.
- Mainstream IS conferences such as ICIS, ECIS and HICSS have started design science tracks. Journals such as MISQ and ISR have added DSR researchers to their editorial boards.

It is difficult to predict what percentage of IS publications today follow the DSR paradigm. However it has become more popular along with behavioral and social science method papers. It is important to mention that one key contribution of the Hevner article was to state the fact that DSR is not about finding the "truth" (or theories) but rather it is all about "efficacy and utility". It was a great opportunity for the IS community to focus on "wicked problems" and design new inventions. In fact "theory" was not even listed as an artifact output or type (Hevner et al., 2004).

In the last several years, the field of DSR has become fragmented. In a recent article, Gregor and Hevner (2013) mention:

> *"Even within the design science paradigm, some differences of opinion have emerged. One case of this is the bifurcation into a design-theory camp (Gregor and Jones 2007; Markus et al. 2002; Walls et al. 1992, 2004) and a pragmatic-design camp (Hevner et al. 2004; March and Smith 1995; Nunamaker et al. 1990-91), with the two camps placing comparatively more emphasis on design theory or artifacts respectively as research contributions. One aim of the current paper is to harmonize what we see as complementary rather than opposing perspectives, a repositioning that can enhance the conduct and reach of rigorous and impactful DSR."*

DSR is not an alternative epistemology, nor is it an alternative to scientific rigor (Lee & Hubona, 2009). Rather, it is an instance of classic engineering research methods (Hevner & Chatterjee, 2010) that have been tailored to the specifics of IS. It is a useful structure for applying the disciplines of academic inquiry to a stream of information systems research. Nunamaker & Briggs (2011) best states this: "*The value and rigor of Design Science could be increased, however, by expanding its scope beyond its engineering roots to bring all four modes of scientific inquiry to bear: exploratory research, theoretical research, experimental research, and applied science/engineering, to improve our design methods, our design products, our technologies, and our systems*."

3 The Development of Theory and Design Theory

In discussing contributions to knowledge, we should consider the vexed questions of what is meant by theory, whether design knowledge can be a legitimate theoretical contribution, and, further, what role an artifact plays in design-science theorizing. The word "theory" is not universally interpreted. A theory describes a specific realm of knowledge and explains how it works.

The American Heritage Dictionary defines theory as a system of assumptions, principles, and rules of procedure devised to analyze, predict, or otherwise explain the nature or behavior. Another definition is that a theory tries to make sense out of the observable world by ordering the relationships among elements that constitute the theorist's focus of attention in the real world (Dubin 1976). Theory is a coherent description, explanation, and representation of observed or experienced phenomena (Gioia & Piter 1990). Theory building is the process or recurring cycle by which coherent descriptions, explanations, and representations of observed or experienced phenomena are generated, verified, and refined (Lynham 2000).

First thing to notice in all the above definitions or perspective of theory is that they refer to the domain of the natural world. But design science research deals with the artificial world. What phenomenon is interesting in that world? Many reviewers and even editors often confuse two distinct terms: "design theory" versus "theory of design". The latter often deals with theorizing the socio-technical environment in which a designer operates. For example, if one were be to observe a group of designers at IDEO Labs (one of the world's foremost design companies), they could theorize about the process. However the former term "design theory' actually refers to a theory that explains why something worked? It is much harder to build such theories as one can argue that it is often through the process of design that we create stuff (elements) which could be used to derive new theories. In fact famous researcher John Hooker (2004) makes a cogent argument in his essay that one cannot have a design theory or design is pre-theoretical.

