DMG NEWSLETTER
design methods group

JANUARY 1971 **VOLUME 5 NUMBER 1**

Sponsored by the College of Environmental Design, University of California, Berkeley in co-operation with the School of Architecture, Washington University, St. Louis. Published by Sage Publications, Inc.

RITTELTHINK

HORST RITTEL ON DESIGN EDUCATION

CONTENTS

1 NEWS ITEMS

2 BACK ISSUES

2 REQUESTS FOR ARTICLES, ABSTRACTS, AND REPORTS

2 CONFERENCES IN 1970: A request for reports and comments on the numerous conferences held during the past year that were of interest to the design methodologist.

2 ARTICLE

"Some Principles for the Design of an Educational System for Design—Part II" (Conclusion)

by Horst W. J. Rittel

11 BIBLIOGRAPHY

The reading list for Horst Rittel's introductory course in design methodology.

NEWS ITEMS

A new journal, ENVIRONMENTAL SYSTEMS, is addressed to the professions concerned with the analysis, design, and management of the environment. The rate is $18.00 per year. Baywood Publishing Co., Box A-114, Wantagh, N.Y. 11793.

The Graham Foundation is funding a fellowship program for advanced study in computer-aided architecture with the Architecture Machine Group at MIT. Applications are invited from candidates with design training and experience, preferably with computer experience and knowledge of a computer language. Two to four fellows may be selected to do a year's work between June 1971 and September 1972. Stipends may be up to $10,000. Each fellow will pursue his own project within the framework of the Architecture Machine Group and the Department of Architecture. Apply to Professor Nicholas Negroponte, Room 9-518, MIT, Cambridge, Mass. 02139, prior to February 1, 1971. Include a curriculum vitae, a statement of intended study, and other supporting material.

The Eighth Annual Design Automation Workshop will be held June 28-30, 1971, in Atlantic City, N.J., sponsored by SHARE, ACM, and IEEE.

CALL FOR PAPERS: International Symposium on Airport Location Methodology, March 8-12, 1971, London. The objective of this Symposium is to contribute to the development and dissemination of advanced techniques of airport location analysis by bringing together experts from many countries for an exchange of ideas and discussion at a high professional level. In particular the Symposium will present the innovative aspects of the Third London Airport study in the context of parallel developments from other centers throughout the world. Write to W. Oxburgh, PTRC, 40 Grosvenor Gardens, London, S.W.1, enclosing an abstract up to 500 words.

BACK ISSUES

Back issues of most copies of the DMG Newsletter are available from the publishers at $1.25 per copy. Please write to: Sage Publications Inc., 275 South Beverly Drive, Beverly Hills, California 90212 and enclose payment for orders of less than $5.00.

REQUESTS FOR ARTICLES, ABSTRACTS, AND REPORTS

Forthcoming issues of the DMG Newsletter will center on the topics listed below. Articles, news items, abstracts, and reports of research in progress are requested from the readers. Each topic-centered issue will attempt to describe the state of the art in that area and include current work. Articles of around 1,600 words and other items described above are needed. Contributions should be typed single-spaced, error-free, with 50 characters (letters or spaces) per line. Send to: Editor, DMG Newsletter, Dept. of Arch., Univ. of Calif., Berkeley 94720. The topics are:

- Design methodology education: present and planned programs
- Human factors and design
- Space allocation techniques
- Dynamic programming and design
- The semantic differential and design
- Counterplanning
- Participatory planning
- Evaluation of designs
- Values and ethics in design
- Behavior in public places
- Futurology
- Creativity
- Gaming and simulation in design

The emphasis in each issue will be on the design methodology-related aspects of the topics, and case studies are appropriate only insofar as they relate to methodological issues.

CONFERENCES IN 1970

There were a number of conferences sponsored by various organizations during 1970 that were of interest from the design methodologist's point of view. Two of these, the Kentucky conference on computers and design, and the EDRA conference, have been reported in detail in the DMG Newsletter. Other conferences included the Gerontological conference in Toronto in October, the ACSA conference in Pittsburgh in October, the AIA-Researchers conference in Cincinnati in November, the Industrialized Building conference in Louisville in November, and the ACM Urban Symposium in New York at the end of August. The Newsletter would like to have reports and comments from participants in these conferences, dealing with those parts of the conferences that are of interest from the standpoint of design methodology. Please submit reports and comments to the Editor.

