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Theory Construction in Design Research.
Criteria, Approaches, and Methods.

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Abstract

Design involves creating something new or transforming a less desirable situation to a preferred situation. To do this, designers must know how things work and why. Understanding how things work and why requires explanation, and it sometimes requires prediction. To explain and predict, we must construct and test theories.

Theories are propositions or sets of propositions that allow us to analyze or explain subjects. Some theories are complex and sophisticated. Others are simple.

Theory can be described in many ways. In its most basic form, a theory is a model. It is an illustration describing how something works by showing its elements in their dynamic relationship to one another. The dynamic demonstration of working elements in action as part of a structure distinguishes a theoretical model from a simple taxonomy or catalogue. A theory predicts what will happen when elements interact.

Understanding design process and design outcomes now implies the kinds of theory construction common in the natural and social sciences. This paper argues that successful design is inherently theory-rich.

The paper outlines a framework for understanding theory construction in design. This framework will clarify the meaning of theory and theorizing. It will explain the nature and uses of theory as a general concept. It will propose necessary and sufficient conditions for theory construction in design. Finally, it will outline potential areas for future inquiry in design theory.
Theory Construction in Design Research: Criteria, Approaches, and Methods

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Definitions: Design, Research, Theory

Before addressing the theme of theory construction in design research, it will help to establish a few basic definitions and parameters. These definitions are not complete and all-inclusive. Rather, they establish terms as I use them in this paper. Establishing clear definitions also encourages reflection on central themes in theoretical inquiry, and each definition is supported by references to multiple sources.

Clarity is important in understanding theory. Theoretical sensitivity and methodological sophistication rest on understanding the concepts we use. None of us is obliged to accept any specific definition of a term such as design, research, or theory. Some of us find that no single definition suits us, and we are often obliged to restate or reshape definitions to the task. Precisely because there is no need for adherence to a single definition, we are obliged to make our usage clear. This does more than help others to understand terms as we use them. It also helps to ensure that we understand what we are saying.

There seems to be a range of emerging agreements on ways to define design. While there are differences in approach and the technical use of the term, most definitions converge on a range of common understandings. Three common understandings involve a goal-oriented process that is used to solve a problem, meet a need, solve a problem, improve a situation, or create something new or useful. There is much room for different positions within this broad and open range of possibilities.

While acknowledging that many definitions of design are possible, this paper uses a definition built on linguistic research, empirical observation, and the contributions of Buckminster Fuller (1969, 1981) and Herbert Simon (1982, 1998). (Those familiar with my work will recognize some of the material in these definitions. I use these definitions to develop a new inquiry here, and add new material that bears on the topic of theory construction.)

Design research is a relatively new field. We have fewer scholars and scientists with research education and training than other fields do. This means that the term research is often confused or misused. The problem is made worse by the fact that design is inherently interdisciplinary. We therefore find ourselves in a situation where terms are often confused. The current generation of design research specialists comes mostly to research from a practitioner education. This gives us a corps of researchers with solid practitioner skills and deep gaps in research skills. This is understandable in people who have devoted their educational training and most of their professional work to practice. This leads to a common problem. Those who are new to research adapt terms and definitions from a wide range of fields in which they have little solid foundation.
The term theory suffers from similar problems. The problem is even greater because of the fact that relatively few scholars or scientists in established fields specifically study the issues and topics involved in theory construction. While the knowledge base of most fields provides a rich array of resources in research methods and methodology studies, few fields offer much material on theory construction.

There comes a moment in the evolution of every field or discipline when central intellectual issues come into focus as the field and the discipline on which it rests shift from a rough, ambiguous territory to an arena of reasoned inquiry. At such a time, scholars, scientists, researchers, and their students begin to focus articulate attention on such issues as research methods, methodology (the comparative study of methods), philosophy, philosophy of science, and related issues in the metanarrative through which a research field takes shape. In many fields today, this also entails the articulate study of theory construction.

This paper will explore the issue of theory construction in design research. To do so requires establishing a range of concepts around such terms as research and theory. While defining the terms research and theory is more difficult in our field than in others, any attempt to develop the topic of theory construction requires an adequate definition. This paper therefore offers definitions. While these definitions are robust enough for wider use, I do not explore their general properties or the many uses to which they may be put. I use them here to establish a foundation for the consideration of theory construction offered here.

Defining Design

In using the word design, I refer to a process that involves creating something new (or reshaping something that exists) for a purpose, to meet a need, to solve a problem or to transform a less desirable situation to a preferred situation.

Herbert Simon (1982: 129, 1998: 112) defines design as the process by which we “[devise] courses of action aimed at changing existing situations into preferred ones.” To the degree that creating something new (or reshaping something that exists) for a purpose, to meet a need, to solve a problem are also courses of action toward a preferred situation even though we may not yet be able to articulate the preferred situation, this definition covers most forms of design. Without accepting all of Simon’s views on how to design, it is a useful starting point.

Design is a process. Merriam-Webster’s (1993: 343) defines design as: “1 a : to conceive and plan out in the mind <he ~ed a perfect crime> b : to have as a purpose : intend <he ~ed to excel in his studies> c : to devise for a specific function or end <a book ~ed primarily as a college textbook> 2 archaic : to indicate with a distinctive mark, sign or name 3 a : to make a drawing, pattern or sketch of b : to draw the plans for c : to create, fashion, execute or construct according to plan : devise, contrive…” (See also: ARTFL Webster’s 1913: 397-8; Britannica Webster’s 2002: unpaged; Cambridge 1999: unpaged; Friedman 2001: 36-40; Link 1999: unpaged; OED Online 2002: unpaged; SOED 1993: 645; Wordsmyth 2002: unpaged.)
Buckminster Fuller (1969: 319) describes the design process as an event flow. He divides the process into two steps. The first is a subjective process of search and research. The second is a generalizable process that moves from prototype to practice.

The subjective process of search and research, Fuller outlines a series of steps:

teleology -- > intuition -- > conception -- >
apprehension -- > comprehension -- >
experiment -- > feedback -- >

Under generalization and objective development leading to practice, he lists:

prototyping #1 -- > prototyping #2 -- > prototyping #3 -- >
production design -- > production modification -- > tooling -- >
production -- > distribution -- >
installation -- > maintenance -- > service -- >
reinstallation -- > replacement -- >
removal -- > scrapping -- > recirculation

For Fuller, the design process is a comprehensive sequence leading from teleology – the goal or purpose toward which the process aims – to practice and finally to regeneration. This last step, regeneration, creates a new stock of material on which the designer may again act. The specific terms may change for process design or services design. The essential concept remains the same. Fuller also used the term design science, though he used it in a different context than Simon did (Fuller 1969, 1981; see also Fuller 1964, 1965, 1967; and Fuller and Dil 1983).

A designer is a thinker whose job it is to move from thought to action. A taxonomy of design knowledge domains (Friedman 1992, 2000, 2001) describes the frames within which a designer must act. Each domain requires a broad range of skills, knowledge, and awareness. Design, properly defined, is the entire process across the full range of domains required for any given outcome.