3.1 Theory building is a messy process

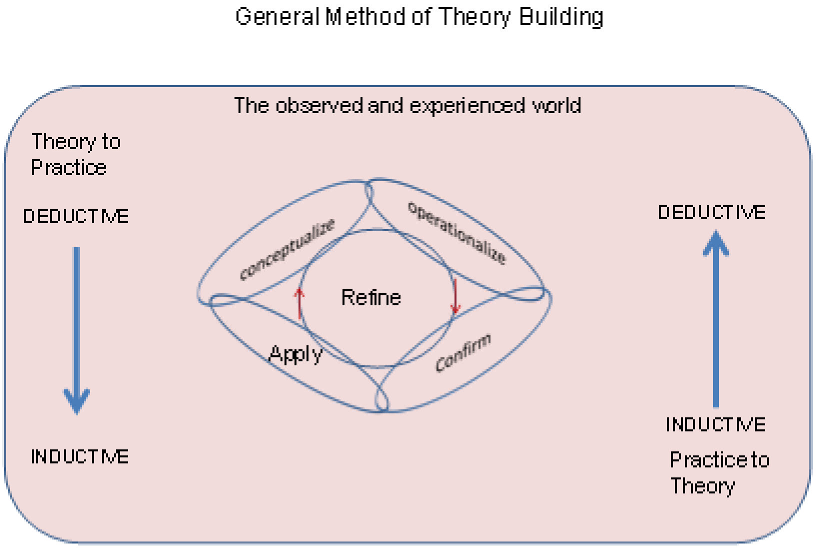

Figure 1. The iterative theory building process

Swanson & Chermack (2013) states that one of the challenges of theory building in applied disciplines are making the process both explicit and accessible. Although different theorists advocate different theory-building research processes, there is an inherently generic nature to theory building in applied disciplines. The generic process is shown in Fig. 1 and comprises of five phases.

We believe in the need for good theories which has utility. Yet we are dumbfounded to repeatedly hear statements like: “Well, that’s all very well in theory, but it doesn’t work like that in practice or in the real world”. Statements like this are rooted in a number of deeply held assumptions about the nature and utility that are generally erroneous:

- that theory is disconnected and removed from practice;
- that the process of theory building happens in isolation of the real world;

DSR researchers are well positioned to build design related theories as they are grounded in the real world of problem solving. In fact it should be mentioned that all the “relevance versus rigor” discussions that our IS community had were meant to address this problem.

There are two commonly used strategies in theory building for applied disciplines. In Research-to-theory strategy, also termed research-then-theory strategy, is related to “deriving the laws of nature from a careful examination of all the available data” (Reynolds1971). Francis Bacon referred to the outcome of this strategy as interpretations of nature. This strategy requires two important conditions – namely, “a relatively small number of variables to measure during data collection” and “a few significant patterns to be found in the data” (Reynolds1971). The second strategy for building theory is that of theory-to-research or the “theory-then-research strategy”. In this approach, theory building is made explicit through the continuous, repetitive interaction between theory construction and empirical inquiry. This theory-to-research strategy was made popular by Karl Popper, in which “he suggests that scientific knowledge would advance most rapidly through the development of new ideas [conjectures] and attempts to falsify them with empirical research [refutations]”.

Several theory researchers have now embraced the fact that research, practice and theory are all intertwined. They have formulated an iterative system of five distinct phases, as shown in Fig. 1:

- Conceptualize,
- Operationalize,
- Apply,
- Confirm, and
- Refine

For additional details on these five phases and how each unfolds, the reader is referred to (Swanson & Chermack 2013).

3.2 Theory boundaries and Types

A theorist should pay attention to three key criteria:

- Emphasize the *purpose* of theory building effort
- Pay close attention to the intended *boundary* of the theory
- Promote *cohesion* among choices throughout the theory building effort.

The effort put in may produce grand, midrange or local theory. Because designers work with a variety of contexts, the specificity of their theories must vary as well.

<u>Grand theories:</u> usually have the widest boundaries in applied disciplines, and are mostly aligned with the quantitative philosophical orientation and aim to establish generalizability of the findings. These theories are aimed to establish laws of nature, or general priciples that apply universally (or as close as possible) to human activities. The theory of human capital – the premise that over our history, educa-

tion is associated with increased income and a better quality of life (Becker 1993) is a grand theory. It applies to all humans regardless of location, race, class, education or other variables.

Midrange theories: are more specific than grand theories, and they tend to be categorical, explaining relationships that exist and predicting outcomes within a bounded domain. These do not attempt to establish universal laws, but go beyond describing single instances of human activity. There is some degree of generalizability or transferability of what is learned from the theory building. Research on financial performance of Fortune 500 companies, research on experiences of women in leadership positions, documented studies of innovation and Knowledge Management at Xerox (Nonaka) are good examples of potential mid-range theories.

Local theories: are very specific and so tightly coupled to a context that the context itself becomes part of the theory. An example of a local theory would be an in-depth study of innovation practices at Apple, Inc., since other companies cannot really compete. Research efforts attempt to describe the uniqueness in ways that generate insight, but they are not intended to be used in alternative situations or contexts.

