

Chapter 4

On Design Theory

Theory thus become instruments, not answers to enigmas, in which we can rest.

We don't lie back upon them, we move forward, and, on occasion, make nature over again by their aid.

– William James (1907)

4.1 What Is Theory?

Science progresses because of advancement in theories. Dictionary definitions show that the word theory can take on many meanings, including “a mental view” or “contemplation,” “a concept or mental scheme of something to be done, or the method of doing it; a systematic statement of rules or principles to be followed,” a “system of ideas or statements held as an explanation or account of a group of facts or phenomena; a hypothesis that has been confirmed or established by observation or experiment and is propounded or accepted as accounting for the known facts; statements of what are held to be the general laws, principles, or causes of something known or observed,” a “mere hypothesis, speculation, conjecture” (Gregor 2006).

Shirley Gregor (2006) in her recent essay examines the structural nature of theory in Information Systems. Many people argue that theory is not even an end goal for design research (March and Smith 1995). But within the business school environment where most IS programs reside, management and IS scholars spend lot of energy defending various research methods. Debates about *deductive* versus *inductive* theory building or field observation versus large-sample numerical data affect our lives. Yet respected members of our community (Simon, Solow, Staw, Sutton, Hayes) 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 tests of time and changing circumstances (Carlile and Christensen 2005). Hence it becomes important to understand how theories are built. We begin by looking at the cycle of theory building.

4.2 Cycle of Theory Building

Carlile and Christensen outline a process of theory building that links questions about data, methods, and theory (Carlile and Christensen 2005). The building of theory occurs in two major stages – the *descriptive stage* and the *normative stage*.

Within each of these stages, theory builders proceed through three steps: *observation*, *categorization*, and *association*. The theory-building process iterates through these stages again and again (see Fig. 4.1).

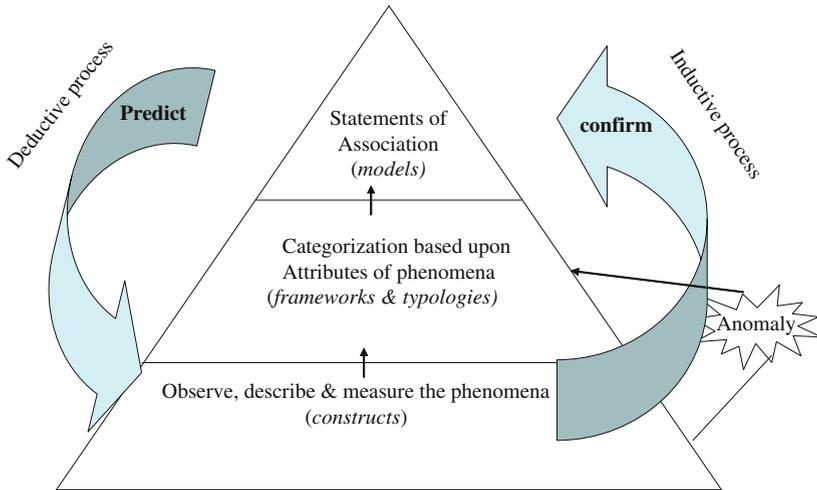


Fig. 4.1 Stages of descriptive theory building

In the past management researchers have quite carelessly applied the term theory to research activities that are conducted within one of these steps.

Terms such as “utility theory” in economics and “contingency theory” in organization design actually refer only to an individual stage in the theory-building process in their respective fields.

4.2.1 Observation

We start at the bottom of the pyramid. As first step researchers **observe** phenomena and carefully describe and measure what they see. Documenting what one sees and measurement of the phenomena in words and numbers are important. This is the foundation work, the base of the pyramid. The phenomena being explored in this stage includes not just things such as people, organizations, and technologies, but processes as well. Researchers in this step often develop abstractions from the messy detail of phenomena that we term *constructs*. Constructs help us understand and visualize what the phenomena are, how they operate. It is necessary to identify the correct constructs.