The field organized around design can be seen as a profession, a discipline, and a field. The profession of design involves the professional practice of design. The discipline of design involves inquiry into the several domains of design. The field of design embraces the profession, the discipline, and a shifting and often ambiguous range of related cognate fields and areas of inquiry. When we speak of theorizing, we necessarily speak of the discipline. The foundation of design theory rests on the fact that design is by nature an interdisciplinary, integrative discipline.

The nature of design as an integrative discipline places it at the intersection of several large fields. In one dimension, design is a field of thinking and pure research. In another, it is a field of practice and applied research. When applications are used to solve specific problems in a specific setting, it is a field of clinical research.
My model for the field of design is a circle of six fields. A horizon bisects the circle into fields of theoretical study and fields of practice and application.

The triangles represent six general domains of design. Moving clockwise from the left-most triangle, these domains are (1) natural sciences, (2) humanities and liberal arts, (3) social and behavioral sciences, (4) human professions and services, (5) creative and applied arts, and (6) technology and engineering.

Design may involve any or all of these domains, in differing aspect and proportion depending on the nature of the project at hand or the problem to be solved.

With this as a background, we are prepared to examine how – and why – theory construction is important to design, the design process, the field of design, the discipline, and the profession.

Let us return to the definition of design as the process by which we “[devise] courses of action aimed at changing existing situations into preferred ones.” Those who cannot change existing situations into preferred ones fail in the process of design. There are many causes of design failure. These include lack of will, ability, or method. Designers also fail due to context or client, lack of proper training or a failure to understand the design process.

Fuller (1981: 229-231) describes design as the difference between class-one evolution and class-two evolution. Class-two evolution involves “all those events that seem to be resultant upon human initiative-taking or political reforms that adjust to the change wrought by the progressive introduction of environment-altering artifacts” (Fuller 1981: 229).

One argument for the importance of design is the increasing number of areas that are now subject to human initiative. The vast range of technologies that surround us mediate most of the human world and influence our daily lives. These include the artifacts of information technology, mass media, telecommunication, chemistry, pharmacology, chemical engineering, and mechanical engineering, along with the designed processes of nearly every service industry and public good now available other than public access to nature. Within the next few years, these areas will come to include the artifacts of biotechnology, nanotechnology, and possible hybrid technologies that meet at what Ray Kurzweil calls “the singularity.”
Kurzweil, a leading authority on artificial intelligence, argues, “We are entering a new era. I call it ‘the Singularity.’ It’s a merger between human intelligence and machine intelligence that is going to create something bigger than itself. It’s the cutting edge of evolution on our planet. One can make a strong case that it’s actually the cutting edge of the evolution of intelligence in general, because there’s no indication that it’s occurred anywhere else. To me, that is what human civilization is all about. It is part of our destiny and part of the destiny of evolution to continue to progress ever faster, and to grow the power of intelligence exponentially. To contemplate stopping that – to think human beings are fine the way they are – is a misplaced fond remembrance of what human beings used to be. What human beings are is a species that has undergone a cultural and technological evolution, and it’s the nature of evolution that it accelerates, and that its powers grow exponentially, and that’s what we’re talking about. The next stage of this will be to amplify our own intellectual powers with the results of our technology” (Kurzweil 2001: unpaged, see also Kurzweil 1990, 1999).

Fuller’s metaphor of the critical path shows a world that can disintegrate as well as grow better. Whether Kurzweil’s optimism is justified or not, his description of how the artificial world affects the natural world has immense ramifications that parallel Fuller’s idea of class-two evolution.

Design plays a role in this evolution, and the design process takes on new meaning, as designers are required to take on increasingly important tasks. These tasks are important not because designers are more visible and prestigious, but because design has greater effects and wider scope than ever before.

Profound design and brilliant concepts are uncommon in design, much as they are in physics, engineering, poetry, or painting. Even so, the success of evolutionary artifacts and craft traditions suggests that most human beings are able to do a competent job of design. Design failures are nevertheless common. The most common reasons include lack of method and absence of systematic and comprehensive understanding. These, in turn, rest on gaps in knowledge and preparation.

It is here that research and theory play a role.
Defining Research

Webster’s Dictionary defines research with elegant simplicity. The noun dates from 1577: “re·search noun Pronunciation: ri-’s&rch, ‘rE-”Etymology: Middle French recerche, from recercher to investigate thoroughly, from Old French, from re- + cercher to search -- more at SEARCH Date: 1577 1 : careful or diligent search 2 : studious inquiry or examination; especially : investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws 3 : the collecting of information about a particular subject. (Merriam-Webster’s 1993: 1002; see also: ARTFL Webster’s 1913: 1224; Britannica Webster’s 2002: unpaged; Cambridge 1999: unpaged; Link 1999: unpaged; OED Online 2002: unpaged; SOED 1993: 2558; Wordsmyth 2002: unpaged).

The verb follows in 1593. As a transitive verb, it means “to search or investigate exhaustively” or “to do research for” something, as to research a book. The intransitive verb means, “to engage in research” (Merriam-Webster’s 1993: 1002; see also sources above).

Design research discussions that label research as a purely retrospective practice have been misleading. Statements that conflate research with positivism are equally misleading. So, too, are essays that proclaim systematic, rigorous research to be inflexible or uncreative. One recent note asked plaintively, “where’s the search in research?” as though rigorous research involves little more than tedious cataloguing of established facts. While some aspects of creative research involve tedium, so do some aspects of painting, music, and dance.

It does not require a comprehensive linguistic analysis of the word research to understand that the prefix “re” came to this word from outside English. The prefix does not modify the core word in the direction of past or retroactive conditions, but it emphasizes or strengthens it.

As the dictionaries note (Merriam-Webster’s 1993: 1002; see others), the word research is, in fact, closely linked to the word and concept of search in general. Webster’s defines the word search this way: “Middle English cerchen, from Middle French cerchier to go about, survey, search, from Late Latin circare to go about, from Latin circum round about -- more at CIRCUM- Date: 14th century transitive senses 1 : to look into or over carefully or thoroughly in an effort to find or discover something; as a : to examine in seeking something <searched the north field> b : to look through or explore by inspecting possible places of concealment or investigating suspicious circumstances c : to read thoroughly : CHECK; especially : to examine a public record or register for information about <search land titles> d : to examine for articles concealed on the person e : to look at as if to discover or penetrate intention or nature 2 : to uncover, find, or come to know by inquiry or scrutiny -- usually used with out intransitive senses 1 : to look or inquire carefully <searched for the papers> 2 : to make painstaking investigation or examination” (Merriam-Webster’s 1993: 1059; see others).”
Many aspects of design involve search and research together. It is helpful to consider this issue in terms of a triad formed by the concepts of clinical research, basic research, and applied research. This shapes a dynamic milieu closer to the reality of professional practice than the common dyadic division between basic research and applied research. While the dyadic division may suffice for the natural sciences, it is not adequate for understanding research in the technical and social sciences or the professions they support.