Similar ideas of knowledge contributions have been presented by Gregor & Hevner (Table 1, p. 6, 2013) in which they distinguish different DSR "outputs" as research deliverables, with three maturity levels of DSR artifact types and examples at each level. Level 1 represents situated implementation of artifact. Here we have more specific, limited and less mature knowledge. This would correspond to local theory. Level 2 is referred to nascent design theory where knowledge is represented as operational principles and architectures. This is analogous to mid-range theories and at this moment, we see emergence of DSR contributions at this level. Level 3 represents well-developed design theory about embedded phenomenon and it is here where we find more abstract, complete and mature knowledge. This would correspond to grand theory as stated above. Grand theory in DSR is elusive at this time.

3.3 Theoretical contributions through empirical studies

The MIS field, irrespective of whether behavioral or design research inquiry mode is practiced, have produced overwhelming empirical articles. The same is true for management research. In fact in an exhaustive study of rating the scientific validity of 73 theories found in management literature (Miner 2003), only a handful were rated as high in scientific validity. The taxonomy shown in Figure 2 below reflects how theory contributions can be validated and presents an interesting view of showing low and high theoretical contributions (Colquitt & Phelan 2007).

Authors of empirical studies test theories (horizontal axis in Fig. 2) to show contributions. Typically they follow the hypothetico-deductive model where they use existing theories to formulate hypothesis and then test those hypothesis with observations. Such theory testing is deemed important in management research because many intuitive theories from literature wind up being unsupported by empirical research.

Another way that empirical articles make a theoretical contribution is by building theory (vertical axis in Fig. 2). Here authors follow an inductive model where they begin with observations and generate theory through inductive reasoning. The taxonomy shows the dual mission of theoretical contribution: theory building and theory testing. But it also shows that empirical studies can be classified into five discrete categories, which are reporters, testers, qualifiers, builders and expanders. Builders, testers, and expanders tend to be higher in their theoretical contribution, whereas reporters and qualifiers tend to be lower in their theoretical contribution (Colquitt & Phelan 2007). Such a taxonomy can be helpful to DSR scholars too.

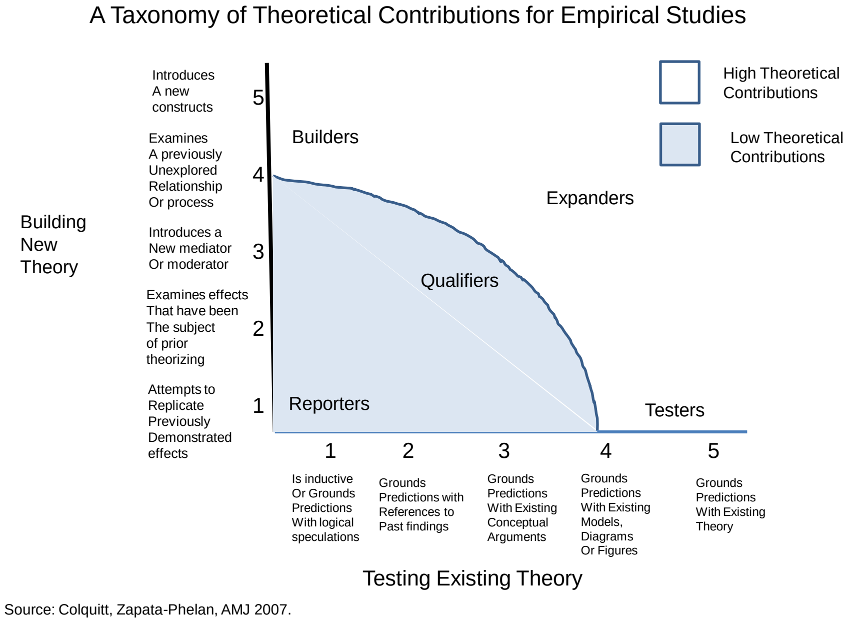

Figure 2. A taxonomy of theoretical contributions for empirical studies

4 Theory in Information Systems

Before we can explore how DSR authors can make a theory contribution out of their work, it is necessary to take a look at broader theory building within the IS community. Sutton & Staw (1995), two respected management scholars of our times, have very nicely written from their experience of looking at management literature of what parts of a paper are NOT theory. They state:

- References are not theory
- Data are not theory
- List of variables or constructs are not theory
- Diagrams are not theory
- Hypothesis (or predictions) are not theory
- A statistical model is not theory either.