As an example, for years, scholars of inventory policy and supply chain system used the tools of operations research to derive evermore-sophisticated optimizing algorithms for inventory replenishment. Most were based on the assumption that managers know what their levels of inventory are. Ananth Raman's (Narayanan and Raman 2004) path-breaking research of the phenomena, however, obviated much of this research when he showed that most firms' computerized inventory records were broadly inaccurate – even when they used state-of-the-art automated tracking systems. Bower (1970) created constructs of *impetus* and *context* in resource allocation process, explaining how momentum builds behind certain investment proposals and fails to coalesce behind others.

4.2.2 Classification

With the phenomena observed and described researchers move up the pyramid to the second stage in which they classify the phenomena into categories. In the descriptive stage of theory building, the classification schemes that scholars propose typically are defined by the attributes of the phenomena. Examples from management phenomena include diversified vs. focused firms, vertically integrated vs. specialist firms, or publicly traded vs. privately held companies (Carlile and Christensen 2005).

Such categorization schemes attempt to simplify and organize the world in ways that highlight possibly consequential relationships between the phenomena and outcomes of interest. These schemes are often referred to as *frameworks or typologies*.

4.2.3 Defining Relationships

In the third step, researchers explore the association between the category-defining attributes and the outcomes observed. Researchers recognize and make explicit what differences in attributes, and differences in the magnitude of those attributes, correlate most strongly with the patterns in the outcomes of interest.

Techniques such as regression analysis typically are useful in defining these correlations. Often we refer to the output of studies at this step as *models*. Descriptive theory that quantifies the degree of correlation between the category-defining attributes of the phenomena and the outcomes of interest is generally only able to make probabilistic statements of association representing average tendencies (Carlile and Christensen 2005). The model helps us to understand which variables actually impact the dependent variable (outcome) of interest through averages. No causality can be inferred yet.

As an example, Hutton et al. (2003) have studied how stock prices have responded to earnings announcements that were phrased or couched in various terms. They coded types of words and phrases in the statements as explanatory

variables in a regression equation, with the ensuing change in equity price as the dependent variable. Research results such as this is important descriptive theory; however, at this point it can only assert on average what attributes are associated with the best results. A specific manager of a specific company cannot know if following those same codes of words for company announcement will lead to a similar gain in stock price. The ability to predict such things awaits the development of normative theory in this field.

4.2.4 Anomaly – Improving Descriptive Theory

The inductive portion of the theory building moves researchers from the bottom to the top of the pyramid using three steps: observation, categorization, association. Theory begins to improve when researchers cycle from the top back to the bottom of this pyramid in the deductive portion of the cycle – seeking to “test” the hypothesis that had been inductively formulated. This is mostly done to see if the correlations between attributes also hold in other data sets than the ones that were used for the original inductive steps. If it correlates in a new data set, this “test” confirms that the theory is of use under the conditions or circumstances observed. The researcher returns the model to its place atop the pyramid tested but unimproved. It is only when an anomaly is identified, an outcome for which the theory cannot account that an opportunity to improve theory occurs. Once an anomaly is found, researchers look for new attributes or further categorization that explains the observed anomaly in the new data set.

4.3 Transition to Normative Theory

It is important to move beyond statements of correlation to define what *causes* the outcome of interest. This is typically achieved by careful detailed empirical and ethnographic observation. It is necessary to leap across to the top of the pyramid of *causal theory*. With their understanding of causality, researchers then work to improve theory by following the same three steps that were used in the descriptive stage.

Hypothesizing that their statement of causality is correct, they cycle deductively to the bottom of the pyramid to test the causal statement. If an anomaly is encountered, they delve into categorization stage. By cycling up and down the pyramid of normative theory, researchers will ultimately define the set of situations or circumstances in which managers might find themselves when pursuing the outcomes of interest. This allows researchers to make contingent statements of causality, i.e., to show how and why the causal mechanisms result in a different outcome in different situations (Carlile and Christensen 2005).

As described above, theory building is a time-consuming and laborious effort that often is a result of several researchers in the community working together to

put different parts of the puzzle. It is only through recursive cycling up (inductive) and down (deductive) that we test and prove (or disprove) theories over time.