Abstracts of papers presented at the AIA-Researchers conference, held November 1-3 in Cincinnati, are available in the AIA Journal (October 1970) pages 76-79.

ARTICLE

SOME PRINCIPLES FOR THE DESIGN OF AN EDUCATIONAL SYSTEM FOR DESIGN — *PART TWO (CONCLUSION)*

Horst W. J. Rittel

This is the second and concluding part of the article by Professor Rittel that was begun in the December 1970 issue. Rittel is Professor of the Science of Design in the College of Environmental Design at the University of California, Berkeley. Professor Rittel was the director of the *Hochschule fur Gestaltung* at

Ulm before coming to Berkeley seven years ago. He has become well known among participants at architectural and design conferences during the last few years. At Berkeley he teaches an undergraduate course in design methodology that is based on the approach described in this paper, as well as courses in scientific method and advanced seminars on design methods and the planning process. His recent work is geared toward structuring and implementing planning systems that elicit and support dialectical display of planning alternatives. Recent consulting work for various government agencies has centered on the development of information systems.

RECURRING DIFFICULTIES IN DESIGN

This picture of the design process and the structure of the designer's knowledge is abstract and not very sophisticated. Therefore one cannot expect any one of its implications to be specific for any particular area of design. What can be derived from it must be independent of the particular object to be designed, whether it is a bridge, an urban renewal policy, an airplane, or the curriculum for a school.

Nevertheless, the model is a framework for the identification of those typical "intellectual" difficulties which are repeatedly encountered by a designer in his work. It is important to enumerate some families of these difficulties—without claiming completeness or that the various items are independent from each other:

(1) *To assess the worthwhileness of a project.* Since everybody's problem-solving capacity is limited he must allocate his resources to the most worthwhile projects—otherwise, he would incur heavy "opportunity costs." This, however, is easier said than done. Whose and which costs and benefits should be included in this assessment? How to discount future benefits into present assets? Answering these questions requires a distinct and sophisticated "ought-to image," explicitly describing what one wishes to become the case, together with a clear picture of the "opportunities." Every project requires the construction of a "case" to which the participants in a project commit themselves.

(2) *To determine the appropriate level of a problem.* A problem originates from a recognized discrepancy between what *is* and what *ought to be.* Any attempt to solve it consists in the search for removing this discrepancy. But every discrepancy can be considered a symptom of a higher order discrepancy. And there are many ways of explaining one and the same discrepancy, since there are many explanations which construe a "because of." The apparent discrepancy may be the deficiency of housing in a blighted area, and one might think of doing something about it. But this deficiency *may* be better understood as being only a manifestation of social imbalances, the removal of which would automatically take care of that blight. And, in turn, social imbalances can be explained as resulting from a particular social value-structure, the adjustment of which would do away with those imbalances. And so on and so forth. This escalation of explanations is not at all uniquely determined. Blight can also be—and occasionally is—understood as the product of the inhabitant's malevolence or negligence. Each explanation will lead to entirely different types of problems, and, therefore, solutions. There is no logical, natural, or objective level on which to settle the problem originating from a discrepancy. The solution level is a matter of judgment and self-confidence.

(3) *To determine the nature of the solution.* Assume that agreement has been achieved as to the formulation and explanation of the discrepancy which has given rise to the problem and its explanation. Then a multitude of different principles can be developed—"morphologies" as they have been called above—which also promise to lead to a solution. The problem of a congested freeway may be attacked by adding a few lanes, by diverting a portion of the traffic through a new artery, or by a rapid transit system. Each of these morphological alternatives leads to entirely different information needs and subdifficulties. How to find reasonable morphological alternatives and how to choose among them?

A related aspect is the appropriate naming of the object to be designed. This is decisive for the class of solution possibilities conceived of by the designer, and also for the "image" of the final product in the eyes of its users. A "dwelling" is not necessarily a "house," and the connotations of "public housing" are very different from those of "economy apartments," even if the "physical" design is the same. So-called physical objects—like buildings—do not have an independent objective meaning. They *are* what they are taken for, and this determines their fates.

(4) *To construct an evaluation system.* In order to do his work, the designer needs an evaluation system to guide his search for a solution. What ought to be accomplished? This system should incorporate all the aspects and viewpoints under which the object will be evaluated. Normally, there will be a multitude of performance variables to be considered. But a mere list of these variables is not sufficient:

–they are not all of equal importance.