Respected researchers such as Sutton, Staw, Hayes and Solow have continued to express concerns that collective efforts of business academics have produced a paucity of theory that is intellectually rigorous, practically useful, and able to stand the test of time and changing circumstances (Carlile & Christensen 2006). The above observation is also true if one surveys IS papers. Many papers say they have theory but on careful scrutiny one fails to see that. Very few scholars understand that theory requires one to go through the five cycles mentioned in Fig. 1. Most do one part of the cycle and rest their case as theory contribution. Theory building requires progress to be made in descriptive stages as well as normative stages. Theory is the product while theorizing is the process (Weick 1995). The theory building process iterates through these stages again and again. It is important to move beyond statements of correlation to define what causes the outcome of interest.

In a seminal MISQ paper, Gregor (2006) shows a way to classify theories which are based on primary goals. The goal of a theory, or what the theory is for can help to understand the IS literature. So theories in IS are entities that aim to analyze, explain, predict, explain and predict and design and action. Gregor further provides a useful structure of the components of theory (see Fig. 3).

Table 3. Structural Components of Theory

Theory Component (Components Common to All Theory)	Definition
Means of representation	The theory must be represented physically in some way: in words, mathematical terms, symbolic logic, diagrams, tables or graphically. Additional aids for representation could include pictures, models, or prototype systems.
Constructs	These refer to the phenomena of interest in the theory (Dubin's "units"). All of the primary constructs in the theory should be well defined. Many different types of constructs are possible: for example, observational (real) terms, theoretical (nominal) terms and collective terms.*
Statements of relationship	These show relationships among the constructs. Again, these may be of many types: associative, compositional, unidirectional, bidirectional, conditional, or causal. The nature of the relationship specified depends on the purpose of the theory. Very simple relationships can be specified: for example, "x is a member of class A."
Scope	The scope is specified by the degree of generality of the statements of relationships (signified by modal qualifiers such as "some," "many," "all," and "never") and statements of boundaries showing the limits of generalizations.
Theory Component (Components Contingent on Theory Purpose)	**Definition**
Causal explanations	The theory gives statements of relationships among phenomena that show causal reasoning (not covering law or probabilistic reasoning alone).
Testable propositions (hypotheses)	Statements of relationships between constructs are stated in such a form that they can be tested empirically.
Prescriptive statements	Statements in the theory specify how people can accomplish something in practice (e.g., construct an artifact or develop a strategy).

Figure 3. Structural Components of Theory (adopted from Gregor, 2006)

There are also well established general criteria for assessing theories such as importance, preciseness and clarity, parsimony and simplicity, comprehensiveness and others. A theory should not be limited to a few situations; rather, it should have relevance to real-world situations. Acceptance by professionals or recognition and persistence in the literature may be an indication of importance. A theory should be understandable, internally consistent, and free of ambiguities. Clarity may be tested by the ease of relating the theory to data or to practice, or the ease of developing hypothesis or making predictions from it. Parsimony has long been considered an important criterion for theory. This means the theory has a minimum of complexity and few assumptions. A theory should be complete (comprehensive), covering the area of interest and including all known data in the field. It is important to note that many IS theories fail these general assessment criteria and even Gregor has shown in her examples (Gregor 2006) that many components of the structure she proposed were left unanswered in IS theoretical contributions.

All this goes to show that there is a lack of clarity in what constitutes good theory, how to present theory and evaluate its importance or impact in the field. If this is true for IS research in general, it is acutely true for design research.

5 DSR Theory and Theorizing in the Sciences of the Artificial

We now come back to our original question: I am conducting design science research, but how do I make a theoretical contribution? The question is challenging and thought-provoking for both beginners and experienced DSR researchers. After having reviewed all the salient points of theory, we now are in a position to ask:

- Simon talked about the inner and outer world of an artifact – where should we theorize?
- How can we think holistically about theorizing in the Sciences of the Artificial?