Basic research involves a search for general principles. These principles are abstracted and generalized to cover a variety of situations and cases. Basic research generates theory on several levels. This may involve macro level theories covering wide areas or fields, midlevel theories covering specific ranges of issues or micro level theories focused on narrow questions. Truly general principles often have broad application beyond their field of original, and their generative nature sometimes gives them surprising predictive power.

Applied research adapts the findings of basic research to classes of problems. It may also involve developing and testing theories for these classes of problems. Applied research tends to be midlevel or micro level research. At the same time, applied research may develop or generate questions that become the subject of basic research.

Clinical research involves specific cases. Clinical research applies the findings of basic research and applied research to specific situations. It may also generate and test new questions, and it may test the findings of basic and applied research in a clinical situation. Clinical research may also develop or generate questions that become the subject of basic research or applied research.

Any of the three frames of research may generate questions for the other frames. Each may test the theories and findings of other kinds of research. It is important to note that clinical research generally involves specific forms of professional engagement. In the rough and tumble of daily practice, most design practice is restricted to clinical research. There isn’t time for anything else.

In today’s complex environment, a designer must identify problems, select appropriate goals, and realize solutions. Because so much design work takes place in teams, a senior designer may also be expected to assemble and lead a team to realize goals and solutions. Designers work on several levels. The designer is an analyst who discovers problems. The designer is a synthesist who helps to solve problems and a generalist who understands the range of talents that must be engaged to realize solutions. The designer is a leader who organizes teams when one range of talents is not enough. Moreover, the designer is a critic whose post-solution analysis ensures that the right problem has been solved. Each of these tasks may involve working with research questions. All of them involve interpreting or applying some aspect or element that research discloses.
Because a designer is a thinker whose job it is to move from thought to action, the designer uses capacities of mind to solve problems for clients in an appropriate and empathic way. In cases where the client is not the customer or end-user of the designer’s work, the designer may also work to meet customer needs, testing design outcomes and following through on solutions.

This provides the first benefit of research training for the professional designer. Design practice is inevitably located in a specific, clinical situation. A broad understanding of general principles based on research gives the practicing designer a background stock of knowledge on which to draw. This stock of knowledge includes principles, facts, and theories. This stock forms a theoretically comprehensive background that no one person can master. Rather, this constitutes the knowledge of the field. This knowledge is embodied in the minds and working practices of millions of people. These people, their minds, and their practices, are distributed in the social and organizational memory of tens of thousands of organizations.

Even if one person could in theory master any major fraction of the general stock of knowledge, there would be little point. The general and comprehensive stock of design knowledge can never be used completely in any practical context.

Good design solutions are always based on and embedded in specific problems. In Jens Bernsen’s (1986) memorable phrase, in design, the problem comes first. Each problem implies partially new solutions located in a specific context. The continual interaction of design problems and design solutions generates the problematics and knowledge stock of the field in tandem.

Developing a comprehensive background through practice therefore takes years. In contrast, a solid foundation of design knowledge anchored in broad research traditions gives each practitioner the access to the cumulative results of many other minds and the overall experience of a far larger field.

In addition to those who shape research at the clinical edge of practice, there are other forms of research that serve the field and other kinds of researchers develop them.

Research is a way of asking questions. All forms of research ask questions, basic, applied, and clinical. The different forms and levels of research ask questions in different ways.

One of the problems in understanding design research emerges specifically from this distinction. Design practitioners are always involved in some form of research, but practice itself is not research. While many designers and design scholars have heard the term “reflective practice,” reflective practice is also not research, and reflective practice is not a research method as is sometimes mistakenly suggested.
What distinguishes research from reflection? Both involve thinking. Both seek to render the unknown explicit. Reflection, however, develops engaged knowledge from individual and group experience. It is a personal act or a community act, and it is an existential act. Reflection engages the felt, personal world of the individual. It is intimately linked to the process of personal learning (Friedman and Olaisen 1999; Kolb 1984). Reflection arises from and addresses the experience of the individual.

Research, in contrast, addresses the question itself, as distinct from the personal or communal. The issues and articulations of reflective practice may become the subject of research, for example. This includes forms of participant research or action research by the same people who engaged in the reflection that became the data. Research may also address questions beyond or outside the researcher.

Research asks questions in a systematic way. The systems vary by field and purpose. There are many kinds of research: hermeneutic, naturalistic inquiry, statistical, analytical, mathematical, physical, historical, sociological, ethnographic, ethnological, biological, medical, chemical and many more. They draw on many methods and traditions. Each has its own foundations and values. All involve some form of systematic inquiry, and all involve a formal level of theorizing and inquiry beyond the specific research at hand.

Comparing two distinct research streams focused on design practice will shed light on some of these issues.

In one of the most interesting research programs of the past decade, Henry Petroski (1992, 1994a, 1994b, 1996, 1997) has studied design failures, the role of failure in moving toward success, and the relationship between the different aspects of the design process. Among the key elements in success are systemic understanding, together with the ability to render tacit learning explicit for analysis and improvement. These are the same factors involved in organizational learning and reflective practice (see Argyris 1977, 1990, 1991, 1992, Argyris and Schon 1974, 1978, 1996; Schon 1983, 1987; Senge 1990; Senge et al. 1994, 1999).

Petroski is engaged in research on the elements of successful design practice. So are Argyris, Schon, and Senge. Reflective practice is a technique that builds successful practice. It is not a form of research into practice. To the contrary, Argyris and others have developed a range of research techniques linked to reflective practice. This is described in Argyris, Putnam, and Smith’s (1985) book on action science, a presentation of concepts, methods, and skills for research and intervention. Argyris and Schon (1990) later contrasted normal science with action science. More recently, Argyris (1993) wrote on ways to apply the findings of action science to practicing professional life, closing the circle in a continuous loop between theory and practice.

What is significant about this, however, is that neither practice nor reflective practice is itself seen a research method. Instead, reflective practice is one of an array of conceptual tools used in understanding any practice – including the practice of research.
In short, research is the “methodical search for knowledge. Original research tackles new problems or checks previous findings. Rigorous research is the mark of science, technology, and the ‘living’ branches of the humanities” (Bunge 1999: 251). Exploration, investigation, and inquiry are synonyms for research.

Design knowledge grows in part from practice. Design knowledge and research overlap, but even though the practice of design is a foundation of design knowledge, it is the action of systematic and methodical inquiry that constitutes research.

Critical thinking and systemic inquiry form the foundation of theory. Research offers us the tools that allow critical thinking and systemic inquiry to bring answers out of the field of action. It is theory and the models that theory provides through which we link what we know to what we do.

Defining Theory

In its most basic form, a theory is a model. It is an illustration describing how something works by showing its elements in their dynamic relationship to one another. It is the dynamic demonstration of working elements in action as part of a structure that distinguishes a model from a simple taxonomy or catalogue.