Now that we understand the basic process of theory building, we turn our attention to design theory in information systems.

4.4 Taxonomy of Theory Types in Information Systems

Gregor, in her essay "The Nature of Theory in Information Systems" (Gregor 2006) provides a comprehensive look at various theories proposed in IS discipline and explores the structural nature or ontological character of those theory. Gregor summarizes and shows theories as abstract entities that aim to *describe, explain, and enhance understanding* of the world. In some cases, it provides *predictions* of what will happen in the future and to give a basis for intervention and action.

Some theories are statements that say how something should be done in practice. Others are statements providing a lens for viewing or explaining the world. Then there are theories that are statements of relationships among constructs that can be tested. By combining the goals of theory, Gregor classifies IS theories into the five types (see Table 4.1) and the distinguishing features of each theory type are shown in the right-hand column. It is important to note that allocating theories to classes is not trivial. A theory that is primarily analytic, describing a classification system, can have implications of causality (Gregor 2006).

Table 4.1 Different types of theory in IS (adopted from Gregor (2006))

| Theory type | Distinguishing attributes |
|-------------------------------------|---|
| I. Analysis | Says what is The theory does not extend beyond analysis and description. No causal relationships among phenomena are specified and no predictions are made |
| II. Explanation | Says what is how, why, when, and where The theory provides explanations but does not aim to predict with any precision. There are no testable propositions |
| III. Prediction | Says what is and what will be The theory provides predictions and has testable propositions but does not have well-developed justificatory causal explanations |
| IV. Explanation and prediction (EP) | Says what is, how, why, when, where, and what will be Provides predictions and has both testable propositions and causal explanations |
| V. Design and action | Says how to do something The theory gives explicit prescriptions (e.g., methods, techniques, principles of form and function) for constructing an artifact |

Table 4.2 shows the components of theories across the taxonomy. This specification allows IS researchers (1) to identify what theory is composed of in general and (2) to analyze the components of their own theory and the theory of others. This is a useful framework as more new theories are developed in the IS community.

Table 4.2 Structural components of theory (adopted from Gregor (2006))

| 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) | |
| 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) |

4.5 Is Design Theory Possible?

The scientific design community is split on this topic. One camp says that there can be a design theory while other camp does not believe that there can be such a theory. In this section, we discuss three views. First, we present the Information

Systems Design Theory (ISDT) (Walls et al. 1992) as an example of an early design theory that exists and have been cited by the IS community. Then we present John Hooker’s (Hooker 2004) contrasting perspective of why such a theory cannot exist (yet)? Finally we briefly discuss Gregor and Jones (2007) in which they list what the anatomy of a IS design theory should have if one has to have a design theory.

4.5.1 Information Systems Design Theory

In 1992, Walls, Widmeyer, and El-Sawy formally specified design theory in IS adapting Simon’s ideas for the IS context. They specified the components of an ISDT as shown in Fig. 4.2. They are the following:

1. Meta-requirements, the class of goals to which the theory applies.
2. Meta-design, the class of artifacts hypothesized to meet the meta-requirements.
3. Kernel design product theories, theories from natural and social sciences that govern design requirements.
4. Testable design product hypotheses, statements required to test whether the meta-design satisfies meta-requirements.
5. Design method, a description of the procedures for constructing the artifact.
6. Kernel-design process theories, theories from natural or social sciences that inform the design process.
7. Testable design process hypotheses, statements required to test whether the design method leads to an artifact that is consistent with meta-design.

| 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 hypotheses 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 hypotheses method results in an artifact which is consistent with the meta-design |

Fig. 4.2 An ISDT (adapted from Walls et al. (1992))

In assessing the extent of use of ISDT the authors again conducted a study in 2004. They found that 26 articles have referenced ISDT and they were able to identify four different levels of usage (Walls et al. 2004):

- Level 1: ISDT is used as a *cloak of theoretical legitimacy* to describe the design features and requirements of a new class of information systems.
- Level 2: ISDT is used as a *common language and framework* for determining the meta-requirements for a new class of information systems and how its instances should be designed.
- Level 3: ISDT is used as a *way of generating new insights* about the characteristics of a new class of information systems.
- Level 4: The *richness of ISDT itself is enhanced* through usage as scholars discover gaps and omissions and improvements that can be made to ISDT that are revealed by working through it in their own context.