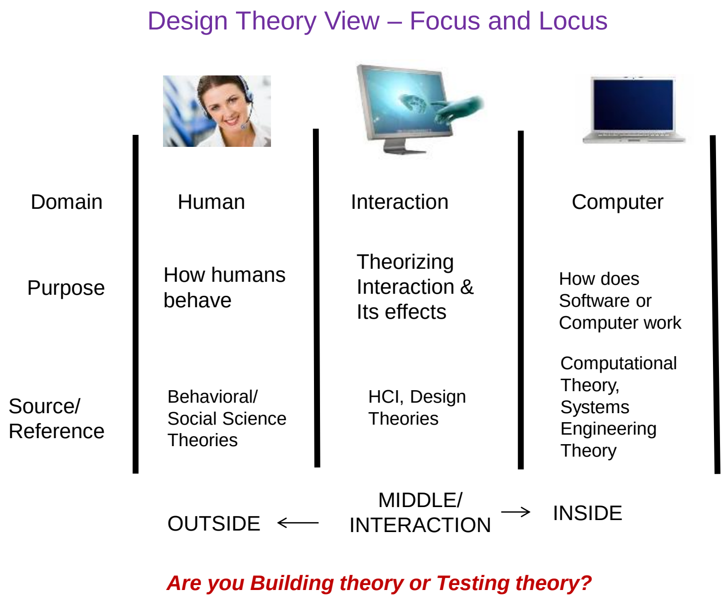

Figure 4. Focus and Locus of Design Theory

5.1 The Focus and Locus of Design Theory – Where should we theorize?

Figure 4 explains both the focus and locus of design theory. As shown, there are three domains interacting with each other in DSR activities. *First*, there is the hardware (or computer) which typically pertains to the field of computer science and computer engineering. *Second*, there is the human element (may include organization) that also affects the designed artifact. This is where our social science colleagues draw their inspiration. *Third*, there is the middle, which might be referred to as the “interaction”. This is where Simon’s “inner” and “outer” work collides. This is also where we run the danger of disappearing and Simon said design critically lies here. So where should we theorize? We must theorize here, the *middle* and understand the interaction and its effects.

The locus of theory testing or building by behavioral researchers has been on the outside or human/organizational domain. Observation, data collection, analysis and theory development have been common. In such studies, the artifact is a black box. Scholars study the impact of the artifact on the outer environment. Empirical studies or even qualitative studies are relevant here.

Computer scientists on the other hand have their locus of study within or the “inner world”. They tend to prove how the software or hardware works? There are many formal verification models (Manna 1969) that have been developed over the years to answer such questions. Computational theory such as NP-completeness (Gary & Johnson 1979) and systems engineering theory all belong here. This requires a level of training that is often beyond the traditional IS students’ curriculum. Theory of computation in itself is a difficult field.

The middle or interaction is the locus of design work and here the field of Human-Computer Interaction (HCI) has made some strides. DSR scholars must focus on the middle.

5.2 How to theorize in the Sciences of the Artificial?

Gregor and Jones (2007) specify the anatomy of a design theory. It is an important contribution because it provides a shared vocabulary and a more systematic and measureable knowledge contributions. However, they fall short of prescribing how to build such design theory and in some ways remain untested. Several other questions remain unanswered: When focusing on the "middle", how does kernel theory fit with design theory? How do you formulate the constructs, principles of form and function, and testable propositions? How is artifact evaluation linked to design theory evaluation? How one show design theory can is valid?

The role of kernel theory in DSR has become extremely problematic (Gregor & Hevner 2013). While the term was originally defined in Walls et al,'s work (1992) to refer to "theories from natural science, social science, and mathematics" that are encompassed on design theories. Today the term is taken to be synonymous with *reference theory* and is some instances *justifcatory theory*. The confusion stems from the fact that the latter term justificatory refers to a descriptive theory that informs artifact construction, and hence, should explain in part, why the design works. The reality is that they don't. Reference theories are just that. These are theories that you consider to inform your design. Using them does not mean you are testing or building theory.

Given that DSR researchers should position their "theorizing" in the "middle", which also happens to be dominated by HCI and socio-technical researchers, we address the question of "how"? This question is also challenging. However we try to provide three recipes towards this based on our own extensive experience conducting DSR projects over many years.