–they are not independent from each other. It is seldom, if ever, possible to maximize all performance values at the same time, since an improvement on one aspect usually reduces the performance of another aspect.

–ideally, the solution ought to perform well in everybody's eyes. But normally, different people assess the same object from different standpoints, and even if they agree on the relevance of a particular performance variable, they might disagree on how to score a certain object on this scale ("How beautiful!" says A, "How trite!" says B). The owners, the neighbors, the architectural profession–all have a "say" about the quality of a building; an investor wants to maximize the return on his investment while the prospective tenants are likely to want to pay as little rent as possible.

Therefore, the designer must:

(a) identify the relevant performance variables for each of the parties to be taken into account

(b) find out the relative importance of the various aspects for the various parties considered

(c) "settle" somewhere in the field of conflicting interests; e.g., by assigning weights of influence to the various parties

(d) construct a measure of "overall performance" for evaluating alternative solutions

All of these items present considerable difficulties. Particularly the last one is most decisive: in view of performance aspect P_1 a solution A may be better than a solution B, but for performance factor P_2 the solution may be just the other way around. This situation is known as a dilemma, and any two solutions under consideration will present a number of them. Which is to be preferred? In order to make up one's mind in favor of either one of the solution possibilities, one needs a procedure that enables one to aggregate the various performance aspects–properly balanced–into one overall judgment of the form "B is better than A," for example. This can, for instance, be accomplished by determining weights of importance for all of the relevant performance aspects, or by finding a common measure of utility into which the scores under each of the aspects can be equally converted. Such an overall performance measure can be constructed for each individual party involved in the project, or it may be tried to accomplish agreement on one particular evaluation system. The rationale of these procedures is to replace "offhand" overall judgments (I just like it!), by sets of detailed evaluations which are then recombined into another overall judgment–which is hoped to represent a more rational and balanced evaluation.

(5) *To anticipate the context of the object.* As discussed above, the performance of something is not a function of the design characteristics alone but also and decisively of the conditions under which it operates and the purposes for which it is used. There are almost no single purpose objects around. A building has to function as a commodity on a market, at the same time it is somebody's house, people "circulate" in it, it has to be cleaned, presents a fire hazard, and it is looked at with the eyes of the connoisseur. Each of these functions takes place under conditions which may change over a time, and even the set of purposes for which the object is used may change (e.g., a bedroom might be converted into a living room). It is a major difficulty to anticipate the relevant characteristics of the context under which the object will perform. Not only have the contextual variables to be identified, but also their values have to be estimated, together with the ranges of variation to be provided for. Frequently, the performance variables are not independent from each other but form nests of functional relationships. Thus, real estate value will depend on demand, on the character of the neighborhood, the state of deterioration which, in turn, is a function of usage and investment into maintenance, and so forth.

Of course, in this category belongs also the anticipation of "environmental factors:" should one design for earthquakes in Missouri, for an H-bomb holocaust, for a social revolution in the United States? If not, why not? Again, answers are a matter of judgment and of the willingness to accept risks, and of the degree of optimism of those who run the project.

(6) *To identify a relevant solution space.* Each morphology determines a set of design variables, representing the range of variation for the design decisions. This is the problem of retrieving the appropriate technological data. Which materials are available? Is it possible to make a glue connection between metals a and b which withstands x degree of heat over y hours?

(7) *To constrain the solution space.* Not all combinations of the design parameters defining the solution space are meaningful: a beam with span X and dimensions u, v, w, made of material y may not be feasible, because in the "context" of load z and gravitation t it would collapse. Or, a prefabricated component may be structurally elegant but useless because it cannot be transported or because it violates the building code. Therefore, it is essential to exhaustively identify the *constraints* which reduce the variety represented by the solution space. Constraints originate from contextual conditions (building code, weight of people) from relationships between the design variables (the interior dimensions of a room cannot exceed its exterior dimensions), and from the so-called *qualitative objectives;* i.e., those performance specifications which are expressed in terms of a binary performance variable ("a garage is either provided for or not; it is required to have one").

Constraints are, however, not at all "givens" which just have to be accepted. Whether something is under a constraint or not depends largely on the decision maker. The building code can be accepted as given and thus becomes a source of constraints, or one can decide to do something against some of its paragraphs. In this case "changing the building code" has become a part of the design project. Every accepted constraint is an indicator of resignation: the decision maker has given in and decided to leave a segment of his reality as it is instead of trying to change it.