While Walls' et al. ISDT may be the first formal specification of a design theory in IS, its limited use to date points toward certain shortcomings. The specification as presented does not lend to immediate use as a theory. Rather more people have found it useful as a framework, which is one step toward a larger theory. Another difficulty with this seems to be the unnecessary separation of theory components for a "design process" on top of a "design product" and the lack of a clear definition as to what comprises a "product" and what comprises a "process." Furthermore, the exact nature of the things that are addressed by the "class of goals to which the theory applies" is not clear.

4.5.2 Hooker's View on Design Theory

Hooker (2004) argues that the notion of a theory of design is problematic because design, like medicine or management, is a practice. "In a sense design is pre-theory. Whereas chemistry or physics is defined by a set of phenomenon it is assigned to study, design is defined by a task it is assigned to do. It is not to dispute that one can theorize about design practice, in the sense that one can theoretically understand the socio-psychological phenomenon of design. But that is not design theory" (Hooker 2004).

Knowledge of how to design cannot be reduced to theory, for reasons that grow out of philosophy of science.

We know that a number of practical sciences are centered on design: physical artifacts, software, organizations, or information systems. This raises the issue of whether there can be in fact a science of design with a theoretical basis. Hooker (2004) maintains that there cannot be a theory of design in the same sense that there is a theory of physics or chemistry. He argues that design is a practice (the process view of IS) that cannot be reduced to theory because practice is essentially pretheoretical. Quinn's indeterminacy of translation thesis (Quinne 1961) implies the following: without pretheoretical discourse to supply the concepts explained by theories, there would be no way to understand what it means for competing theories to offer different explanations of the same phenomenon.

Design theory should provide knowledge of how to design. Much of this exists within the creative mind, is highly problem and scenario dependent, and is extremely dynamic to be generalizable. Hooker points out that there can be a supporting theory that is uniquely associated with a practice, even though it does not completely explain the practice itself. Design theory must organize our knowledge of design practice. However, this “knowledge of design practice” has two very different meanings and implications. It can refer to knowledge about socio-physiological theory of what designers do (our supporting theory) or knowledge one must have in order to practice design. The latter is much harder.

4.5.3 *Toward the Anatomy of an IS Design Theory*

One can argue that the goal of design science is all about efficacy and utility. There is no truth that we seek. Hence theory is unimportant. Gregor and Jones on the other hand argue that we can begin to lay out the anatomy of what constitutes a good IS design theory (Gregor and Jones 2007). They state the following:

Our argument is that any design theory should include as a minimum: (1) the purpose and scope, (2) the constructs, (3) the principles of form and function, (4) the artifact mutability, (5) testable propositions, and (6) justificatory knowledge.

Figure 4.3 explains these core components.

The above is a useful first step toward building a design theory. However, we claim that this in itself is not a theory. A design theory or a science of design is a noble goal that remains elusive as of yet.

| Component | description |
|-----------------------------------|--|
| Core components | |
| 1. Purpose and Scope | “What the system is for”, the set of meta-requirements or goals that specifies the type of artifact to which theory applies |
| 2. Constructs | Representation of the entities of interest in the theory. |
| 3. Principle of form And function | 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 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) |

Fig. 4.3 Six components of an information systems design theory

4.6 Conclusions

Design work and design knowledge in information systems are very important for both research and practice. There has been little effort paid to date to the problem of specifying design theory so that it can be communicated, justified, and developed. In this chapter, we presented what theory is and how theories should be developed. We then presented the two sides of the argument in which one side claims that there can be such a thing as design theory while the other argues against it. We would like to leave the reader with the understanding that an IS design theory is still a work in progress and Gregor and Jones' anatomy of the IS design theory is a very good starting point to conduct further research.

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