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A COURSE IN GENERIC DESIGN

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November 1985

NOTE: This is the typed, original manuscript produced by the author shortly after coming to George Mason University. It is based on courses in generic design for engineering students which he taught at the University of Virginia in the early 1980's. The same material was taught in course offerings for non-engineering students at George Mason University, after 1984. The manuscript was first submitted to the ASEE Journal, but was withdrawn by the author following editorial delay. In 1986 the paper was given to Wojciech Gasparski, for publication in his Polish journal, with a planned publication date of 1987. Publication of the paper was delayed while it was being translated into Polish, but it was finally printed in 1990. The Polish-language version is in IASIS File No. 90/011.

Cit: This is the English language version of the paper titled "PROJEKTOWANIE OGOLNE DLA INZYNIEROW. KURSOWY WYKLAD UNIWERSTECKI" Projektowanie i Systemy (Design and Systems) Vol. XI (1990) 25-43.

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submitted to
Engineering Education

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ABSTRACT

A COURSE IN GENERIC DESIGN FOR ENGINEERS

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A course in generic design has been offered on three occasions. The course offers substantial economy of scale in teaching design, while providing numerous pedagogical benefits. It is based on a reconceptualization of design, developed from fundamentals. Theory of generic design leads to methodology for generic design, then into roles and applications. A specially designed laboratory, equipped to support the other components of the design process, enhances efficient, effective group work. Students emerge from such a course well prepared for learning to carry out specific design in a very wide variety of disciplines and professions.

Key words: Generic design, design theory, design methodology, design environment.

A COURSE IN GENERIC DESIGN FOR ENGINEERS

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A new approach to the development of individuals capable of doing design is described in this paper. The description of a course in generic design is based on eight years of research in reconceptualization of the meaning of design and how it ought to be learned. The research was coupled with offering a course in generic design three times at two different universities. This experience allowed the research ideas to be tested in real learning situations, which helped focus the ideas and develop them to the point where they can be shared with engineering faculty.

It is necessary to explain the reconceptualization of design in order to explain the organization and conduct of the course. To complement the overview given here of this reconceptualization and of the course itself, an annotated bibliography is offered for the reader who wishes to pursue the subject in greater depth. Two of the references^{1,2} discuss applications outside the university.

Goals of the Course

Table 1 shows the goals of the course.

TABLE 1

COURSE GOALS

1. To introduce to the student a new mind set that:
 - does not fear design
 - has respect for its difficulty
 - can distinguish synthesis from analysis
 - sees design as a major opportunity in many areas of life
 - has confidence (gained from practice in the course) in the generic design methodology
 2. To sensitize the student to the importance of a thorough analysis of the design situation, and to the hazards of narrow formulations
 3. To develop design competence through practice and reporting
 4. To show by example the benefits of group work in design teams integrated to meet the requirements identified as part of the generic design theory
 5. To connect both the generic design theory and the methodology to the existing corpus of knowledge (including contemporary cases), and to orient the theory and methodology within the framework provided by the existing corpus of knowledge
-

Course Organization and Pedagogy

The outline of the course organization is shown in Figure 1. The six components shown in Figure 1 are connected by conceptual links, as will be illustrated in this paper. A down link (FD) means that the fundamentals germane to a boxed component are found in the lower-lying component(s), while an up link (AU) means that applications for a given component are found in the higher-lying component(s). Fundamentals in the scholarly literature are related to cases drawn from media coverage which are connected to the scholarly literature through the course materials and lectures.

The course includes lectures that discuss the generic design theory and methodology, as well as the generic design roles and working environment. Numerous handouts (in lieu of a textbook) provide an orientation to design, design case studies, descriptions of methodologies, and designs achieved by students in a prior course. Practice in the design environment involves two team designs and prepared oral and written reports on these designs.

The lectures are offered three times a week for the first six weeks of the semester. The remainder of the semester involves design work and student presentations in the design environment, which occupies about 60% of the semester.

The generic design theory, which is one of the components in Figure 1, is further elaborated in Figure 2, where it is seen to consist of four postulates that imply three laws of design, which