(8) *To construct a system of functional relationships which connect design variables, context variables, and performance variables with each other.* This may be called the central difficulty of designing. In almost no case will one succeed in setting up one big model that represents a whole, realistic problem. Usually, one starts out with a crude overall model, representing the idea of the solution principle. This model, along with increasing elaboration of the solution, is fragmented into submodels for partial problems which can be treated somewhat independently. By "model" is here understood any "mental" construct which is assumed to be homomorphic to that which it is meant to represent. It may be a cardboard model, a system of equations or a narrative: it is the picture somebody makes for himself about something. In any real design problem the great number of variables and the fuzziness and the complicatedness of the relations between them makes the construction of complete, communicable models extremely difficult, if not impossible. Nonetheless, the "rational designer" must feel obliged to attempt the construction of such models which tell him how a certain configuration of design decisions, if the object is subjected to a certain context, will perform with respect to the overall performance measure (since he is trying to anticipate the consequences of his design decisions). In addition—as the discussion of the nature of the design process has shown—such a model is incessantly subjected to modification and revision, due to the steady stream of new information during the whole design phase of the project.

(9) *To find an appropriate solution in the solution space.* If the system of accepted constraints is not contradictory (which happens often enough) the number of feasible solutions is very large. Which of them yields a good overall performance? How does one know that, if solution A is good, that there is not another solution B in another area of the same solution space which is considerably better than A? Occasionally, this difficulty presents itself as the task of optimization. However, because of the aforementioned difficulties, overall optimization almost never occurs in design. Optimization requires three conditions:

(a) that there is a manifold of well-defined solutions

(b) that there is a criterion which enables one to compare the performance of any two solutions of that manifold leading to the judgment about which of them will perform better

(c) that, if optimality for a certain solution is claimed, it can be proved that—according to the criterion—there is no better solution in the manifold

In design, usually none of these conditions is fulfilled. As discussed before, it is normally impossible to construct a comprehensive solution space for the whole problem (which would include all models belonging to all conceivable morphologies of the whole and its parts). Second, even if one succeeded in setting an overall evaluation system, it will frequently be impossible to "read" the future performance of every particular solution from its representation in the solution space. The reason for this is that we simply do not know what the impact of an additional inch in the width of a room will be for its use as a bedroom. Finally, who knows of a solution proposal to a design problem and can *prove* that one *could not* have done better? Therefore, categories like "acceptable," "good enough," and so on, are commonly used to terminate the search for a solution.

(10) *To avoid undesired side- and after-effects of a plan.* A plan may literally accomplish what it was intended to, but it may produce additional effects which come as unpleasant surprises. They are due to forgotten factors or to cumulative effects which none foresaw. To apply DDT to the extermination of insect pests is a good idea; to find insecticides 15 years later as a stable and harmful compound in almost every organism on earth is alarming. It is a "scale-effect" caused by the ubiquity of insect pests. A freeway, designed in order to take care of traffic congestion, leads to a further dispersion of residential, commercial, and industrial locations and therefore "generates" even more traffic than there was before, thus stimulating its own suffocation. There are many dramatic examples of unforeseen after- or side-effects. How can they be avoided or at least made to occur less likely? The larger the scope of the project, the more consequential they tend to be.

(11) *To implement a solution proposal.* It was said that the result of the design process is a plan which if carried out is expected to lead to the desired result. But the best plan is of no value if it is not carried out. It has to be implemented in two ways: First, it has to be accepted by the decision maker; second, it has to be realized. Therefore, a good designer has the implementability of his plans in his mind all the time. It is useless to make "platonic" plans which look promising but which cannot be realized because of the deficiencies of this bad world.

(12) *To test the results.* In order to learn for the future, the designer has to rely on a careful review of what he has accomplished in the past. Ideally, he would check a list of hypotheses against that which actually happens later on. But because of the independence of performance from both the design decisions and the context, how can he attribute a particular deficiency to either of them? Is the present system of assigning legal liabilities a sufficient testing device for the designers and the other parties? Is a housing project which turned into a slum badly designed, or was it subjected to the unforeseeable intervention of new social factors?

