# Scientific Inquiry-Theory Construction: A Primer

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## Abstract

Constructing, creating, discovering, building or growing theories—and teaching it—is the central focus of this paper. The paper targets anyone desiring a more complete understanding of this fundamental building block of research and how to teach it. An explanation and description of theories (theories on theories, one might say) precedes insights on how to develop theories and teach it.

**Keywords:** Theory construction, epistemology, research methods, scientific inquiry

## 1. INTRODUCTION—WHY THEORIES?

More than sixty years after Lewin (1945) noted "nothing is so practical as a good theory," information systems researchers and authors continue to discuss the implications of the use of theory on the practicality of research and teaching. Most of the published articles on the topic have been critical.

Robey and Markus (1998) disparaged IS research and teaching relevance and framed the issue as one of scientific rigor versus practical relevance. Among their many reasons for irrelevance—including "arcane explanations," "advanced statistical analyses," and "excessive references to other published work"—was "theoretical abstractions." Theory is a well established part of scientific rigor, but practitioners do not usually equate theory with practical relevance. Robey and Markus argued there is no inherent conflict between rigor and relevance, and they provided four strategies for optimizing practical relevance with rigorous, theoretical research and teaching: "cultivating practitioner sponsorship, adopting new research models, producing consumable research reports, and supporting nontraditional research outlets" (pg. 7).

Benbasat and Zmud (1999) set off a series of articles and responses on IS academic research rigor and business practitioner relevance. They highlighted some scathing criticisms about research by business leaders and authors, explained why irrelevance occurs, and gave their recommendations for making research efforts and articles more relevant. Lyytinen (1999) added his European perspective, and noted how important teaching is to bringing IS research relevancy to business.

During the same period, however, there were calls for more "pure theory" articles (e.g., Zmud, 1998) and more theory *constructing* than theory testing (e.g., Weber, 2003) in a leading IS journal. Similar streams of articles and issues surrounding "good theory," theory construction, and practical relevance have surfaced in management (e.g., Van de Ven, 1989) and administrative science (e.g., Weick, 1995). Most follow the same line that good theory and scientific rigor are absolutely required for good research and teaching, and that relevance to practical problems is absolutely required to justify research.

Scientific knowledge is a system for describing and explaining the universe. It is not enough to contribute to scientific knowledge by proclaiming that something exists—one must describe and explain why it exists and how. Because all entities and events in the universe are related in some way (if only in time and place), the universe is a system of entities, events and their relationships. Scientific knowledge, therefore, in describing and explaining the universe is, itself, a system of descriptions and explanations with relationships.

In the system of scientific knowledge, one can infer from knowledge and relations of system subcomponents, their interrelative effects, and the logical consequences on the system as a whole as well as subcomponents not even discovered. Talcott Parsons had this systemic view of science and knowledge; he spent over 50 years gathering what he labeled "dynamic knowledge"—knowledge of the relationships that exist simultaneously between many events and entities. He tried to formulate that knowledge in what he called "theory of action," a system of concepts (Adriaansens, 1980). Theory, as Parsons formulated it, is the basis and the currency of scientific knowledge.

Theories communicate scientific knowledge and, therefore, embody that knowledge. Mullins highlights theories as a "bridge between language and experience"(Mullins, 1971a). Stinchcombe states that theory is the basis of all science (Stinchcombe, 1968a). The central purpose of a theory is explaining to mankind why one event or phenomenon is associated with another—or what causes an event. In that sense, all we truly know and communicate through teaching about our universe can be summarized as *theories*.

As Reynolds states, "A scientific body of knowledge consists of those concepts and statements that scientists consider useful for achieving the purposes of science" (Reynolds, 1971a). The goals or purposes of scientific knowledge are: *typology* (organizing and categorizing), *predictions of future events*, *explanations of past events or present situations*, *understanding causality*, and *controlling events*.