FIGURE 1
ORGANIZATION OF A COURSE
IN GENERIC DESIGN

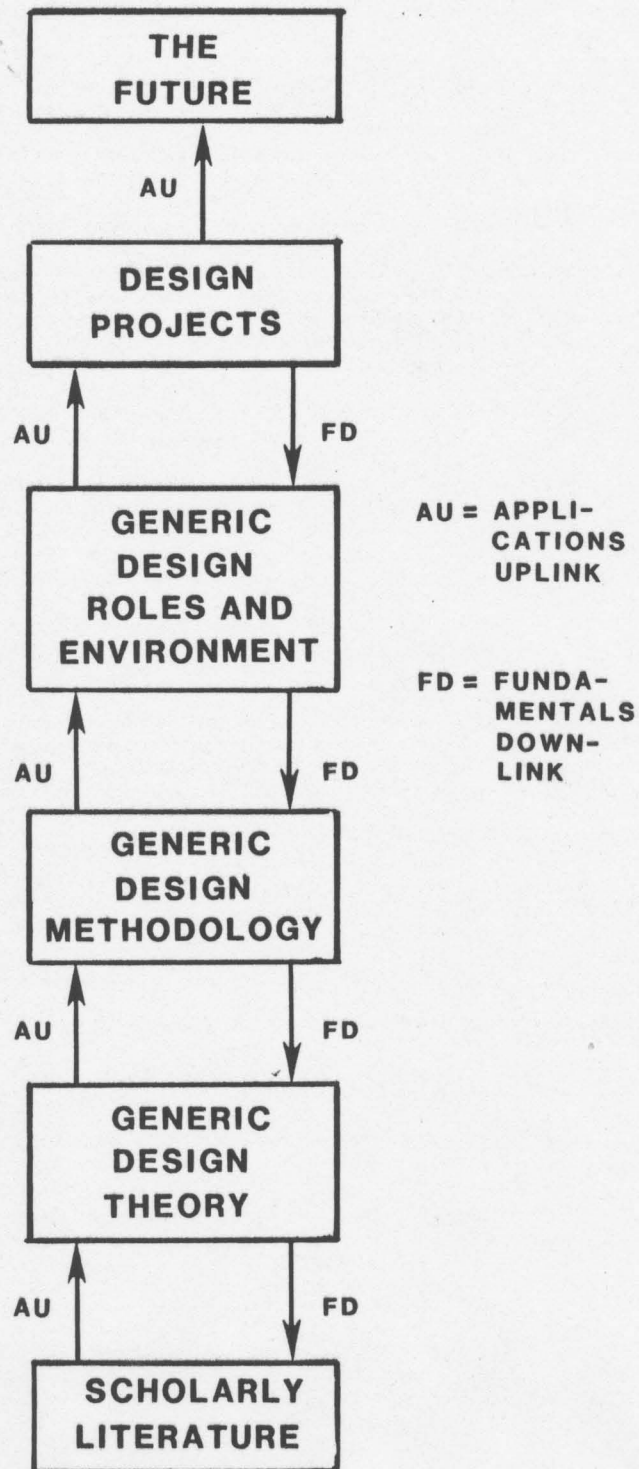
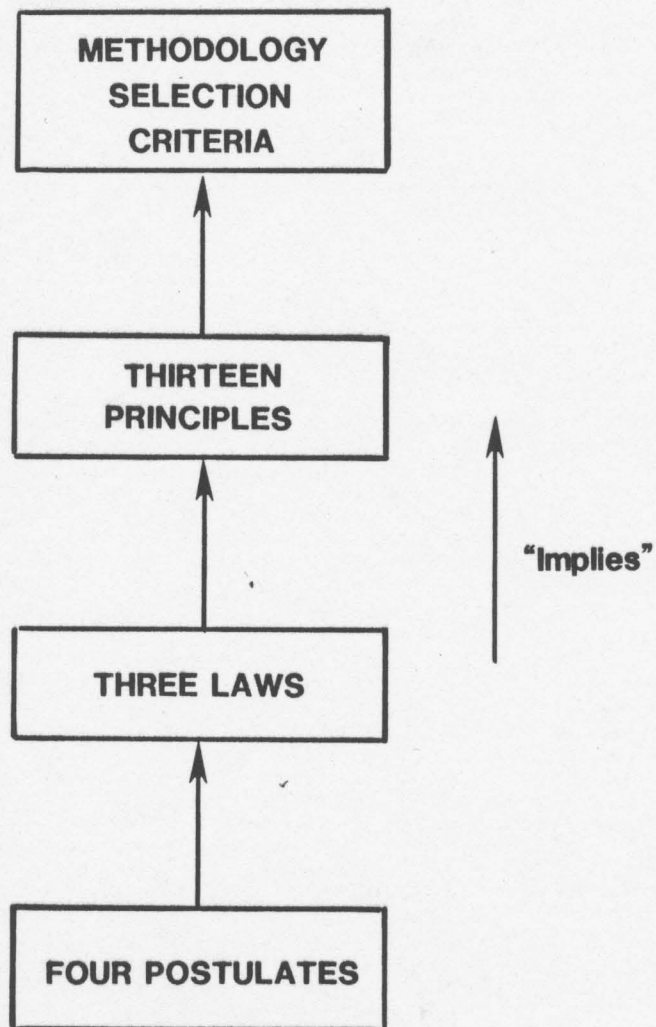


FIGURE 2
IMPLICATION STRUCTURE FOR
GENERIC DESIGN THEORY



imply thirteen design principles and criteria for selecting design methodology. Elaboration follows.

What is Generic Design?

Design is considered to be a process that has outcomes which consist of alternatives for resolving something that is unsatisfactory in the human environment or for adding value in some way. There are many different processes that are used to produce such outcomes. How can generic design be distinguished within this variety of possibilities?

Classification of generic design can be achieved with the help of Figure 3, which shows five categories that can be used in various combinations to sharpen a description of a design concept.

A design process may be partly distinguished by the design target (from A), the desired outcome of the process. It may also be partly distinguished by whether the process produces a conceptualization (from B), or whether it produces an implementation (e.g., a breadboard, prototype, first draft, pilot plant, etc.). It may be partly distinguished by whether it is carried out by a group (from C) or an individual. It may be distinguished by whether the necessary knowledge to produce the outcome is congruent with knowledge in one or more disciplines (from D) or at the other extreme is orthogonal to knowledge in the disciplines. Finally, there is the distinction (from E) as to whether the design process is generic or specific.