The word theory entered the English language in 1597 via Latin from the original Greek. Merriam-Webster (1990: 1223) defines theory as:

“1 : the analysis of a set of facts in their relation to one another 2 : abstract thought : speculation 3 : the general or abstract principles of a body of fact, a science or an art <music ~> 4 a : a belief, policy, or procedure proposed or followed as the basis of action <her method is based on the ~ that all children want to learn> b : an ideal or hypothetical set of facts, principles or circumstances – often used in the phrase in theory <in ~, we have always advocated freedom for all> 5 : a plausible or scientifically accepted general principle or body of principles offered to explain phenomena <wave ~ of light> 6 a : a hypothesis assumed for the sake of argument or investigation b : an unproved assumption : conjecture c : a body of theorems presenting a concise systematic view of a subject <- of equations>.”

The first theorists were the Greek philosophers. They developed a vocabulary of theoretical distinctions in their effort to explain the world around them. They considered the distinctions between epistem, the knowledge that can be explained or demonstrated to the satisfaction of others, either through experimentation or presentation, episteme haplos, unconditional knowledge of principles which always hold true and hos epi to polu, knowledge which holds true for the most part. They considered different kinds of practical knowledge and skill: praxis, doing, performing, accomplishing through practical knowledge or know-how; poiesis, knowledge needed to put things together, for instance a poem; phronesis, practical knowledge needed to address political or ethical issues; téchne, now translated as what we would call skill. To the Greeks, theoria, meditation, speculation, contemplation, involved seeking to know the highest and eternal principles. Aristotle believed this to be life’s highest function.
In Plato’s *Phaedo*, Socrates says that, “the superlative thing to know is the explanation of everything, why it comes to be, why it perishes, why it is.” Explanation makes empirical demands. Aristotle understood this, and he was a practitioner of empirical observation. Although limited by human imperfection and available technology, Aristotle was concerned with apprehending the mortal, physical world in an attempt to explain. Aristotle, as much an empirical biologist as a speculative philosopher (Morowitz 1993: 160-163), has been ill served by the work of scholastic philosophers who concentrated on his other work to the neglect of his research and writing on the life sciences. By the Middle Ages, Aristotle was the hostage of empty scholasticism. Ignorance of the central role that biology and philosophy of science held in Aristotle’s Academy continues to this day.

Nevertheless, something was missing, even in the Academy. Of the “three great conceptual approaches to science – observation, experimentation, and theory – experimentation was unknown to the classical Greek savants. They worked back and forth between observation and theory and therefore lacked the powerful weapon of falsification to prune wrong theories” (Morowitz 1993: 161-2). Plato’s science stood on one leg, Aristotle’s on two. In the great age of physics, Galileo, Newton, and Bacon developed the concept of robust experiment. This made scientific progress possible by stabilizing scientific method with its third leg. Experiment allows us to choose among alternative theories, moving in increasingly better directions.

The distinction between a science and a craft is systematic thought organized in theory. Craft involves doing. Some craft involves experimentation. Theory allows us to frame and organize our observations. Theory permits us to question what we see and do. It helps us to develop generalizable answers that can be put to use by other human beings in other times and places.

This, in effect, is the central issue in design. To “[devise] courses of action aimed at changing existing situations into preferred ones” on a predictable basis means understanding “things: how they are and how they work,” which is Simon’s (1982: 129) explanation of science. One form of design practice is allied to art and craft. It is intuitive. It sometimes produces desired results. On occasion, this practice of design produces desirable results that may have been unpredictable, but results that can nevertheless be seized retrospectively as the useable result of muddling through.

The other face of design practice involves predictability. It is created by the effective response to problems, and it has similarities to science, engineering, and technology. The basis of design science is the idea of applicable theories of how to devise courses of action aimed at changing existing situations into preferred ones. This science is geared to industrial production, including production in the digital industries of the knowledge economy.
Industry now meets the vast majority of the world’s physical needs, and industrial productivity is a necessity in a world of billions of people. Industrial production, and therefore design, touches nearly everything we do, use or consume. It begins with the morning newspaper that we read while we eat breakfast to the food itself. It moves on as we drive a car, take a bus or train, and it involves the computers most of us now plug in at work – if we are not commuting to work from a computer in our home office. Some of the day’s events will take place on the phone, and therefore, we will be reaching out via switchboards, long-distance networks or even satellite. From the start of the day until the end, designed artifacts, industrial artifacts, information artifacts, technical artifacts, and graphic artifacts in hundreds of combinations and forms will surround us. We will interact with them, and they will shape our waking experience. The designers who plan and create these artifacts are not simple artisans. They are involved in the industrial process whether or not they think of themselves in industrial terms.

Design is of necessity in transition from art and craft practice to a form of technical and social science focused on how to do things to accomplish goals. To meet the challenges of the design process requires understanding the actions that lead from existing situations to preferred ones. This means understanding the principles of predicting and measuring outcomes based on what W. Edwards Deming (1993: 94-118) terms profound knowledge. This knowledge is comprised of “four parts, all related to each other: appreciation for a system; knowledge about variation; theory of knowledge; psychology” (Deming 1993: 96). According to Deming (1986: 19), “Experience will answer a question, and a question comes from theory.”

Theory can be described in many ways. Some theories are complex and sophisticated. Others are simple. Mautner (1996: 426) defines theory as “a set of propositions which provides principles of analysis or explanation of a subject matter. Even a single proposition can be called a theory.” This often depends on the nature of the subject.
McNeil (1993: 8) proposes eleven characteristics of any general theory. 1) A theory has a constitutive core of concepts mutually interrelated with one another. 2) A theory has a mutually productive, generative connection between central concepts and the peripheral concepts where theory verges onto practice. 3) The core concepts of a theory are stated in algorithmic compression, parsimonious statements from which the phenomena in the theory can be reproduced. 4) A theory has an irreducible core of concepts, a set of concepts in which no central concept can be removed without altering the scope and productivity of the theory or perhaps destroying it entirely. 5) Two or more of the core concepts in a theory must be complementary to each other. 6) The central concepts of a theory must be well defined and must harmonize as much as possible with similar concepts of enlightened discourse. 7) The central concepts of a theory must be expressed at a uniform level of discourse. Different levels of discourse must be distinguished and used consistently. 8) More general theories (higher-level theories) must relate to less general theories (lower-level theories) and to special cases through a principle of correspondence. This principle confirms and guarantees the consistency of the more particular theories and their applications. 9) Explicitly or implicitly, a theory describes dynamic flows with contours that trace relatively closed loops as well as relatively open links. 10) A theory states invariant entities in its assumptions or formulas that provide standards for measurement. 11) Theories describe phenomena in the context of a conceptual space. This implicitly establishes a relationship between the observer and the phenomena observed.