<u>Recipe #1 (local theory)</u>: *State your design principles and mark your impact*

Our first recipe is meant as a guiding insight into what DSR scholars can present until they have a full design theory on hand (see recipe #2 or #3). It is important to acknowledge the contribution of visible artifacts. At this stage the DSR researcher can enlist certain design principles that have been adopted in the design. They can list the principal form and function that the artifact is designed to exhibit. Further they can apply Gregor & Hevner's (2013) knowledge contribution matrix as a way to show their impact. The four quadrants represent:

- *Invention*: invent new solutions to new problems (this is parse as of now)
- *Improvement*: develop new solutions for known problems
- *Exaptation*: extend known solutions (perhaps from reference disciplines) to new problems
- *Routine design*: apply known solutions to known problems (this is typically what consultants do).

Much of the actual contributions at this level may be at the local level most suitable for the situated instantiation on hand. Unique design knowledge at the local level can generate insights for later stage theorizing.

<u>Recipe #2 (mid-range theory)</u>: *Expand the boundary of applicability to Simon's "middle" across a range of similar problems*

Mid-range theories in DSR are nascent theories. A recent theory that has dominated the HCI community is called "activity theory" may shed some light towards developing these. HCI researchers have been confined to the realm of cognitive science but are looking to theorize in practical domains such as design and evaluation. Activity theory with its roots drawn from Russian psychologist Leont'ev work (1981) is a powerful and clarifying descriptive tool rather than a strongly predictive theory (Nardi 1995). The object of activity theory is to understand the unity of consciousness and activity. It offers a set of perspectives on human activity and sheds light into concepts such as "context", "situation" and "practice". As Nardi states:

> "*Activity theory also proposes a strong notion of "mediation" – all human experience is shaped by the tools and sign systems we use. Mediators connect us organically and intimately to the world; they are not merely filters or channels through which experience is carried……activity theory connects consciousness, the asymmetrical relation between people and things, and the role of artifacts in everyday life.* " (Nardi 1995)

The goal of Activity Theory is to understand the mental capabilities of a single individual (Wikipedia 2014). However, it rejects the *isolated* individuals as insufficient unit of analysis, analyzing the cultural and technical aspects of human actions. Activity theory (see Fig. 5) is most often used to describe actions in a socio-technical system through six related elements (Bryant et al. as defined by Leont'ev 1981) of a conceptual system expanded by more nuanced theories (Wikipedia 2014):

- Object-orientedness - the objective of the activity system. Object refers to the objectiveness of the reality; items are considered objective according to natural sciences but also have social and cultural properties.
- Subject or internalization - actors engaged in the activities; the traditional notion of mental processes
- Community or externalization - social context; all actors involved in the activity system
- Tools or tool mediation - the artifacts (or concepts) used by actors in the system. Tools influence actor-structure interactions, they change with accumulating experience. In addition to physical shape, the knowledge also evolves. Tools are influenced by culture, and their use is a way for the accumulation and transmission of social knowledge. Tools influence both the agents and the structure.
- Division of labor - social strata, hierarchical structure of activity, the division of activities among actors in the system
- Rules - conventions, guidelines and rules regulating activities in the system

A mid-range design theory in the "middle" will bear resemblance to activity theory as stated above. But it is elusive at this time.

Recipe #3 (Grand theory): *Towards a universal theory of design (or science of design)*

This is the holy grail and remains elusive today. A Grand Design theory should be a collective denomination for all the permanent knowledge that is intended to assist the design of various new IT artifacts. The information is essentially of two types:

1. **Nomothetic** knowledge, i.e. general rules that have been gathered from several different products/artifacts.
2. **Idiographic** knowledge which actually concerns only individual products but is nevertheless suitable to be generalized to other artifacts as well

The classic work by Chris Alexander (1977) on "pattern languages" described a practical architectural system in a form that a theoretical mathematician or computer scientist might call a generative grammar might be the closest form of a grand design theory today.

Referring back to Fig. 4, a possible holistic approach to creating DSR theories would be to work collaboratively with social and behavioral scientists (outer world), and computational scientists (inner world) and bridge the salient effects of the artifact and design using something like activity theory (middle world). This is a complex endeavour but something worth pursuing.