The *study* of theory itself can be viewed from an *epistemological* view—i.e., the mechanism by which we study knowledge , or from a *scientific or sociological* view—i.e., the philosophy of science (Popper, 1972; Russel, 1968). From the epistemological point of view, theory can be viewed as the effective evolution and sometimes, although rarely, a revolution of science. This description can be discerned from the study of the historical conditions leading to the evolution of knowledge (Monod, 2002). From the philosophy of science viewpoint, historically two distinctively differing groups have formed:

*empiricists* and *rationalists*. Empiricists, led by the teachings of Locke and Hume, believe all concepts come from experience. Rationalists, originating with the philosophies of Descartes and Leibniz, believe concepts come only from reason, completely independent of one's experiences.

The other scientific philosophical camp debates *intellectualism* vs. *materialism*. The intellectualists, originating with Plato, believed that objects of research do not necessarily have to be perceived by the senses. On the other hand, the materialists, beginning with Epicurus, believe the intellect can only grasp *sensible* objects of research. All ideas and concepts have their origins in worldly objects that we, as sentient individuals, have incorporated a lifetime of experiences through our five senses.

These varying philosophical camps are a necessary background for teaching theory. An explanation and description of theories (theories on theories, one might say) precedes insights on how to develop and teach theories.

## 2. THEORIES—WHAT ARE THEY?

A theory, in short, is an idea—an abstract idea with specific form, purpose, qualities and derivative—but a mental, communicable idea not contained in the form of its representation, but with substance conveyed by its form. Represented by natural (such as English) or artificial language (such as mathematical symbology), theories take three general forms(Reynolds, 1971b):

- a set of laws
- a set of definitions, axioms, and propositions
- a set of descriptions of causal processes.

### Theory as a set of laws

As a set of laws, theories are well-supported empirical generalizations of natural laws. They are, fundamentally, statements that describe situations and relationships about which scientists are so confident—repeatedly confirmable by empirical data—that they consider these theories absolute "truths." Under the set-of-laws form, all scientific knowledge is a set of laws about the universe, laws that in the aggregate constitute "real truth." All set-of-laws theories have concepts that have operational definitions measurable in concrete situations. One way to categorize theories using the set-of-laws concept is to consider abstract theoretical statements as having different degrees of empirical support. Those with no support are considered hypotheses, those with some support are considered empirical generalizations, and those with overwhelming support are considered laws. In any case, categorization is subjective based on acceptance by scientists as a whole. While some scientists prefer that only relational statements be called laws (and preferably those that state a causal relationship); to do so would eliminate useful descriptions of phenomena such as "all matter has energy."

Scientific knowledge in the form of a set of laws is useful for providing typology, providing predictions and explanations, and, if the statements are sufficiently precise, allowing the potential for control. However, they do not provide any "sense of understanding" with regard to any of the discussed phenomena—they simply state "truths." Set-of-laws theories have other disadvantages. Since they are based on empirical evidence, every concept used in a law must be measurable—prohibiting many concepts currently employed in social science such as authoritarianism or kindness; one can only measure the consequences of the concept but not the actual concept itself. Moreover, the statements that compose a set of laws are supposed to be independent—unrelated to one another. This means that research in support of one statement or law cannot provide support for another statement or law. There is no way to organize these set-of-law theories, and therefore research may be inefficient and the resulting set of statements very large (since no relationship can represent sets of theories).

### Theory as a set of definitions, axioms, or propositions

An axiomatic theory is typically defined as an interrelated set of definitions and statements, any one of which can be ultimately derived from the others (e.g., most mathematical theories). Axiomatic theories are highly consistent (they must be to be highly interrelated), they are simple (as opposed to complex combinations of axiomatic theories), and they are "elegant" in that they are completely independent of a form of representation. Blalock suggests that only those statements that describe a direct causal relationship between two concepts should be labeled as axioms to reduce the ambiguity in the description of theories (Blalock, 1969).