All these complexes of interlocked difficulties, which could only be adumbrated here, deserve further analysis and more detailed classification. They are familiar to every designer. In everyday practice they are overcome "somehow," more or less consciously. For each of them, there is a host of negative examples. Positive examples are harder to find because they do not show up: good design is unobtrusive.

For the purpose of this paper, two questions arise:

—is it possible to master these difficulties systematically or, at least, more consciously?

—if yes, is it possible to teach this mastery?

GRAND APPROACHES

All these difficulties are different expressions of a basic dilemma of human existence: if one tries to be rational (i.e., tries to anticipate the consequences of one's doings) there is no beginning and no end to reasoning. One can think a further step "backward" and also another step forward. The more one tries to anticipate and to justify one's actions the more difficult it becomes to act. On the other side, nonrational spontaneous action on a large scale is likely to get the actor and others into trouble: It is irresponsible. Thus both extremes have little survival value.

For all of these reasons there cannot exist anything like "the" design method which smoothly and automatically resolves all those difficulties. Those people who claim the existence of such a device postulate nothing less than the solution of all present and future problems of this world. They are likely, however, to produce nothing but "platonic" schemes, impossible to implement.

Everybody knows the patent-ideologies which are meant to overcome the difficulties "by principle." There are those who say that the designer is a "need fulfiller," a reaction-jar into which people pour their needs. The designer is just a catalyst for the crystallization of the solution. These people forget that the designer commits himself in his work. Knowingly or inadvertently, he uses his judgment all the time, as does anybody else. Every constraint is a matter of decision. If he tries to remain neutral and uninvolved he is likely to do the job of some middle-class opportunist or even that of a reactionary: "Whose bread I eat, his design I do."

A related doctrine demands the belief in the existence of a list of basic human needs, common to all people at all times. The designer has just to identify them objectively and to design accordingly. There are numerous attempts to list basic needs, one and for all and for everybody. Unfortunately, in this list "food" becomes "protein," "carbohydrates," and "fat," breathing requires "oxygen," a house becomes a "shelter," measured in terms of square feet. Because of their generality, such lists tend to oversimplify the problem: it is easier to provide protein than beef. Such lists wipe out the enormous diversity between peoples and cultures (even if they list "privacy as a basic need!") thus erasing the unique and specific constellation of values in which every design project takes place and leading to solutions which cannot be implemented because people want beef and not algae. It takes a long and difficult argument to convince people that they should better have algae. Therefore, it is hopeless to attempt the construction, for instance, of a standard catalog of performance specifications for all buildings or even only for a particular type of building—say schools. Behind any such list is somebody's particular "ought-to" image of schools in response to a particular "is state," and not at all timeless objectivity.

Another variant is the beloved doctrine that "form follows function." If this comes together with the "need fulfiller" doctrine, its triumphs are the jeep and other forms of military equipment. If the designer believes that technical perfection automatically provides optimum usefulness, he forgets that "technical" criteria have no independent meaning, and that lists of requirements do not at all determine a solution (otherwise Russian rockets would not look Russian and American rockets American). The list of requirements may be long: they either prescribe no solution at all or an infinite number of them. And "form" is no opposite to function: "To be looked at" is just one function of an object, which has many other functions.

BETTER DESIGN

Does this mean that nothing can be done to master those difficulties better than before? I refuse to believe it. It must be possible to design better.

But what does "better design" mean? Let me use a weak definition, based on the pragmatic criterion that since the quality of a plan will be proved only after its execution—it is "better" to the extent it has accomplished that which it was meant to accomplish, and the fewer undesirable side- and after-effects to which it has given rise. Then a designing system is the better (in its own terms) the less frequently it produces bad plans. This does not preclude the possibility of good designing systems, which are evil for somebody else, since this definition does not evaluate the particular moral or political commitment of the system. Then, on a very modest level, we might search for tools, techniques and methods which are likely to enhance the designer's capability to make better plans in view of his commitment. Naturally as with all tools, such aids are "value free." A hammer can be used to drive a nail or to hit somebody's head.

Perhaps even this simplistic understanding of how to improve design capabilities can have a desirable net effect. Most bad plans are the result of ignorance and fallibility, and not of bad will. If, therefore, the capability of a design system "can be improved in its own terms," it is not unlikely that the number of bad plans and the impact of their consequences can be reduced.