The ability to theorize design enables the designer to move from an endless succession of unique cases to broad explanatory principles that can help to solve many kinds of problems. Warfield (in Francois 1997:100) describes the generic aspect of design as “that part of the process of design that is indifferent to what is being designed, being applicable whatever the target may be.” He contrasts this with the specific aspect of design, “that part of the design process that is particular to the target class.” Warfield (1990, 1994) identifies thirty-two basic postulates of the generic design process, which he groups under six categories: the human being, language, reasoning through relationships, archival representation, the design situation, and the design process. This generic design process is inevitably theory-rich. But it is not entirely abstract, any more than science is abstract. Quite the contrary, theory relies on an engagement with empirical reality.

Brockhampton (1994: 507) defines theory as “a set of ideas, concepts, principles or methods used to explain a wide set of observed facts.” A designer who fails to observe facts cannot theorize them. Design requires humility in the face of empirical facts. Design based on the idea of individual genius or artistic imagination involves the externalization of internalized images. This involves a priori ideas and images. The designer comes first in this model of the design process. In contrast, solving problems demands robust engagement with the problem itself. The problem comes first.
The problem sets the premise by establishing the boundary conditions of a solution. At the same time, the problem opens a forum for the imagination and expertise of the designer. Social science depends on what Mills (1967) described as “the sociological imagination.” Mathematical invention involves a journey of psychological discovery through what Hadamard (1996) termed “the mathematician’s mind.” Across the many fields of the natural and social sciences, progress comes when individuals and groups apply their genius to the understanding of how the world works and why. Understanding why things come to be, why they perish, and why they are as they are involves discipline and imagination both. Thus, Weick (1989) describes theory building as “an act of disciplined imagination.”

**How Theory Works**

Sutherland (1975: 9) describes theory as “an ordered set of assertions about a generic behavior or structure assumed to hold throughout a significantly broad range of specific instances.” To understand the nature of a behavior and organize an ordered set of assertions that describe it in a valid and verifiable way requires the characteristics described by McNeil (1993: 8).

Weick (1989) addresses the question of shaping a theory that fulfills these criteria – or similar criteria – while functioning at a sufficiently rich and non-trivial level to be useful. A body of writings equivalent to the rich literature of inquiry on theory construction in the natural and social sciences has yet to be developed in design studies. This is understandable in a discipline that is quite new compared with information science, physics or sociology, let alone philosophy, mathematics or geometry. This is also understandable in a field where the graduate programs, doctoral seminars, and research conferences that constitute the forums of theory development are just now beginning to blossom.

Having defined theory, we must therefore ask the question, “What constitutes a theoretical contribution?” David A. Whetten (1989) explored this question in an article of the same title. Whetten (1989) begins by identifying the four elements of any theory. These four elements answer six questions: 1) “what,” 2) “how,” 3) “why,” and 4) “who-where-when.” The “what” element articulates the factors that must be considered part of an explanation of the phenomena under study. Whetten identifies two criteria as central to judging the value of a “what.” These are comprehensiveness and parsimony. Are all the elements identified? Are there enough elements to account for all issues without a surplus? Whetten (1989: 490) describes “sensitivity to the competing virtues of parsimony and comprehensiveness” as the mark of a good theorist.
The “how” of a theory shows how the factors identified in the “what” are related. Whetten (1989: 491) describes this as a process of using metaphorical arrows to connect the boxes in a model. This delineates the patterns that show elements of a phenomenon in their dynamic relationship to one another (Friedman 1996). This description often reveals causality, and it builds a foundation for the explanatory power of the model represented by a theory (Friedman 1996).

The “why” element involves the underlying “dynamics that justify the selection of factors and the proposed causal relationships… (t)his rationale constitutes the theory’s assumptions – the theoretical glue that welds the model together… What and how describe. Only why explains” (Whetten 1989: 491).

Finally, the “who, where, and when” of a theory substantiate theory with empirical data while setting limits on its uses and applications.

According to Whetten, there are several ways to make significant contributions to theory. Discovering or amending new items in the “what” of an existing theory will generally make only a marginal improvement, but the ability to identify the ways in which the structural relationships of a theory change under the influence of new elements is often the beginning of new perspectives. New explanations – changes in the “why” of a theory – offer the most fruitful, and most difficult avenue of theory development. As an editor of a leading journal, Whetten (1989: 494-5) asks seven key questions of theoretical contributions. Of these, three apply to theory-construction in general: 1) what’s new? 2) so what? 3) why so? Two of the remaining four questions involve the internal qualities of the contribution as a paper, 4) well done? and 5) done well? The last two deal with context and the field within which the contribution is offered. 6) why now?, and 7) who cares?

Sheth, Gardner, and Garrett (1988: 29-33) have developed a matrix of metatheoretical criteria for evaluating theories. These consist of three categories with two criteria in each. The categories are syntax criteria, semantics criteria, and pragmatics criteria. Within syntax, they place the criteria of structure and specification; within semantics, testability, and empirical support; within pragmatics, richness, and simplicity.

Syntax criteria involve the organization and composition of a theory. Structure involves the systematic modeling of relationships. Specification involves specifying the relationships among theoretical concepts in a way that allow the theorist to delimit hypotheses. Semantics criteria involve reality and evaluate the relationship of a theory to reality. Testability means that the theory permits operational definition to permit testing and the development of intersubjective agreement. Empirical support refers to the degree to which empirical evidence supports the theory. Pragmatics criteria involve relevance. The criterion of richness involves the degree to which a theory is comprehensive and generalizable. The simplicity criterion is akin to the standard of parsimony, and it involves the degree to which a theory can be explained readily while accounting in a powerful manner for the observed phenomena.

Theories in any field develop in a pattern of increasingly sophisticated types.
Parsons and Shils (1951: 49-51) describe several levels of theoretical systems. They state that “in one sense, every carefully defined and logically integrated conceptual scheme constitutes a ‘system,’ and in the sense, scientific theory of any kind consists of systems” (49). They go beyond this, to ask three questions about theoretical systems. The first question involves generality and complexity. The second involves what they call “closure,” the degree to which a system is self-consistent, and the degree to which the assertions of any one part of the theory are supported or contradicted by the other parts. The third question involves what they label “the level of systematization.” This involves the degree to which theory moves toward general scientific goals.

Parsons and Shils (1951: 50) propose four different levels of systematization for theories, moving from the most primitive to the most advanced. These are 1) ad hoc classification systems, 2) systems of categories, 3) theoretical systems, and 4) empirical-theoretical systems.

This implies a schema of increasingly useful kinds of theories based on the relations among the parts of a theoretical system. In Parsons’s and Shils’s schema, theoretical development implies a “hierarchy from ad hoc classification systems (in which categories are used to summarize empirical observations), to taxonomies (in which the relationships between the categories can be described), to conceptual frameworks (in which propositions summarize explanations and predictions), to theoretical systems (in which laws are contained within axiomatic or formal theories)” (Webster and Watson (2002: xiii).

While it is useful to distinguish between taxonomy and theory, it is fair to say that at some points, taxonomy is a kind of theory because it offers a model of existing data and demonstrates the relationships between and among facts.