The axiomatic form has several advantages over the set-of-laws form. First, since some statements can be derived from others, it is not necessary for all concepts to be measurable (and therefore unmeasurable or hypothetical concepts can be used in developing a theory). Secondly, the number of statements that express scientific knowledge can be smaller since a set of axioms may be used to generate a larger set of statements. Third, research may be more efficient since empirical support for any one statement tends to provide support for the entire theory. Finally, the axiomatic form allows the theorist to examine all the consequences of his assumptions, or axioms. Like the statements in set-of-laws theories, however, the statements in the axiomatic form of theory can be used to logically derive explanations and predictions, classify and organize events, but, again, they generally fail to provide a sense of "understanding."

**Theory as a set of descriptions of causal processes**

A causal process form of theory is an interrelated set of definitions and statements that describe those situations in which one or more causal processes are expected to occur, or identify the effect of one or more independent variables on one or more dependent variables. The major difference between this form of theory and the axiomatic form is that all statements are presented in terms of a causal process in a system—explaining "how" something happens. The causal form is useful in providing a typology, providing explanations and predictions, and providing a potential for control—same as set-of-laws theories. The prime difference, and the prime advantage of causal theories, is that arranged causal theories can provide a sense of understanding which is crucial to scientific knowledge. They can start as laws or axioms, but when described in a causal form they can give the reader a greater sense of knowledge than the sum of the parts. Like axioms, causal theories allow for hypothetical or unmeasurable concepts, they allow more efficient research, and they allow the researcher to examine the consequences of the formulation. Reynolds contends that, in the case of social research, causal theories allow easier development than axiomatic or set-of-laws (pg. 106). The only disadvantage may be in knowing when to stop investigating relevant causes; *explanatory* causal theories require extensive research while *predictive* causal theories need only be accurate (within an agreed confidence) no matter how many ultimate independent causal variables may exist.

## 3. CHACTERISTICS OF THEORIES

Regardless of the form of a theory, there are certain similar characteristics of all theories. First, they are abstract—that is, they are independent of time and space rather than linked to a "concrete" time and space. Any theory limited to a time and place is too specific; research on non-abstract theory would be too inefficient. Secondly, they are intersubjective; that is, there is agreement about their meaning due to their inherent logical rigor. If scientists cannot agree on the predictions derived from combinations of statements, then there can be no agreement as to the usefulness of the statements; if they cannot agree on the usefulness of the statements for achieving the goals of science, the statements are useless to the scientific body of knowledge. Finally, all theories have empirical relevance; they are either based on empirical data or they relate to empirical forms (i.e., it's not private philosophy). Explaining why one event is associated with another, or what causes an event, is the basic purpose of a theory. Scientists must be able to examine the correspondence between a particular theory and objective empirical data. The follow-on test of any concept or statement, however, is whether it is adopted by other scientists as useful for the goals of science.

**Some Definitions**

If an idea is to be shared, it must be communicated; if it is to be communicated, it must use words or symbols that are commonly understood—whose definitions are shared. Derived definitions are composed of primitive terms that refer to concepts shared by the relevant scientists; real definitions describe the "real essence" of an object or phenomenon. Concepts refer to an object or phenomenon or refer to characteristics of an object that can differ in degrees (levels of quantification). According to Stinchcombe, a concept is a hypothesis that a certain sort of thing causes other things to happen; it is a variable that has a value in the world (pg 38).

Once a concept is presented and there is agreement among scientists about its meaning, it can be used in statements to describe the "real world." A statement is basically the description of a relationship between two or more concepts (in terms of association or causal relation) with empirical relevance (it's possible to compare the statement with some phenomena). Some statements, however, claim the existence of phenomena referred to by a concept (existence statements). The heart of scientific knowledge, though, is expressed in relational statements (Stinchcombe, 1968b). Knowing the existence of an instance of one concept conveys information about the existence of an instance of another concept. Explanations, predictions, and a sense of understanding depend on relational statements.

Statements can also be thought of in terms of levels of abstraction: theoretical, operational, and concrete (Kant, 1965). The most general is the theoretical level, when a statement contains theoretical concepts. If the theoretical concepts are replaced with the operational definitions related to the theoretical concepts, then the statement is said to be at the operational level. Finally, if the operational definitions are replaced by the findings of a particular research project or the description of a specific concrete event, the statement may be said to be at the concrete level.