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The most cogent test as to whether a design process is generic or not is found through inspecting the applicability of the methodology. If, for example, the methodology can be used to do conceptual design of any of the design targets in A, the methodology is generic, and that makes the process generic.

But if the methodology is generic, this normally implies that it does not consist of target-specific information, thus the design information must be elicited from the designer. Frequently the situation requires a scope of knowledge that lies beyond the grasp of any individual designer; or alternatively the situation requires that those who will carry out any implementation of a conceptual design should take part in the design. As a result, it is characteristic of generic design that it is done by a group, although merely saying that a group does it does not ensure, by itself, that the process is generic.

If the knowledge required to carry out the design is not simply congruent with a discipline, or perhaps two or three disciplines, but rather tends to be orthogonal to the disciplines; or if it involves knowledge from several disciplines, but the knowledge must be integrated to produce a good outcome; the design process is required to be generic, and will focus upon information handling and structuring that is common to all conceptual design work. Of course it is possible to deal with cross-disciplinary knowledge without using generic design methodology, but it is certainly not commendable.

In summary, a design process can be described as generic if

- i) the methodology used in the process facilitates conceptual design without regard to the detailed nature of the design target

and, because of the conditions under which such design is needed, it will usually (but not always) be true that a design process will be generic if it incorporates the following:

- i) the design is carried out by a group
- iii) the design involves knowledge to be integrated from several disciplines, along with knowledge that is not usually thought of as being associated with disciplines

By contrast, a design process can be described as specific if

- i) the methodology used in the process is confined to designing a particular design target

and, because of the conditions under which such design is needed, it will often be true that the specific design process is characterized by:

- ii) a single designer performing the conceptual design
- iii) the use of knowledge congruent with one or perhaps two disciplines.

Generic and specific design are not competitive with each other. In practical design situations, generic design takes the work a certain distance, producing the essential structure and intellectual framework; whereas specific design sets the parameters and generates the prototype. Good system design

practice will involve multiple process styles. The assumption that either the generic design process or a specific design process will, by itself, produce outstanding outcomes will seldom be warranted. Rather a mature approach to design will recognize the power gained by proper integration of generic design with specific design.

A hypothesis that has not been tested, but to which it is hoped this paper might lend credibility, is that engineering education could benefit significantly by making it possible for students to learn generic design early in their education (in the fourth semester, for example). Later courses involving specific design could then draw heavily on the methodology and facilities used in learning generic design. Not only are there potential benefits in learning to do generic design, but also there is economy of scale in that specific design need involve only the supplements to what is learned in generic design.

What's New?

What is new in a course in generic design? The most important idea that the course reflects is that there is important academic and practical value in learning in one course those things that are important to the design of anything, before getting into the narrowness of applicability that characterizes much design in individual disciplines.

Other than this, two other features seem to be new. The first is the package of factors that are collectively applied as an integrated unit in the course. These factors are illustrated

in Figure 4. Each of the five key factors is shown at one vertex of the Greek letter "Sigma". The latter is chosen because it is often used in science and engineering to represent a summing or bringing together and, in the limit, becomes an integration. The five factors are: a design team, a computer with software and displays to help the team organize its thinking and stay constantly aware of design status, a set of carefully chosen methodologies called "consensus methodologies" (explained later), a skilled process facilitator who knows the methodologies as well as having group facilitation skills, and a room especially designed and equipped to support the other four factors. The room that constitutes the generic design environment has been named "Demosophia", which in Greek represents "wisdom of the group".

Figure 5 shows a photograph of the design environment. Readers who want more details can contact the author.

The third feature that is new in the course is the unified presentation of the generic design theory (including certain laws of design), the design methodology (using the "consensus methodologies"), the bases for their development, and their connections to fundamentals and applications, as illustrated in Figure 1.

Generic Design Theory

As illustrated in Figure 1, generic design theory takes its fundamentals from the scholarly literature. This literature mostly involves philosophy and the psychology of groups, elements