The importance of taxonomy is often underestimated. An interesting case in point is the discovery of a new genus of centipede, Nannarup hoffmani (Bjerklie 2002: 39). The decline in taxonomic skills since the grand era of taxonomy in the nineteenth century means that it took four years between the time that Richard Hoffman decided that he had found a new kind of centipede and the final identification, classification, and naming. Hoffman attributes this to the current preoccupation with molecular biology, but he points out the problem inherent in the dearth of skilled taxonomists: “We’re coasting on the glamour of biodiversity, but losing the ability to identify the creatures on this planet” (Quoted in Bjerklie 2002: 39). This, in turn, renders theory development more difficult in several major fields, including economy, biology, and environmental studies.

Theories that describe structures offer models without moving parts. In this sense, theories are models that resemble maps or model houses. Theories that describe processes, activities, or systems generally require dynamic descriptions. In this sense, theories are models that resemble model engines or model train sets, and they must move to demonstrate the properties of the systems they resemble.
Hal Varian (1997) addresses some of these issues in a playfully titled but scientifically astute article, “How to Build an Economic Model in Your Spare Time.”

“Most of my work in economics involves constructing theoretical models,” writes Varian (1997: 1). The article discusses the challenges of theory construction and some of the approaches that Varian himself found helpful. “Over the years, I have developed some ways of doing this that may be worth describing to those who aspire to practice this art. In reality, the process is much more haphazard than my description would suggest – the model of research that I describe is an idealization of reality, much like the economic models that I create. But there is probably enough connection with reality to make the description useful – which I hope is also true for my economic models.”

Varian’s key involves representing aspects of reality in robust yet simple ways. Rather than starting with literature or seeking general features, he advocates seeking useful data on interesting issues:

“So let’s skip the literature part for now and try to get to the modeling. Lucky for you, all economics models look pretty much the same. There are some economic agents. They make choices in order to advance their objectives. The choices have to satisfy various constraints so there’s something that adjusts to make all these choices consistent. This basic structure suggests a plan of attack: Who are the people making the choices? What are the constraints they face? How do they interact? What adjusts if the choices aren’t mutually consistent?

“Asking questions like this can help you to identify the pieces of a model. Once you’ve got a pretty good idea of what the pieces look like, you can move on to the next stage. Most students think that the next stage is to prove a theorem or run a regression. No! The next stage is to work an example. Take the simplest example---one period, 2 goods, 2 people, linear utility---whatever it takes to get to something simple enough to see what is going on.

“Once you’ve got an example, work another one, then another one. See what is common to your examples. Is there something interesting happening here? When your examples have given you an inkling of what is going on, then you can try to write down a model. The critical advice here is KISS: keep it simple, stupid. Write down the simplest possible model you can think of, and see if it still exhibits some interesting behavior. If it does, then make it even simpler.

“Several years ago I gave a seminar about some of my research. I started out with a very simple example. One of the faculty in the audience interrupted me to say that he had worked on something like this several years ago, but his model was ‘much more complex.’ I replied ‘My model was complex when I started, too, but I just kept working on it till it got simple!’

“And that’s what you should do: keep at it till it gets simple. The whole point of a model is to give a simplified representation of reality. Einstein once said ‘Everything should be as simple as possible but no simpler.’ A model is supposed to reveal the essence of what is going on: your model should be reduced to just those pieces that are required to make it work.”

The point of modeling – and of theory construction – is showing how things work.
Theory Construction Problems in Design Research

Until recently, the field of design has hitherto been an adjunct to art and craft. With the transformation of design into an industrial discipline come responsibilities that the field of design studies has only recently begun to address.

Design is now becoming a generalizable discipline that may as readily be applied to processes, interfaces between media or information artifacts as to tools, clothing, furniture, or advertisements. To understand design as a discipline that can function within any of these frames means developing a general theory of design. This general theory should support application theories and operational programs. Moving from a general theory of design to the task of solving problems involves a significantly different mode of conceptualization and explicit knowledge management than adapting the tacit knowledge of individual design experience.

So far, most design theories involve clinical situations or micro-level grounded theories developed through induction. This is necessary, but it is not sufficient for the kinds of progress we need.

In the social sciences, grounded theory has developed into a robust and sophisticated system for generating theory across levels. These theories ultimately lead to larger ranges of understanding, and the literature of grounded theory is rich in discussions of theory construction and theoretical sensitivity (Glaser 1978, 1992; Glaser and Strauss 1967; Strauss 1991; Strauss and Corbin 1990, 1994)

One of the deep problems in design research is the failure to engage in grounded theory, developing theory out of practice. Instead, designers often confuse practice with research. Instead of developing theory from practice through articulation and inductive inquiry, some designers simply argue that practice is research and practice-based research is, in itself, a form of theory construction.

Many of the problems in design research arise from category confusions. In recent years, designers have become acquainted with the term “tacit knowledge” articulated by Michael Polanyi (1966) in The Tacit Dimension. Proposing tacit knowledge as the primary foundation of design research reflects a surface acquaintance with the term by people who have not read Polanyi’s work.
Tacit knowledge is an important knowledge category. All professional practice – including the practice of research – rests on a rich stock of tacit knowledge. This stock consists of behavioral patterns and embodied practice embedded in personal action. Some aspects of tacit knowledge also involve facts and information committed to long-term memory. This includes ideas and information on which we draw without necessarily realizing that we do so, and it includes ideas and information that we can easily render explicit with a moment’s thought. It also includes concepts, issues, ideas, and information that can only be rendered explicit with deep reflection and serious work.

In social life and professional work, tacit knowledge is also reflected in the larger body of distributed knowledge embedded in social memory and collective work practice. Our stock of tacit knowledge enables us to practice. Putting tacit knowledge to use in theory construction requires rendering tacit knowledge explicit through the process of knowledge conversion (Friedman 2001: 44; Kriger and Friedman 2002; Nonaka and Takeuchi 1995: 59-73).

Tacit knowledge is necessary for human action. Without tacit knowledge, embodied and habitual, nothing human beings do would be possible. Each action would require explicit conceptualization and planning each time. The limits on immediate attention and cognition means that it would be impossible to store and act on enough knowledge for effective individual practice in any art or science, let alone accumulate the knowledge on which a field depends (Friedman 2001: 42-44; Friedman and Olaisen 1999: 16-22). All fields of practice rest, in part, on tacit knowledge. (See, f.ex., Chaiklin and Lave 1993; Bourdieu 1977, 1990; Friedman 2001: 42-44).

To say that tacit knowledge is not research and that design theory is not identical with the tacit knowledge of design practice does not diminish the importance of tacit knowledge. It merely states that mistaken arguments about tacit knowledge as design knowledge demonstrate the confusion of the scholars who make such statements. The confusion rests on a simple failing, the failure to read Polanyi. The notion that tacit knowledge and design knowledge are identical as sources of theory development is linked with the idea that practice is a research method. Both rest on category confusions and both arguments are generally supported by references to Polanyi and Schon by scholars who have not read the works they cite.