## 4. THEORY CONSTRUCTION—HOW DO WE DEVELOP THEORIES?

There are two basic strategies for constructing or developing theories: derive theory from empirical research (a posteriori or "research-then-theory"), or invent a theory then test by empirical research (a priori or "theory-then-research"). A third strategy is a composite of the first two.

### Research-Then-Theory

This strategy is commonly known as the Baconian approach (for Francis Bacon as set forth in "Aphorism XIX," *Novum Organum*, 1620). Essentially, the steps are:

1. select a phenomenon and list all the characteristics of it

2. measure all the characteristics of the phenomenon in a variety of situations (as many as possible)

3. analyze the resulting data to determine if there are any systematic patterns among the data worthy of further attention

4. formalize the significant patterns as theoretical statements constituting laws of nature (or axioms to Bacon).

This strategy can be an efficient approach under two conditions: a small number of variables to measure during data collection (which can be easily measured accurately and reliably), and only a few significant patterns to be found. Unfortunately, the Baconian approach has three major drawbacks: the amount of data that can be collected is theoretically infinite, a lack of agreement on what may be the most important variables, and trying to find substantially significant patterns among large amounts of data can be overwhelming. As Mullins states, experience can be the richest source of motivation but the most difficult source of ideas (Mullins, 1971b). In particular, social and management sciences are characterized by many variables that are hard to measure and an overwhelming number of patterns to sift. On the other hand, the research-then-theory approach can be highly efficient (when appropriately used); a successful research-then-theory strategy can reap a high number of theories from one empirical study (high number of laws per unit of empirical data).

### Theory-Then-Research

This is, obviously, the opposite to the Baconian approach and the one strongly recommended by Stinchcombe (pg 3). With this strategy, one:

1. develops an explicit theory in either axiomatic or process description form

2. selects a statement generated by the theory for comparison with the results of empirical research

3. designs a research project to test the chosen statement's correspondence with empirical research

4. makes appropriate changes in the theory or the research design if the statement and the empirical data do not correspond, then continues with empirical research (return to step 2)

5. selects further statements for testing or attempts to determine the theory limitations when the statement does correspond with the empirical data.

This approach is strongly developed and recommended by Popper, but with the idea that the goal of the empirical research is to prove the theories *false*, thereby advancing—he contends—scientific knowledge most rapidly (Popper, 1963). Indeed, Stinchcombe maintains that the logical process of science is "the elimination of alternative theories by investigating as many of the empirical consequences of each theory as is practical" (pg. 22). The major focus of this strategy is the development of an explicit theory through continuous interaction between theory construction and empirical research. As that interaction progresses, the theory becomes more precise and complete as a description of nature and, therefore, more useful to the goals of scientific knowledge. Empirical research likewise becomes steadily more focused, ignoring directions proved unfruitful.

But how does one select the statement to research empirically? The three most likely options are to select the statement most likely true, select the statement most likely false, or select the statement most crucial or significant to the theory. If we assume that the basic purpose of scientific activity is to develop useful theories, then it would appear that the crucial statements should be tested first—otherwise a great deal of effort may be expended on a theory that turns out to not be useful. In that vein, the weakest part of a theory should be tested first so that required theory adjustments will be obvious early on. (A problem, however, may come when the empirical data indicates that the theory must be altered or discarded completely; it is often tempting to cling to a theory until collected data supports it.) A second problem with this approach comes from the inefficiency of nailing down one statement at a time—unless the overall research project is well planned and coordinated in order to build on results of earlier empirical research.