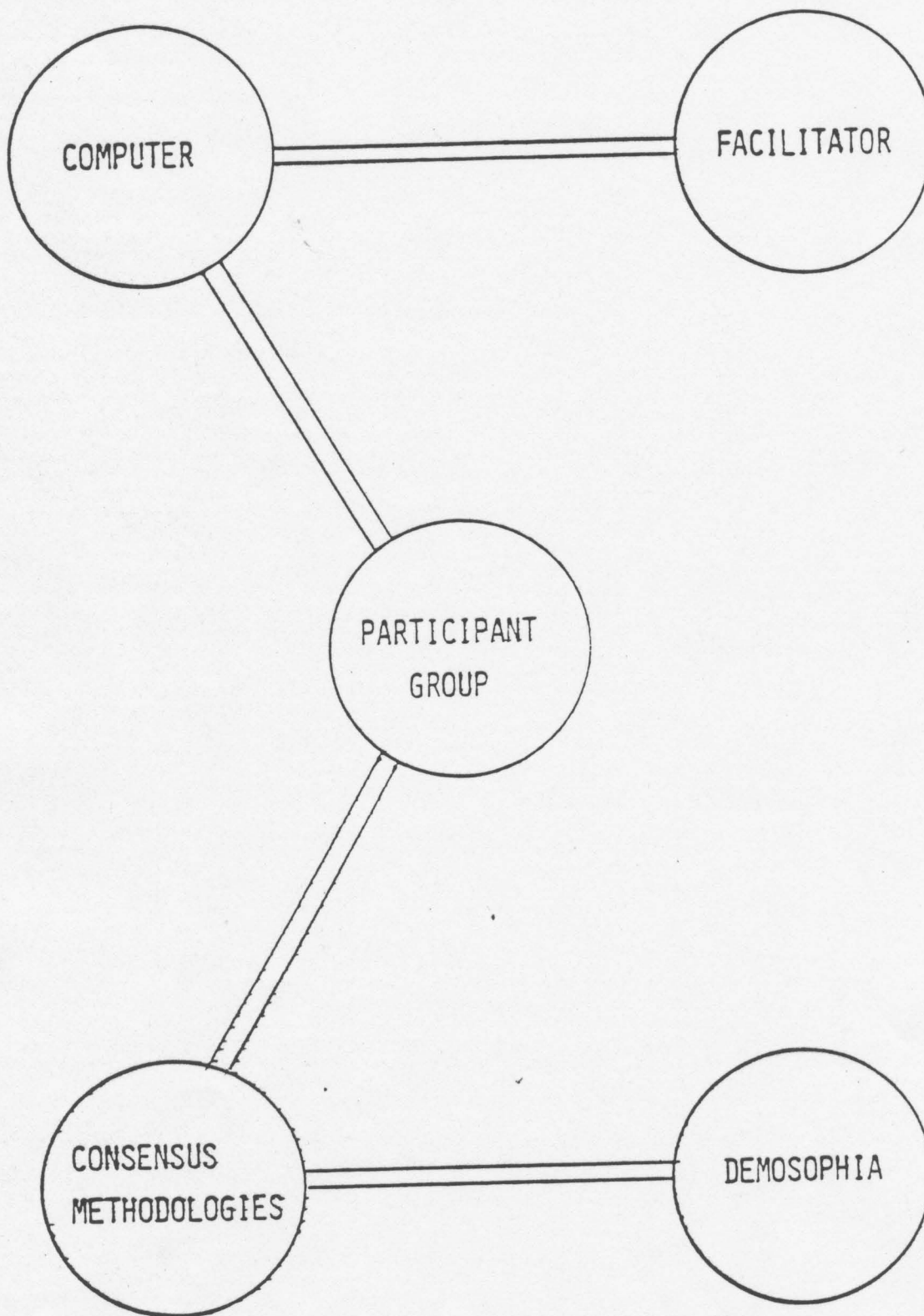


Figure 4. The SIGMA-5 Basis for Generic Design Work

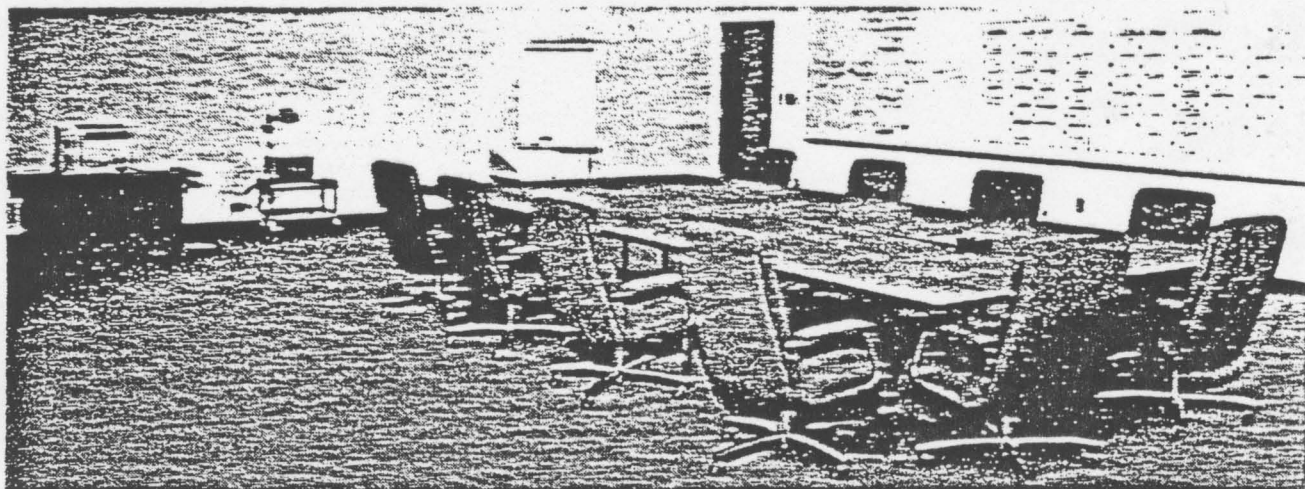


Fig. 5 "DEMOSOPHIA", a generic design environment, is equipped to fulfill a variety of essential functions in carrying out generic design. It is one of the five components of the SIGMA-5 basis for generic design work.

of which can be directly related to major causes of bad design as portrayed in the mass media.