If there is any confusion on Polanyi’s views, however, he settles the matter at the beginning of another book, Personal Knowledge. Where tacit knowledge is embodied and experiential knowledge, theory requires more. “It seems to me,” he writes, “that we have sound reason for . . . considering theoretical knowledge more objective than immediate experience. (a) A theory is something other than myself. It may be set out on paper as a system, of rules, and it is the more truly a theory the more completely it can be put down in such terms” (Polanyi 1974: 4).
Polanyi’s (1974: 3-9) discussion of the Copernican Revolution uses different language to state some of the significant themes that are seen in Varian (1997), Deming (1986, 1993), and McNeil (1993). These address such concepts as descriptive richness, theory as a guide to discovery, and modeling. As a guide to theory construction, this is also linked to Herbert Blumer’s idea of sensitizing concepts (Blumer 1969; see also Baugh 1990, van den Hoonard 1997). All of these possibilities require explicit knowledge, rendered articulate for shared communication and reflection.

One of the little noted points in many design research debates is the fact that reflective practice itself rests on explicit knowledge rather than on tacit knowledge. While Schon’s concept of reflective practice is not a method of theorizing, (1991: 5-11), but it does raise many questions on the kinds of thinking and reflection that contribute to effective practice in many fields. Central to most of these is the struggle of rendering tacit knowledge explicit in some way. While Schon (1994: 9) suggests that there may be more possibilities for reflection than words alone, he clearly distinguishes between the epistemology of theoretical research and reflective inquiry.

Much of this confusion is linked to an ambiguous definition of design research proposed by Frayling in a 1993 paper. Frayling (1993) suggested that there are three models of design research, research into design, research by design, and research for design. Frayling is unclear about what “research by design” actually means and he seems never to have defined the term in an operational way. In a 1997 discussion (UK Council 1997: 21), he notes that it is “distantly derived from Herbert Read’s famous teaching through art and teaching to art.” This leads to serious conceptual problems.

Read’s (1944, 1974) distinctions deal with education and with pedagogy, not with research. The failure to distinguish between pedagogy and research is a significant weak area in the argument for the concept of research by design. In addition to the difficulties this has caused in debates on the notion of the practice-based Ph.D., it also creates confusion for those who have come to believe that practice is research. The confusion rests, again, on a failure to read.

Frayling’s proposal seems to have been an effort to establish possible new research categories. As an inquiry or probe, this is a worthy effort. The problem arises among those who mistake an intellectual probe with a statement of fact. To suggest that such a category is possible does not mean that it exists in reality. Dragons may exist, but we have no evidence that they do. Medieval mapmakers created great confusion and limited the growth of knowledge for many years by filling in the empty edges of their maps with such phrases as “here there be dragons” rather than admitting, “we know nothing about what lies beyond this point.”
Beyond this arises the problem of what “research by design” might mean. If such a category did exist – and it may not – the fact of an existing category would tell us nothing of its contents. Unlike dragons, we know that the planet Jupiter exists. Like the edges of the map, however, we know relatively little about conditions on the surface of the planet. Even though the laws of nature mean that some facts must be known – gravity and pressure, for example – these facts tell us little about the myriad realities that may play out depending on specific factors.

As a probe, Frayling’s discussion was intended to open possibilities. Those who mistake it for a report mistake its potential value.

In one sense, however, Frayling misread Read. In adapting the surface structure of Read’s terms, he failed to realize a distinction that is implicit in Read’s project. This is the fact that education can be developed though the direct practice of an art. This is the case in socialization and modeling, in guild training, and it is the basis of apprenticeship (Friedman 1997: 55, 61-65; Byrne, and Sands 2002). In many situations, education and learning proceed by practicing an art or craft. One can also learn the art and craft of research by practicing research. Nevertheless, one does not undertake research simply by practicing the art or craft to which the research field is linked.

So far, the category of research by design has proven fruitless. Around the time that Frayling published his 1993 paper, Nigel Cross wrote the first of two editorials in Design Studies on the theme of research by design.

In his first editorial, Cross (1993: 226-7) points out the distinctions between practice and research and the value of connecting research to teaching and to practice.

In his second editorial, Cross notes how little progress had been made in research by design over the two years between 1993 and 1995. He writes that part of the problem involves the claim that “works of design are also works of research” (Cross 1995: 2).

Cross (1995: 3) states that the best examples of design research are: purposive, inquisitive, informed, methodical, and communicable. This requires articulation and shared knowledge within and across the field. This, again, requires articulate communication of explicit knowledge. In 1999, Cross addressed this issue again in a debate on research methods in design.

Looking back over the failed efforts of the past decade to produce valid examples of research by design, Cross (1999: unpaged) wrote, “. . . as I said in my Editorial in 1995, I still haven’t seen much strong evidence of the output from the ‘research for and through design’ quarters. Less of the special pleading and more of the valid, demonstrable research output might help.”
While the phrase “research by design” has been widely used by many people, it has not been defined. I suspect, in fact, that those who use the phrase have not bothered to read either Frayling’s (1993) paper or Read’s (1944, 1974) book. Instead, they adopt a misunderstood term for its sound bite quality, linking it to an ill-defined series of notions that equate tacit knowledge with design knowledge, proposing tacit knowledge and design practice as a new form of theorizing.

While these problems are relatively inconsequential outside our field, it is important to understand that they exist if we are to develop a foundation for theory construction in design research. This is why I have given them so much thought.

Again, I want to be clear on the many values of tacit knowledge. Tacit knowledge is central to all human activity, and the background of embodied individual and social knowledge provides offers the existential foundation of all activities, including intellectual inquiry. The only issue I raise here is that tacit knowledge and reflective practice are not the basis of research and theorizing. This is not to say, however, that there are no relations between those different categories of construct.

While ancient science was hypothetical and deductive, it offered no way to select among theories. While the river civilizations of Mesopotamia, Sumeria, Egypt, and China made great advances in practical knowledge, administrative routine, and professional practice in many fields, they had nothing in the way of scientific theory. Explanations were traditional and practical or mythic (Lloyd 1970: 1-23; Cromer 1993: throughout).

Thales proposed the first scientific theory when he suggested that the earth was once an ocean. While he could not test his theory, what made it scientific as contrasted with mythic was the fact that Thales proposed a natural explanation rather than a story of divine action.

Greek mathematics offered another foundation for science, and the Pythagoreans and Euclid built theories that are still used today. Again, however, there were no tests. Mathematical and geometrical theories are entirely axiomatic, and they can be tested by deduction and logic. While empirical inquiry found a few early champions in such medieval scholars as Robert Grosseteste and Roger Bacon, it was not until Francis Bacon (1999, 2000) published The New Organon in 1620 that a philosophy of science was articulated requiring a foundation in empirical observation.