It may happen that a higher degree of reasonableness, sophistication, and communication in the production of plans leads to less "evil" plans.

METHODS, TOOLS, AND TECHNIQUES

Certainly, the harder one tries to cope with those difficulties in a conscientious and rational fashion, the more intellectual capabilities are required; i.e., reasoning, understanding, argument and critical ability. But, besides, they demand power of judgment and commitment. The more one intends to understand one's decision, the greater the number of decisions to be made, and the more complicated the relationships to be handled. What was an offhand judgment or a routine, turns into a set of nasty problem complexes, leading to deeper causes and requiring more, and more fundamental, assessments and decisions. It is a matter of judgment and basic conviction where to stop proliferating complexity and intellectual penetration, to settle the problem at hand. No methodology can substitute for this judgment.

There are methods, techniques, and tools, however, which can aid the designer in structuring and manipulating a problem. As weather forecasting, structural engineering, or market research benefit from the use of rational procedures (and thereby improve their performance in the sense defined above), the designer can also employ more conscious and sophisticated modes of approach which allow the controlling of more factors and more complicated relationships on which to base his decisions. These do not guarantee better plans. The most sophisticated mathematical model can be useless or even detrimental if applied and interpreted unwisely.

At present, the set of methodologies is insufficient for mastering all those difficulties (and there is good reason to postulate that the difficulties can never be removed by any method), yet there exists a considerable "tool-chest" to aid the designer in his work. Statistical techniques may support his predictive efforts; procedures of systems analysis can be used for interlocking a greater number of variables than the "unarmed mind" can manipulate; symbolic logic can serve as a means for describing and analyzing the structure of a problem; techniques of operations research will find the optimal solution in a fixed solution space with a given performance measure; one can employ a simulation model in order to better anticipate how a certain solution will perform under a variety of conditions; techniques of empirical research can generate more reliable knowledge about "what there is"; combinatorial techniques may support the search for solution principles, and so forth. Besides, there are many procedural systems to attack and carry through a design project. They are not really methods, but disciplines of procedure, which suggest when to do what, and checklists reminding the designer of those things he should take into consideration.[7]

Perhaps the least developed but the most important family of design-aids can be subsumed under the name of "social technology."[8] These are methods of providing for social interactions and events in view of a specified goal. They are meant to apply to problems of instruction, forecasting, coordinating expert opinions, organizing a group, obtaining corporate decisions, implementing solutions, and legislating. Many of these center around the problem of appropriate "display": how to communicate one's way of understanding to others? how to display one's value-structure? Although many systematic devices for setting up evaluation systems have been developed, much research remains to be done for their improvement. Likewise, it ought to be investigated how to better display alternative plans, together with their pros and cons, in order to provide a basis for understanding the implications of the alternatives and a debate about their acceptance.[9] Such displays could have just the form of graphic materials, but also—and this would perhaps be more interesting and useful—they could be rules for stimulating controversy and debate which hopefully lead to the detection of concealed weaknesses and to wider and better founded bases of agreement among the participants. How badly this aspect is mastered is impressively demonstrated by the failures of almost all urban renewal projects, rapid transit systems and the like. Persuasion and secrecy seem to dominate the decision makers or the designers, their intentions, ideologies and beliefs (which are decisive for the outcome of design projects as discussed above) tend to remain implicit and unargued. But a necessary condition for improving our capability to plan lies in clearly recognizing and spelling out the foundations of the participants' positions. Otherwise, planning degenerates into "muddling along," and it would be surprising if the results of this practice would be not unpleasantly surprising.

One might argue that this critique is directed against basic "inbuilt" faults of human nature, and that nothing can be done about them. But the existence of Robert's Rules of Order, of the decision-making procedures of democracy, the rules of legal proceedings show that it is not impossible to "engineer" social technologies of the "dialectic" type.

IMPLICATIONS FOR DESIGN EDUCATION

I had assumed that an educational system for design should prepare and equip the student for practice, and that, therefore, it should focus on the typical and recurring difficulties of designing, on ways to overcome these difficulties, and on that knowledge necessary to obtain the knowledge needed for a particular project.

It was the purpose of the preceding considerations to demonstrate that such fundamental difficulties can be formulated in a way pertinent and valid over a long period of time. The significance of these difficulties is increasing because of the changing nature and the widening scope of design projects, which allow the designer less and less frequently to rely on precedents or habitual ways of doing a job.