Before presenting the outlines of theory, the functions it should exhibit are shown in Table 2, where it is seen that theory should provide laws, principles, and criteria.

The search for laws focuses mainly on the scholarly literature. Extended study of the literature has uncovered a set of four postulates that appear to be fundamental to generic design theory. These postulates stem, respectively, from the work of John Dewey³, George Miller⁴ and H. A. Simon⁵, Charles S. Peirce⁶, and the literature of cybernetics research.

The Postulate of the Situation³ focuses upon the importance of research and analysis to understand what is involved in motivating a particular design, as well as what information may be available that relates to the design. Experience shows that in many designs individual belief is often substituted for such study, to the detriment of the design; particularly when the design involves knowledge that transcends the discipline of the designer.

The Postulate of Bounded Rationality^{4, 5} asserts that an individual cannot simultaneously handle more than about seven pieces of information. Clearly any design process that violates this postulate introduces hazards related to human behavior and poorly conceptualized design outcomes.

The Postulate of Unshakeable Cognitive Burden⁶ was Peirce's response to the question first explored by Aristotle and

TABLE 2

FUNCTIONS OF GENERIC DESIGN THEORY

1. To identify and justify any laws that should apply to the practice of generic design
 2. To establish principles that should be applied in conducting generic design activity
 3. To identify and justify criteria for screening candidate methodologies for use in generic design
-

later considered by Bacon and Descartes: how should an investigation be started? In contrast to the views of earlier writers, Peirce pointed out that people must start from where they are, and that they are invariably burdened with a mass of cognition that they could not eliminate even if they wished to do so. This picture of cognitive burden has strong implications for the fragility of the thought of the individual designer, and motivates the fourth Postulate, the Postulate of Individual Cybernetic Embedding. This Postulate asserts that the design practitioner should design himself into a cybernetic network that automatically provides corrective measures for those individual weaknesses that the designer has by virtue of being a human.

The four Postulates, summarized in Table 3, tempered by experience and informed by considering how the Postulates have demonstrably been ignored in numerous publicized cases of bad design, provide a basis for formulating three Laws of Design. Before introducing these Laws, it is appropriate to consider what conditions a statement should satisfy in order to be designated as a law.

Historically, the term "law" has been applied to physical situations in nature, but it has also been applied to formulations by legislative bodies to govern human behavior. Generally the former type of law is descriptive, while the latter type is prescriptive. The three Laws of Design to be presented

TABLE 3

POSTULATES UNDERLYING GENERIC DESIGN THEORY

1. The Postulate of the Situation
 2. The Postulate of Bounded Rationality
 3. The Postulate of Unshakeable Cognitive Burden
 4. The Postulate of Individual Cybernetic Embedding
-

are intended to be both descriptive and prescriptive, and in this respect as well as others, they tend to be different from both historical uses of the term, while having elements of each.

Consider that a typical physical law is expected to apply to a set of situations whose members are isomorphic to each other. An apple that fell in Newton's time should be subject to the same law as an apple that falls today. The situations are not identical, but they are isomorphic. Isomorphic situations are typically measured by standard instruments that are essentially observer-independent.

A typical act of legislation is expected to apply to a set of situations whose members are isomorphic to each other. However, there will often not be standard instruments for assessing situations to which the law is intended to apply, and the courts are set up to adjudicate observer-dependent measurements.

Since the members of a set of design situations chosen at random are unlikely to be isomorphic to each other, it is not likely that a law of generic design will lend itself to standard observer-independent measurements. On the other hand, a set of non-isomorphic design situations may well have isomorphic features that are shared by all members of the set or an important subset. This characteristic is what makes laws of generic design possible.

One cannot expect that design laws will be like typical physical laws, nor can they be like typical legislation. Rather they will share some features of both types of law.

Nevertheless there must be some distinctive features that justify the term "design law". Table 4 shows some conditions that should be satisfied by a law of design for incorporation in generic design theory.

Given these conditions, the following discussion will present three Laws of Design that satisfy them. The reader is encouraged to test the Laws against these conditions, and to reflect on the dual descriptive-prescriptive character of the three Laws.

The First Law of Design

The First Law of Design, Ashby's Law⁷, known as the Law of Requisite Variety, has been phrased as follows for use in the course on generic design:

A design situation embodies a requirement for Requisite Variety in the design specifications. Every design situation S implicitly represents an integer dimensionality K_S such that if the designer defines an integer number K_m of distinct specifications (whether qualitative or quantitative or a mix), then:

- i) If K_m is less than K_S , the design is underspecified and the behavior of the design is outside designer control

TABLE 4
CONDITIONS TO BE SATISFIED
BY A
LAW OF DESIGN

1. It should deal with an invariant property of each member of the set of all design situations
 2. It should be relevant to the generic design process for any design situation
 3. Non-observance in the generic design process should have demonstrative potential to yield poor design outcomes
 4. Nothing in the law should work against recognition of
 - the need to study carefully the design situation
 - human limitations, biases, and historically identified counterproductive behavior in performing design
 - variable saliency of pieces of design information, including possible interdependence of design options
 5. To the extent feasible, the law should not be neutral to the three points in Condition 4, but rather should be facilitative.
-