Perhaps the biggest problem with the theory-then-research approach is developing the initial theory, either by inventing one or by adjusting or modifying existing theories. Stinchcombe says that a good theoretical statement logically derives an empirical statement to be tested (pg. 16). He recommends focusing on the causal process that we think might be operating to (tentatively) locate a concept (pg. 198). Kuhn states, after studying the history of scientific breakthroughs (now known as the Kuhn Paradigm), the following conditions that have led to significant increases in scientific knowledge (Kuhn, 1962):

1. *Individuality*. The necessity for explicity communicating ideas in any group endeavor implicity hampers the development of radically new ideas. Any new idea will not be easy to describe in terms of existing vocabularies or existing ideas; the requirement to discuss ideas as they develop may inhibit the development of new and uncommunicable ideas. Indeed, most major paradigms have been attributed to single individuals working alone (Reynolds, 1971c).

2. *Understanding "Good and Bad"*. Bright, solitary thinkers in the past appeared very adept at identifying a good idea from a bad idea; they are highly discriminating. They ignore the bad ideas and concentrate fully on the good ideas.

3. *Knowledge of Field*. Although working alone, they have a high degree of knowledge of existing theories in the field of interest; they know when a good idea is a new idea.

4. *Not Dogmatic*. New ideas seem to come more readily to those who are not steeped in or a slave to existing paradigms, theories or ideas. In fact, the greatest advances in the physical sciences have come from either the very young or from older individuals who were new to the field—both with little commitment to dogma

5. *Close to the Phenomenon*. New theories apparently come from individuals who are deeply engrossed in the subject matter, so engrossed that an intuitive or uncommunicable new idea with relationships appears more substantial in thought than other, unrelated interests.

Hadamard holds emphatically that invention is really discovery, that the initial theory would come from logic and systematic reasoning (Hadamard, 1945). He asserts four stages of invention applicable to theories:

1. preparation by gathering information

2. incubation by intense thought

3. illumination after unconscious work

4. verification and precise definition.

**A Composite Approach to Theory Construction**

As explained, the research-then-theory and the theory-then-research approaches have advantages and disadvantages. The idea of slaving over data to find theories and the picture of dreaming up new theories in isolation suggest that a third, and optimized, strategy for constructing theories would be a composite of the first two. A composite approach would divide scientific activity into three stages:

1. *Exploratory*. Research is designed to allow an investigator to just "look around" some phenomenon, looking for ideas. There should be some structure to the research in order to provide guidance to stage two.

2. *Descriptive*. The goal is to develop careful descriptions of patterns suspected from the exploratory research—developing empirical generalizations or intersubjective descriptions. A generalization that is considered worth explaining, is worth a theory.

3. *Explanatory*. This stage develops explicit theory to explain the generalizations formed in step two. It is actually a continuous cycle of theory construction, testing, and reformulation.

This approach seems to contain all the advantages and avoid all the disadvantages of the first two strategies. Resources are not wasted in gathering a massive amount of information expecting to find laws by searching through the data. Theories are not invented until there is some information about the phenomenon that will help in the development of a useful initial theory. Finally, when a theory is ready to be tested, a wealth of experience in doing research on the phenomenon allows for a sophisticated comparison of the theory with the empirical world.

**Example of the Composite Approach**

Weill and Vitale began a research effort with four pre-conceived, specific objectives (Weill, 1999). First, they sought to provide a theory for assessing and interpreting the health of an organization's IS application portfolio (exploratory). As their foundation, they investigated past efforts on how to measure IS success, keying on the work of Delone and McLean (Delone and McLean, 1992). They emphasized the importance of senior management's evaluation of the information system centering on five, interrelated attributes:

- the importance of the system to the business unit
- management's investment in the system
- the technical quality of the system
- the level of use of the system
- the perceived quality of management of the system.

Second, they studied these five attributes in a $2 billion revenue firm with 18 different business units in order to validate their theory (description). The organizational and information infrastructure were described in great detail including lines of authority, current cost structures, performance evaluation methodologies, and the relationship of the IS function to the organization.

