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ABSTRACT

This paper discusses the nature of natural and social sciences in order to point out the need for adapting standard logic more appropriately to a design approach. The IDEALS CONCEPT, an acronym for Ideal Design for Effective and Logical Systems, is presented as a move toward a calculus of design methodology with an emphasis on problem orientation rather than method orientation. (JM)

THE NEED FOR A DESIGN METHODOLOGY: TOWARD AN EXPANDED CONCEPTION OF SCIENTIFIC METHODOLOGY, PROBLEM ORIENTATION, AND A CALCULUS OF DESIGN METHODOLOGY

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The development of more effective programs to train individuals to solve problems, conduct research, and structure designs is of serious concern to us in this era when "systemic change," "improvements," "alternatives" and special interest group concerns have become highly visible social and political criteria.

Our perceptions of and the characteristics of problems that we are currently faced with have become more dynamic in nature, often calling forth applications of psychological, sociological, economic, national resource and political spheres of knowledge and influence, systemically organized within a scientific process oriented toward problem solution.

Researchers have become increasingly aware that the manner in which they go about solving our problems determines the quality and quantity of the results they achieve.

Traditionally, it may be that academicians have tended to lose sight of this because of their need and desire for scientific legitimacy. Inappropriate distinctions between the natural and social sciences, coupled with an either-or attitude and often a veneer of rigor based upon mathematical metaphors and analogies, have led to "toughminded" versus "tenderminded" conclusions of methodology, status, and legitimacy. This has tended to dictate narrow limits of methodology (and problem selection) rather than allowing the nature of the problem to point the direction toward appropriate methodology, and utilizing in this latter process the conceptual tools which would assist them in delineating the domain of the problem and determining constructions for its solution.

In a critique of the scientific method, Herbert Feigl called forth the more important distinction between pure mathematics as an independent formal-conceptual discipline, and the factual or empirical sciences, including in the latter both the natural and socio-cultural sciences. According to Feigl, the certainty and exactness of pure mathematics are dependent upon its detachment from empirical fact. "Mathematics as applied in the empirical sciences," he says, "merely lends its forms and deductive structures to the content. furnished by experience. But no matter how predominant mathematics may be in the formulations and derivations of empirical facts, factual knowledge cannot attain either the absolute precision or necessity of pure mathematics." The knowledge claimed in both the natural and social sciences is a matter "of successive approximations and of increasing degrees of confirmation." Hence probability is all we can establish in the sciences (natural and social) that deal with the facts of experience, and truth claims are to be held only "until further notice."

In addition to Feigl's distinction, Rudolph Carnap more specifically calls attention to a syntactical-logical delineation between the formal and factual or empirical sciences. The formal sciences, pure mathematics and logic, contain only analytic statements, whereas the empirical sciences, naturalism, and socio-cultural sciences contain both analytic and synthetic statements. He states that "the fa ual or empirical sciences establish synthetic statements, that is, singular statements for the description of observable facts, or general statements which are introduced as hypotheses and used tentatively. From the statements thus established the scientist tries to derive other synthetic statements in order, for instance, to make predictions of the future."

The analytic statements serve an ancillary function for these inferential operations. All of logic including mathematics considered from the point of view of our linguistic system is thus no more than an ancillary calculus for dealing with synthetic statements. Formal science has no independent significance but is an auxillary component utilized for technical reasons in order to help us make linguistic transformations in the empirical sciences. This is not to deny the great importance of mathematics and logic but to identify and emphasize their special function, and to amplify the synthetic and artificial quality of our scientific methodology, which we often negate by attributing to it a magical independent significance in the name of scientific legitimacy.

Both the natural and social sciences become mediated by and subject to the syntactical and semantical precision of our linguistic system.

Recognizing the creative, imaginative, and synthetic nature of the language and tools of science, can we not expand our considerations and hopefully find more productive ways to both scientifically assimilate and accommodate to experience and its problems?

Although standard logic is well suited for scientific assimilation and description of experience, that is, for assertions about phenomena and inferences from those assertions, how well does it help us to accommodate to the variety of problems experience presents such as answering the practical question of how things ought to be, structuring solutions to attain goals, identifying search processes for generating information about problem structure that would make its solution transparent, delineating alternatives, or deciding questions of precedence or sequence in the design process?

In the words of Herbert Simon, "In ordinary logic from dogs are pets and cats are pets, one can infer dogs and cats are pets. But from dogs are pets, cats are pets, and you should keep pets, can one infer you should keep cats and dogs?"