- ii) If K_m is greater than K_S , (except in cases of complete redundancy) the design is overspecified and the behavior of the design cannot be compatible with the designer's wishes
- iii) If $K_m = K_S$, the design exhibits Requisite Variety (i.e., it is an RV design), provided the designer has correctly identified and specified the dimensions, and the behavior of the design should be that which the situation can absorb and which the designer can control, subject to the requirement that the dimensionality of the situation is not changed by introducing the RV design. (If the latter condition is unmet, the First Law can be applied iteratively, taking into account the dynamics of the situation).

An understanding of the importance of the design situation can be gathered by studying Wojciechowski's descriptions of the Ecology of Knowledge⁸, which views the body of knowledge as an entity distinct from individual knowers, and as a rapidly growing element of the human environment.

The Second Law of Design

The Second Law of Design, Miller's Law⁴, the Law of Requisite Parsimony, is an often-cited result from research in psychology. This law has been amplified by H. A. Simon⁵. It is stated in the following form for purposes of the design course:

Every individual's short-term brain activity lends itself to dealing simultaneously with approximately seven items. Attempts to go beyond this scope of reasoning are met with physiological and psychological limits that preclude sound reasoning, but do not prevent unsound responses. For a given person in the role of designer, there is some number K_d that is characteristic of that person's limit in processing capability, and which is approximately 7. If a design methodology or work situation requires a designer to cope mentally with some number of concepts K_c as an integral set of items to be simultaneously reconciled, then

- i) If K_c is less than K_d , the designer is uninfluenced by the Second Law, since the designer is operating in a situation that exhibits the Requisite Parsimony (i.e., an RP situation).
- ii) If K_c is equal to K_d , the designer is operating at the limits of his reasoning capacity, (i.e., is working with the limiting RP situation).
- iii) If K_c exceeds K_d , then no reliance can be placed on the designer's decision, and it can be confidently expected that the design will embody outcomes that are beyond the designer's control, because the design process did not ensure the Requisite Parsimony.

The First Law and the Second Law may work at cross purposes. One stresses variety, while the other stresses parsimony. This is

one reason why the design of the design process is so important.
The design process must provide a reconciliation of the First Law
and the Second Law.

The Third Law of Design

The Third Law of Design, the Law of Requisite Saliency, (also referred to previously as the Law of Shifting Limits, but since re-titled to provide for consistent terminology among the Laws), stems directly from the empirical study of human behavior in various design situations and cases. It recognizes that unless specifically urged to do so, people often will not sort out the relative saliency in the design effort. The tendency to exhibit "spurious saliency" is one of the three factors cited by Kenneth Boulding⁹ as a major reason for low human intellectual productivity.

The third law is stated in this way for purposes of the course in generic design:

The situational factors that require consideration in design work seldom are equally salient. Typically one of these factors will have highest saliency; i.e., will dominate the design performance by limiting it in some way.

A factor that limits a design at one point in time might, at some later time, recede in saliency as the design situation changes; in which case some other factor takes its place.

Sometimes a subset of the factors may be so closely "packed" in terms of near-equal saliency that it is necessary to change the entire subset in order to detect any change in performance.

Sometimes members of a subset are interdependent, so that a change in one member may cause a change in another member or even rule out the possibility of some design choice due to incompatibility. In this case, saliency is recognized through the grouping of interdependent factors into a cluster.

It is therefore required that there be a Requisite Saliency in the design process in order to match the need for Requisite Saliency in the design itself.

Differences in saliency may be exploited in the design process by clustering that recognizes the interdependencies, and by sequencing design choices in a way that takes advantage of saliency to make the more influential choices earlier than those of less influence on performance.

Thirteen Generic Design Principles

The three Laws of Design suggest certain Principles of generic design. These Principles are identified in Table 5, where there is also an indication of which Law or Laws support each Principle. The latter is an illustration of the linkage between Laws and Principles.

TABLE 5

PRINCIPLES OF GENERIC DESIGN	SUPPORTING LAWS		
	1	2	3
1. Design options should be generated by groups	X		
2. Groups should sort design options into design dimensions, normally with computer assistance	X		
3. There should be division of labor between the design group and the computer, according to relative competence		X	
4. There should be computer-assisted group determination of dimensional interdependence		X	
5. The design process should have capacity for vertical iteration*		X	
6. The design process should have capacity for temporal iteration		X	
7. At least one vertical iteration and one temporal iteration should routinely be carried out in any design process		X	

* Vertical iteration refers to iterating from "top to "bottom" of the design, where the top reflects the most general concerns and the bottom the least general

TABLE 5
(CONT'D)

PRINCIPLES OF GENERIC DESIGN	SUPPORTING LAWS		
	1	2	3
8. There should be computer-assisted group sequencing of choice making in the design dimensions		X	X
9. A large, continually updated display should be available to show design status to the design group	X	X	X
10. There should be a specially designed and equipped design environment to enable efficient, effective, and (when necessary) prolonged group design work	X	X	X
11. There should be distinctive roles that differentiate responsibility for design <u>content</u> , design <u>process</u> , and design <u>context</u>	X	X	X
12. Multiple, self-governing, self-reference criteria should be applied by designers to control their own behavior	X	X	X
13. A choice of criteria-selected consensus methodologies should be available to enable design groups to achieve satisfactory and effective outcomes	X	X	X

(In the Principles identified in Table 5, the term "dimension" is associated with the dimensionality and each of the dimensions is identified as part of the design process. The explanation of how this is done is found in the methodology discussion dealing with the Options Field methodology¹⁰.)