At the same time, observation linked with inventive theorizing accounted for the great advances of Copernicus, Galileo, Newtown and many more. The tradition of empirical inquiry lies beneath two great activities in design: design science and reflective practice. These meet in research traditions of many kinds, including those traditions anchored in social science and critical inquiry.
Because this paper does not describe a philosophy of science, I will not explain how or why this is so, and I will not develop an argument for any specific research tradition or the kinds of theory construction on which a tradition must be established. I merely point to the fact that explicit and articulate statements are the basis of all theoretical activities, all theorizing, and all theory construction.

This true of interpretive and hermeneutical traditions, psychological, historical, and sociological traditions, and it is as true of these as of quantitative research in chemistry, descriptive biology or research engineering, logistics, and axiomatic mathematics. The languages are different. However, only explicit articulation permits us to contrast theories and to share them. Only explicit articulation allows us to test, consider or reflect on the theories we develop. For this reason, the misguided effort to link the reflective practice of design to design knowledge, and the misguided effort to propose tacit knowledge or direct making as a method of theory construction must inevitably be dead ends.

All knowledge, all science, all practice relies on a rich cycle of knowledge management that moves from tacit knowledge to explicit and back again. So far, design with its craft tradition has relied far more on tacit knowledge. It is now time to consider the explicit ways in which design theory can be built – and to recognize that without a body of theory-based knowledge, the design profession will not be prepared to meet the challenges that face designers in today’s complex world.

Future Directions

The goal of this paper has been to examine criteria, approaches, and methods for theory construction in design research. To do this, I began with a foundation of definitions, using these to build a range of applicable concepts.

There is not enough room in one paper to go beyond the general consideration of methods to a specific description of how to develop theory and build specific theories. This remains to be done in a future paper.

Many avenues deserve exploration in the future. These include linking theory building to the perspectives of design science, proposing models of theory construction from other perspectives, generating theory from the practice of leading contemporary designers, and developing such basic tools as a bibliography of resources for theory construction and developing theoretical imagination and sensitivity.

Theory-rich design can be playful as well as disciplined. Theory-based design can be as playful and artistic as craft-based design, but only theory-based design is suited to the large-scale social and economic needs of the industrial age.
This systemic, theory-driven approach offers a level of robust understanding that becomes one foundation of effective practice. To reach from knowing to doing requires practice. To reach from doing to knowing requires the articulation and critical inquiry that leads a practitioner to reflective insight. W. Edwards Deming’s experience in the applied industrial setting and the direct clinical setting confirms the value of theory to practice.

“Experience alone, without theory, teaches . . . nothing about what to do to improve quality and competitive position, nor how to do it” writes Deming (1986: 19) in his critique of contemporary manufacturing. “If experience alone would be a teacher, then one may well ask why are we in this predicament? Experience will answer a question, and a question comes from theory.”

It is not experience, but our interpretation and understanding of experience that leads to knowledge. Knowledge emerges from critical inquiry. Systematic or scientific knowledge arises from the theories that allow us to question and learn from the world around us. One of the attributes that distinguish the practice of a profession from the practice of an art is systematic knowledge.

As artists, we serve ourselves or we serve an internalized vision. This internalized vision is essentially a facet of the self. In the professions, we serve others. In exploring the dimensions of design as service, Nelson and Stolterman (2000) distinguish it from art and science both. My view is that art and science each contributes to design. The paradigm of service unites them.

To serve successfully demands an ability to cause change toward desired goals. This, in turn, involves the ability to discern desirable goals and to create predictable – or reasonable – changes to reach them. Theory is a tool that allows us to conceptualize and realize this aspect of design. Research is the collection of methods that enable us to use the tool.

Some designers assert that theory-based design, with its emphasis on profound knowledge and intellectual achievement, robs design of its artistic depth. I disagree. I believe that a study of design based on profound knowledge embraces the empirical world of people and problems in a deeper way than purely self-generated artistry can do.
The physicist Richard Feynman once argued for the imaginative power and beauty of science. He did not argue against the other arts. Rather, he stated that understanding how things work and why adds another dimension to beauty.

"Poets say science takes away from the beauty of the stars – mere globs of gas atoms. I, too, can see the stars on a desert night and feel them. But do I see less or more? The vastness of the heavens stretches my imagination – stuck on this little carousel, my little eye can catch one-million-year-old light. A vast pattern – of which I am part... What is the pattern, or the meaning, or the why? It does not do harm to the mystery to know a little about it. For far more marvelous is the truth than any artists of the past imagined it. Why do poets of the present not speak of it? What men are poets who can speak of Jupiter if he were a man, but if he is an immense spinning sphere of methane must be silent?" (quoted in Gleick 1993: 373)

Understanding how things work and why expands the powers of the human mind and soul.

However, I also argue for a theory-rich practice of design for an intensely practical reason. The world’s population recently exceeded six billion people for the first time. Many people in today’s world live under such constrained conditions that their needs for food, clothing, shelter, and material comfort are entirely unmet. For the rest, most needs can only be met by industrial production. Only when we are able to develop a comprehensive, sustainable industrial practice at cost-effective scale and scope will we be able to meet their needs. Beyond art, beyond poetry, beyond science, this is the purpose of design. Design will never achieve this purpose until it rests on all three legs of science. To do this, design practice – and design research – requires theory.
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About the Author

Ken Friedman works at the intersection of three fields: design, management, and art. As professor and dean of design at Swinburne University in Melbourne, Australia, he works with theory construction and comparative research methodology for design while leading the work of the Faculty of Design. He also holds a research appointment at Denmark’s Design School in Copenhagen, and he is Professor of Leadership and Strategic Design at the Norwegian School of Management, focusing on knowledge economy issues, culture, and leadership.

Ken Friedman has done research in the philosophy of science, the philosophy of design, and doctoral education in design. He also works with national design policy projects in Estonia, Latvia, Lithuania, and Wales. He plays an active role in developing international research networks and conferences for the design research community as editor of the journal *Artifact*, as book reviews editor of *Design Research News*, and Communications Secretary of the Design Research Society. He co-chaired the La Clusaz Conference on Doctoral Education in Design in 2000, the 2006 conference of the European Academy of Management in Oslo, and the 2006 conference of the Design Research Society in Lisbon.

In 2007, Loughborough University honored Friedman with the degree of Doctor of Science, honoris causa, for outstanding contributions to design research. The award citation by Public Orator Tony Hodgson appears at:

http://www.lboro.ac.uk/service/publicity/degree_days/2007/Summer/Friedman.html

Ken Friedman is also a practicing artist and designer active in the international laboratory known as Fluxus. He had his first solo exhibition in New York in 1966. His work is represented in major museums and galleries around the world, including the Museum of Modern Art and the Guggenheim Museum in New York, the Tate Modern in London, the Hood Museum of Art at Dartmouth College, and Stadtgalerie Stuttgart. The University of Iowa Alternative Traditions in the Contemporary Arts is the official repository of Friedman’s papers and research notes. Archiv Sohm at Stadtgalerie Stuttgart and the Mandeville Department of Special Collections at the University of California also hold extensive collections on Friedman’s work in the 1960s and 1970s.
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