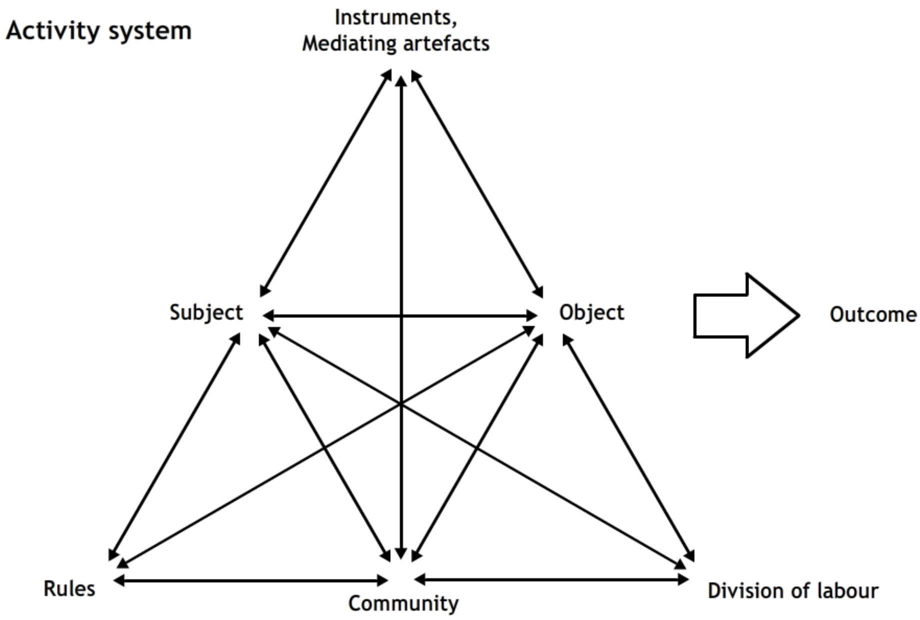

Figure 5. Showing basic elements of Activity System (adopted from Wikipedia 2014)

6 Concluding Thoughts

In this essay, we have taken a critical look into the ongoing debate of the role of theory in DSR. We have laid the basic foundational terminology and knowledge base for future discourse. What we have attempted to answer is that good design theories should be located in the middle ground (something that Simon alluded to) and pointed out the fact that holistic development of design theories are very challenging but through three recipes we have shown a possible path forward.

In conclusion we should also reiterate that the intention of bringing DSR into IS community as a methodology was to solve wicked problems and show IT artifacts if designed well could have efficacy and utility. To make this a science, our community and peer reviewed system has shifted the balance heavily towards theory. That may be stifling the creativity of our next generation of young minds. Until we find true design theories as explained here, we should be happy and try to promote elegant good designs that solve problems. Design principles in the form of local theories should suffice. Let creativity and innovation flourish.

References:

Abdel-Hamid, T. K. & Madnick, S. E. 1989. Lessons learned from modeling the dynamics of software development. Comm. ACM 32, 12, 1426–1438.

Alexander, Christopher (1977). *A Pattern Language: Towns, Buildings, Construction*. Oxford University Press, USA. p. 1216. ISBN 0-19-501919-9.

Bacharach, S. B. 1989. Organizational theories: Some criteria for evaluation. Academy of Management Review, 14: 496–515.

Bapna, R.,Goes, P., & Gupta, A. 2003. Analysis and design of business-to-consumer online auctions. Manag. Sci. 12, 85–101.

Becker, G. S. 1993. Human capital: A theoretical and empirical analysis with special reference to education (3rd ed.). Chicago: University of Chicago Press.

Briggs, R. O. & Sschwabe, G. 2011. On expanding the scope of design science in IS research. In Proceedings of the Design Science Research in Information Systems Conference.

Buhl, H. U., Müller, G., Fridgen, G., & Röglinger, M. (2012). Business and information systems engineering: a complementary approach to information systems–what we can learn from the past and may conclude from present reflection on the future. Journal of the Association for Information Systems, 13(4), 236-253.

Carlile, P. R., & Christensen, C. M. 2006. The Cycles of Theory Building in Management Research. Technical Report, Harvard Business School.

Chen, H., Zeng, D.,Atabaksh H.,Wyzga, W., & Schroeder, J. 2003. COPLINK: Managing law enforcement data and knowledge. Comm. ACM 46, 1, 28–34.

Chatterjee, S., Dutta, K., Xie, Q., Byun, J., Pottathil,A., & Moore, M. 2013. “Persuasive and Pervasive Sensing: a New Frontier to Monitor, Track and Assist Older Adults Suffering from Type-2 Diabetes”, in Proceedings of IEEE Hawaii International Conference in System Sciences (HICSS-46), Maui, HI, Jan 7-10.