The Principles suggest criteria that methodology should satisfy in order to be acceptable in conducting generic design. The criteria need not be applied individually to every component methodology, since it may not be possible for every methodology to satisfy every criterion. Nevertheless when a methodology is recommended for a particular function, the relevant criterion or criteria should certainly be used to test that methodology for suitability. A set of methodologies as a package for use in generic design should collectively satisfy all of the criteria listed in Table 6.

Having discussed the functions of generic design theory, the postulates underlying it, the conditions to be satisfied by a law of design, the three Design Laws, the Principles suggested by the Laws, and the criteria for methodology suggested by the Principles, a basis has been laid for the discussion of generic design methodology. The generic design methodology is heavily informed by the foregoing discussion of generic design theory.

Generic Design Methodology

Generic design is most sharply delineated in terms of the generic design methodology, which includes the processes that are

TABLE 6

SCREENING CRITERIA FOR GENERIC DESIGN METHODOLOGY

1. Provide constructive group capabilities for generating and structuring ideas, for designing alternatives, and for doing tradeoff analyses.
 2. Possess explicit dual design (behavioral and technical) basis.
 3. Provide in the behavioral basis full role definition, enhancement of facilitator credibility, and means for group maintenance.
 4. Couple to a strong, sound historical basis.
 5. Show openness.
 6. Enhance transferability of the product of its use.
 7. Promote efficiency of the design group.
 8. In promoting group maintenance, do not demand infeasible behavior from participants; promote full participation; provide opportunity for focused group dialog in structuring, designing alternatives, and doing tradeoffs.
 9. Offer special properties (such as some unique benefit when compared to other methodologies with similar functions), such as anticipating future automation to increase utility, and being transferable from source organization to client organization without a major training requirement.
-

invoked to carry out generic design. Table 7 shows the goals of the generic design methodology.

Given these goals, the design methodology must be capable of enhancing certain key functions, outlined in Table 8.

The Consensus Methodologies

The methodologies selected for use in generic design have been described previously as "consensus methodologies". A full description of these methodologies is beyond the scope of this paper, but is available in detailed form in¹⁰. In this paper the connection between these seven methodologies and the criteria and functions given in Tables 6 and 8 is shown in Table 9, where the names of the consensus methodologies are given.

It can be seen from Table 9 that the methodologies satisfy the criteria across the board, with only one minor exception. The functions tend to be more methodology specific, hence there are several instances where methodologies do not fulfill certain of the functions. All of the functions are, nevertheless, fulfilled by several of the methodologies which, collectively, blanket the criteria and the functions.

Functions of the Generic Design Environment

It was mentioned earlier that a specially designed room is an integral part of the SIGMA-5 basis for generic design. In days when money for space and laboratory facilities is scarce, there is a strong temptation to try to carry out any educational function in space that was probably created to serve a broad

TABLE 7

GOALS OF THE GENERIC DESIGN METHODOLOGY

1. To help assure the quality of the design work.
 2. To help assure that the conceptual design will be implementable in an informed way.
 3. To exert process controls that prevent recurrence of classic prototypes of past design mistakes.
 4. To exert controls on the nature and quality of the information that is used in carrying out the design.
 5. To make the design process both efficient and effective.
 6. To build in a concern for the interests of the consumer of the design outcomes.
-

TABLE 8

FUNCTIONS OF GENERIC DESIGN METHODOLOGY

To enable and facilitate:

1. Generation of ideas.
 2. Understanding and consensus on the meaning of ideas invoked in expressing the design.
 3. Efficient structuring of ideas, using structuring relations from members of the following relation classes (and other classes, when discovered): influence, comparison, definitive, spatial, temporal, and mathematical.
 4. Documentation of design logic and decisions.
 5. Iteration in decision making.
 6. Creation of design alternatives, each comprising a compatible set of design options (with at least one option chosen from each design dimension).
 7. Use of a wide scope of situational information
 8. High-quality, sustained, coherent communication concerning the reasoning about the design situation, the design, and its implementation.
-