In the Karl Taylor Compton Lecture series at M.I.T., Herbert Simon stated that it has been the role of the science disciplines to teach about natural phenomena and the role of the engineering schools to teach about artificial things: how to make artifacts that have desired properties and how to design. "Engineers," he says, "are not the only professional designers. Everyone designs who devises courses of action aimed at changing existing situations into preferred ones. The intellectual activity that produces material artifacts is no different fundamentally from the one that prescribes remedies for a sick patient or devises a social welfare policy for a state. Design so construed is the core of all professional training." A hypothesis we might emphasize is that it is isomorphic across disciplines.

In spite of the importance of "designing," Simon contends that the natural sciences have almost driven the "sciences of the artificial" or design from professional school curricula. "Engineering schools have become schools of physics and mathematics; medical schools have become schools of biological science."

The use of words like "applied" hides but does not alter the situation. In the professional schools, such as engineering, medicine, and education, topics are selected from mathematics and the empirical sciences which are held to be relevant to professional practice. However, design is not presented as distinguished from analysis. Our colleagues in architecture would question this inherent assumption that function follows form. They would certainly prefer form to follow function.

Traditionally we have taught the same methodology to describe, explain, and predict the behavior of phenomena as to invent, plan, structure, implement, decide, or model using the knowledge, laws, and theories generated from the same methodology.

Are these not different functions or purposes suggesting new criteria and yielding a different methodological form? Yet the same general approach has been taught to meet these different purposes. This approach has focused on the steps or sequence of observation and/or literature search, hypothesis, experimentation or (more observation) and conclusion. This method of inquiry has analysis as its hallmark. The analytic approach is valuable and necessary in research, but its location and emphasis in the design process should be questioned.

The conceptual and practical distinctions between the design approach and the research or analytic approach are central to this symposium and should elicit serious thought, study, and debate. The purposes of research and of design are held to be essentially different. We need to expand our conception of "Scientific Methodology" to respect, accommodate, and subsume these differences.

Nadler in "An Investigation of Design Methodology" points out that analysis which is basic to traditional research implies already existing phenomena to be analyzed. The design approach seeks purposeful and functional action through new and different combinations of phenomena. The analytic approach focuses on elements rather than a configuration. Attention to elements is essential to research but in design, he says, "it may often lead to sub-optimization for the entire solution."

In addition, the analytic approach may often lead to an over-emphasis in techniques to separate the whole into its constituent parts and seeking ways to apply techniques rather than attending to an optimum design for a particular problem and then utilizing deduction and induction, analysis and synthesis, in relation to conclusion-making or decision-making needs.

Toward a Design Methodology

We need to find ways of adapting standard logic to the search for alternatives when alternatives are not evident. Design constructions and solutions are sequences of action that lead to "possible worlds" meeting specified limitations or constraints.

By definition, the IDEALS CONCEPT, the subject of this symposium, is a design strategy and structure, applicable to present and contemplated systems for the purpose of formulating the most effective system for achieving a set of desired functions.

The IDEALS CONCEPT, an acronym for Ideal Design for Effective and Logical Systems, is held to achieve its results through three major points of emphasis as reported by Nadler in Work Design: A Systems Concept, 1970. These points are:

1. A universally applicable definition of system
2. A strategy for designing and improving systems that produces much better results than conventional strategies
3. A program for utilizing the approach and elements of the system in a manner that emphasizes the system design involvement of all people at all levels in any type of organization of any size.

The focus of the approach is design and improvement.
A system is defined in the IDEALS CONCEPT as "the specified and organized conditions for the elements of function, inputs, outputs, sequence, environment, physical catalyst, and human agents detailed in physical, rate, control, interface, and state dimensions."

The aforementioned parameters and dimensions are represented as giving structure to a design matrix, and the strategies for representing boundaries and the solution space of a problem, project, subsystem or system will be discussed by Professor Nadler in the next paper presentation.

As we move toward a design methodology, we should remember that this is but one approach presented here today.

There exist a number of conceptual tools and approaches ranging in purpose, focus, and scope, which may be useful for the researcher and designer to know about. It is not the purpose of this symposium to present other approaches. However, as examples, the listener and reader are referred to the writings on facet design and facet analysis by

Guttman, Foa, and Runkel; convergence technique by Louis Carrese and Karl Baker; componential analysis by Goodenough, and response surface designs by G.E.P. Box.

In addition, as we move toward a Calculus of Design Methodology, the places of evaluation theory, utility theory, statistical decision theory, optimization methods, and imperative and declaritive logic must be resolved.

In closing, we are reminded of the admonition by John Platt in his writings on "Strong Inference." "Beware of the man of one method or one instrument, either experimental or theoretical. He tends to become method-oriented rather than problem-oriented. The method-oriented man is shackled; the problem-oriented man is at least reaching toward what is important. . . Problem orientation requires one to be willing to put aside his last method and teach himself new ones." To this we might add--the applicability of method may be necessary, but it is not a sufficient condition for solution. Solutions, like good designs, require invention!

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