Colquitt, J. A., & Zapata-Phelan, C. P. 2007. Trends in theory building and theory testing: A five-decade study of Academy of Management Journal. Academy of Management Journal, 50, 1281-1303.

Denning, P. J. 1997 “A New Social Contract for Research”, Communications of the ACM, (40:2), February, pp. 132-134

DiMaggio, P. J. 1995. Comments on “what theory is not.” Administrative Science Quarterly, 40: 391–397.

Dubin, R. 1976. Theory building in applied areas. In M. D. Dunnette (Ed.), Handbook of industrial and organizational psychology: 17–40. Chicago: Rand McNally.

Gary, M. R. & Johnson, D. S. 1979. Computers and Intractability: A Guide to the Theory of NP-Completeness. WH Freeman and Company, New York.

Gioia, D. A., & Pitre, E. 1990. Multiparadigm perspectives on theory building. Academy of Management Review, 15: 584-602.

Gregor, S. 2006. “The Nature of Theory in Information Systems,” MIS Quarterly (30:3), pp. 611-642.

Gregor, S. and Hevner, A. 2013. Positioning and Presenting Design Science Research for Maximum Impact. MIS Quarterly. Vol. 37 No. 2, pp. 337-355, June.

Gregor, S., and Jones, D. 2007. “The Anatomy of a Design Theory,” Journal of the Association of Information Systems (8:5), pp. 312-335

Hevner, A., and Chatterjee, S. 2010. Design Research in Information Systems, New York: Springer Publishing,

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

Hooker, J.N. 2004. Is design theory possible? Journal of Information Technology Theory and Application, 5, 73–82.

Iivari, J. 1983. Contributions to the Theoretical Foundations of Systemeering Research and the PICO-CO Model, Oulu, Finland: Institute of Data Processing Science, University of Oulu.

Iivari, J. 2007. “A Paradigmatic Analysis of Information Systems as a Design Science,” Scandinavian Journal of Information Systems (19:2), pp. 39-64.

Lee, A. S., & Hubona, G. S. (2009). A scientific basis for rigor in information systems research. MIS Quarterly, 237-262.

Leont'ev, A. 1981. Problems of the development of mind. English translation, Progress Press, 1981, Moscow.

Lynham, S. A. 2000. Theory building in the human resource development profession. Human Resource Development Quarterly, 11(2), 159-178.

Manna, Z. 1969. "The correctness of programs." J. Computer & System Sciences 3, 2 (May 1969), 119-127.

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

Miner, J. B. 2003. The rated importance, scientific validity, and practical usefulness of organizational behavior theories: A quantitative review. Academy of Management Learning and Education, 2: 250–268.

Nardi, B. (1995). Context and Consciousness: Activity Theory and Human-Computer Interaction. MIT Press.

Nunamaker, J. and Briggs, R. 2011. Toward a broader vision for information systems, ACM Transactions on Management Information Systems, Vol. 2, No. 4, Article 20.

Nunamaker, J. F., Jr., Dennis, A. R., Valacich, J. S., Vogel, D. R., AND George, J. F. 1991. Electronic meeting systems to support group work. Comm. ACM, 34, 7, 40–61.

Österle, H., J. Becker, U. Frank, Th. Hess, D. Karagiannis, H. Krcmar, P. Loos, P. Mertens, A. Oberweis, and E. Sinz (2010). "Memorandum on design-oriented information systems research." European Journal of Information Systems 19(1)

Reynolds, P. D. (1971). A primer in theory construction. New York: Macmillan.

Simon, H. 1996. The Sciences of the Artificial (3rd ed)., Cambridge, MA: MIT Press.

Sutton, R. I., & Staw, B. M. 1995. What theory is not. Administrative Science Quarterly, 40: 371–384.

Swanson, R. A., and Chermack, T. J. 2013. Theory Building in Applied Disciplines. Berret-Koehler Publishers, Inc, San Francisco.

Vaishnavi, V., and Kuechler, W. 2008. Design Science Research Methods and Patterns: Innovating Information and Communication Technology. Boston, MA: Auerbach Publications.

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

Weick, K. E. (1995). What theory is not, theorizing is. Administrative Science Quarterly, 385-390.

Wikipedia, accessed 2014. Activity Theory at http://en.wikipedia.org/wiki/Activity_theory