TABLE 9

CONSENSUS METHODOLOGIES AND THEIR RELATION TO CRITERIA AND FUNCTIONS																	
Name of Methodology	Criterion									Function							
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8
1. Brainwriting	X	X	X	X	X	X	X	X	X	X	O	O	X	O	O	X	O
2. Nominal Group Tech- nique (NGT)	X	X	X	X	X	X	X	X	X	X	X	O	X	O	O	X	X
3. DELPHI	X	X	X	X	X	X	X	O	X	X	O	O	X	O	O	X	O
4. Interpretive Struc- tural Modeling (ISM)	X	X	X	X	X	X	X	X	X	O	X	X	X	X	X	X	X
5. Options Field	X	X	X	X	X	X	X	X	X	+	+	+	+	+	X	X	+
6. Options Profile	X	X	X	X	X	X	X	X	X	+	+	+	+	+	X	X	+
7. Tradeoff Analysis	X	X	X	X	X	X	X	X	X	+	+	+	+	+	O	X	+
X = Satisfies the criterion, fulfills the function + = Fulfills the function indirectly, by including one of the other methodologies as a subprocess O = Does not satisfy the criterion, does not fulfill the function																	

variety of situations, and almost certainly was not created to facilitate efficient, effective design.

It is important, then, to note specifically the functions of the generic design environment. An understanding of these functions requires an understanding of most of what has gone before in this paper. Table 10 lists the functions of the generic design environment.

Evaluating Generic Design Practice

When something new is offered, practitioners and theorists often insist that its validity should be established before any claims are made for its efficacy or scope of application. The more specific, narrow, and conservative the claims, the easier one imagines that such an evaluation can be done. The more general, broad, and revolutionary the claims, the more difficult one expects evaluation will be.

Surveys have shown that there are about 4 billion meetings per year in the U.S. alone. If one postulated that one tenth of these meetings involved a search for design alternatives, the size of the sample space for evaluating generic design would be about 400,000,000 meetings per year; an impossibly large sample space with impossible conditions of access. To give a truly scientific evaluation in such a varied and voluminous situation requires access that is impossible to achieve. By contrast, however, in specific areas of design such as design of electrical equipment or design of houses, the number of elements in the sample space is much smaller. Where are the statistical

TABLE 10

FUNCTIONS OF THE GENERIC DESIGN ENVIRONMENT

1. Enable the design team to work long hours without physical distraction or body abuse caused by uncomfortable factors in the design environment.
 2. Provide ample, well-positioned, display facilities for portraying design status in a readily visible way.
 3. Minimize or eliminate the set-up or tear-down costs and delays present when ad hoc facilities are used.
 4. Provide thoroughly checked out and readily accessible computer terminal facilities, connected to machines that hold the software required by the consensus methodologies.
 5. Maintain continuity in the work environment when it occupies several consecutive days.
 6. Eliminate or minimize local environmental barriers to high-quality, productive, human interaction.
 7. Provide responsive facilities for documentation.
 8. Provide for retention of key information needed for later documentation of outcomes.
 9. Allow videotaping of processes for later use in instruction in group process, methodology, and design facilitation.
 10. Permit non-conventional academic design work to take place.
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evaluations for these specific designs? Doubtless those who might desire the (impossible) evaluation of generic design methodology are less prone to require a more feasible evaluation or set of evaluations in specific design areas. No matter. We are already aware of the great advances made in Japan by following the Deming quality control prescriptions. The aims of generic design theory and methodology are very similar in many ways to the aims of the Deming approach in industrial practice.

While scientific evaluation through a controlled experiment with statistical testing seems out of the question, what can be done is to assess views of people who have participated in generic design activity, comparing results attained with this process with results attained by other means. When viewed in this way, experience so far (both in and out of classrooms) fully justifies the presentation of generic design in a course of the type described, and to the audience of this publication.

Conclusion

A course in generic design has been offered three times with good results. The course is based on fundamental knowledge that leads to a generic design theory which, in turn, buttresses a selection of generic design methodology that provides the means for carrying out generic design.

The SIGMA-5 basis for generic design involves bringing together a collection of five integrally related factors which, collectively, enable generic design to be carried out in a way

that meets the goals of the course and of generic design as a kind of universal concept.

Transferability of this concept is feasible, the generic design environment and the methods having already been transferred to several other public sector organizations (names on request).

It is hypothesized that if engineering schools offered a course in generic design during the first two years, they could expand considerably the quality and quantity of specific design carried out within disciplinary confines. Testing of this hypothesis is encouraged^{11, 12, 13}.

Acknowledgments

For creating the conditions that allowed this course to be offered and tested, thanks go to Drs. John E. Gibson and David Morris of the University of Virginia; and to Drs. George Johnson, J. Wade Gilley, and David King of George Mason University.

Appreciation is also extended to Dr. Alexander Christakis and Dr. David Keever of George Mason University, Dr. William Wood of Elon, and to the Rodman Scholars at the University of Virginia who made the course exciting.

Dr. James Palmer kindly commented on the manuscript.

Support for theoretical work in this area was partly provided by the National Science Foundation under Grant Number DMC-8515517.

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FIGURE CAPTIONS

- FIGURE 1: The organization of a course in generic design.
- FIGURE 2: An Implication Structure for generic design theory.
- FIGURE 3: A field basis for making design distinctions.
- FIGURE 4: The SIGMA-5 Basis for Generic Design Work.
- FIGURE 5: "DEMOSOPHIA", a generic design environment, is equipped to fulfill a variety of essential functions in carrying out generic design. It is one of the five components of the SIGMA-5 basis for generic design work.