Third, they provided details of the relationships discovered from the application of their theory (intersubjective descriptions/observations. To operationalize their theoretical model, Weill and Vitale used multiple-measures. *Investment* in each system included the annual costs of system development, provision, operation, and maintenance. Additionally, the authors identified the *technical quality* of each system by six constructs including 1) source code quality, 2) data quality and reliability, 3) system reliability, 4) ease of use, 5) output quality, and 6) portability. They also measured the *use of the system* by evaluating the number of accesses to the system by each manager's department. Lastly, *management value of a system* was measured in terms of its usefulness to executives in performing typical management tasks (planning, investigating, coordinating, evaluating, supervising, staffing, negotiating, and representing) in their various functional areas. Managers rated the usefulness of their information system on a five point scale with relation to each of the tasks.

Finally, Weill and Vitale suggested a general approach for assessing the health of any firms application portfolio (explanatory). Through a complex examination of the data fit to their original theoretical model, the authors were able to validate certain causal relationships, resulting in the practical guide for assessing the health of an organization's application portfolio. This guide provided the manager strengths, weaknesses, and practical advise including a clear case for action to improve the quality, efficiency, and effectiveness of future application development projects.

## 5. TEACHING THEORY AND THEORY CONSTRUCTION

Theory can seem so conceptual and esoterical that students may doubt its usefulness in or out of the classroom. But as the fundamental building block of scientific knowledge, research, and practical application, teaching theories and the theory development process should be an essential part of an IS education. Teaching IS theories can make scientific knowledge relevant to IS practice.

First, IS students should be taught what a theory is—in all its forms—as explained in this paper. Someof the simplest IS theories can be useful in showing how a theory explains and predicts natural phenomena. These simple theories can include The Strategic Grid or Organizational Transformation—simple 2x2 matrices and process steps. More complex theories can then be examined, such as the Theory of Reasoned Action and the Technology Acceptance Model. Students can be introduced to resources that list, explain, and summarize theories used in IS research, such as the ISWorld web site.

Then students can learn the various methods of constructing or developing theories as explained in this paper—with the example. Students can perform exercises building theories on some IS phenomenon they've observed or postulated. The framework for a good theory building paper proposed by Zmud (1998) can be used for evaluating theory building efforts:

- an introduction describing the phenomenon explained
- a description of the theoretical model including the constructs, relationships, and boundaries
- implications of the theory to research and practice
- conclusions.

Finally, students can gain a better appreciation for the relevance of IS theories by examining teaching cases that highlight practical situations that could be resolved by applying specific theories. Many teaching notes to teaching cases underscore specific theories; those cases and the applicability of the theories could be used in a classroom.

## 6. SUMMARY

The Information Systems field has debated the relevance of IS research but not IS theories to scientific knowledge. Scientific knowledge is a system of theories that explain and describe the universe. Those theories are abstract, intersubjective, and have empirical relevance. They may be thought of as a set of absolute laws describing "real truth," as axioms that are interrelated, or as descriptions of causal process that can provide a sense of understanding crucial to scientific knowledge and practical, relevant application of that knowledge. The authors believe that teaching theories and their relevance to IS practice is essential.

There are two main strategies for constructing theories—and a third that is a composite of the first two. The first is research-then-theory (the Baconian approach) which comes from exhaustive data collection then analysis for all applicable theories. The second is theory-then-research; developing a theory, testing a related statement, then cycling between adjusting the theory/statement and conducting more empirical research. The composite approach is to conduct exploratory empirical research, develop a generalization, then cycle among theory construction, testing, and theory reformulation. The latter strategy has the advantage of not wasting resources collecting vast amounts of data in search of an elusive theory while not inventing theories without any empirical basis. In all strategies, the ultimate problem is discovering or inventing the theory; the composite approach offers the best likelihood of progressively refining a general idea into a precise theory that can add to the body of scientific knowledge.

Students can be taught the essentials of what a theory is, perhaps starting with the more simple theories before the more mature, complex theories. Students can learn the variousl methods of building theory, and practice writing them using a standard format. Finally, students can learn the practicality of IS theories by examining real-world IS teaching cases in light of the theories they illustrate.

IS theories are relevant to IS practice, and belong in IS curricula.

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