These procedural aspects of designing offer a principle for the design of a curriculum, since they provide a plausible framework for selecting and relating the host of factual knowledge and skills to be transmitted. Some implications of this strategy are:

—the student should be exposed to and familiarized with those typical difficulties as articulately as possible.

—design problems should be developed which emphasize one difficulty at a time. ("The influence of different measures of performance on a solution," "To generate relevant morphological alternatives to a given problem," "To anticipate the performance of a proposed layout for a supermarket," "Set up the system of relationships between the design variables, the patterns of use and the performance of a lecture hall," "Determine A's image of building B1," "Compare the social costs and the benefits of the alternative plans for School S.")

—"software" technologies which are apt to support the work toward the solution should be taught systematically and thoroughly exemplified ("methods of prediction," "procedures of evaluation," "theory and model construction," "the division, organization and scheduling of design labor").

—the principles and the present state of theories of environmental systems should be conveyed to the students and their further development encouraged ("theory of floor plans," "theories of growth, rehabilitation, decay, and obsolescence," "environmental control").

—whenever possible, the emphasis on the knowledge of present "hardware" technologies should be reduced to the principles of these technologies. How should one obtain the particular technological knowledge required in a particular situation? How should one keep abreast of the change of technological principles (the organization and the use of data banks and experts)? How should one determine the technical feasibility of a solution idea?

—the vast areas of factual knowledge should be taught in a problem-oriented way (i.e., as relationships between design, contextual- and performance-variables).

—it should be shown how to mesh the factual knowledge of many disciplines and slices of reality into one system (how do the dimensions of trucks, the building code, production facilities, material properties and wages affect the design of a prefabricated concrete slab?).

—it should be discussed and demonstrated how cultural, social, economic and political factors influence design, and how these factors themselves can become subjected to design.

—particularly in the more advanced segments of the curriculum, real design problems should be given instead of mock-up projects, because—as discussed before—design problems are notoriously "ill-behaved" and cannot be formulated exhaustively and definitely. Therefore it is difficult if not impossible to simulate the conditions of real world problems in the studio. Public design projects, competitions and industrial corporations might be considered as sources of realistic design problems.

This listing of teaching items can easily be extended in width and detail. It is more essential, however, to point to their implications for basic attitudes and the foundations of this strategy. It requires that the designer be fully aware of the inescapable dilemmas produced by his attempts to design responsibly. He must know that his results are "political" by necessity because they are based on his and others' images of how the world is and how it ought to be. The more a project matters the more crucial its political implications will become ("political" without the derogative American connotation but in the Aristotelian sense: every act is political if it affects the affairs of the community, if it reaches beyond the boundaries of privacy). The good designer will know that he shall never find the best solution, but nevertheless he will continue to search for better ones. For him it is at least as important to be familiar with today's unsolved problems as with yesterday's approved practices. He will have learned to live with the fact that everything he is doing is due to his own free decisions, that there are almost no necessities, that almost everything–including values, habits and beliefs–are subjected to potential change, and that this change can be designed. He should be prepared for the change of accepted values and he must learn to live with the thought that the more systematic and rational he tries to be, the wider the scope of possibilities becomes and the heavier the burden of ethical commitment.

One might ask whether a person with such an extent of awareness can still be capable of designing. Can anybody make design decisions in face of the universe of possibilities and consequences? The answer lies in the pattern one can observe in the behavior of design students. As a freshman, full of naive enthusiasm, they are dedicated to the redesign of the whole world, fast and thoroughly. They ask for the real problems and attack them impatiently, though not very realistically or efficiently. Some students get stuck to this phase; they are disillusioned the hard way, after school. Others enter a second phase: accidentally, or by instruction, they stumble into the difficulties of designing, and they find out that they do not know enough to overcome them. They look for reliable knowledge and appropriate procedures. The result is often resignation or cynicism; they lose courage to draw a base line on a blank sheet. Some give up the idea of becoming designers and switch to a science (preferably psychology), or go into business. A few survive this period of frustration without quitting, resigning or resorting to opportunism. They learn to design in spite of difficulties, paradoxes, and dilemmas. They also deduce that balancing masses against the void, sequencing spaces, considering buildings as "statements" of esthetic preferences, glass-bead games with "megastructures," are only one group of factors in the much richer context of building design, urban planning and construction.

Perhaps an educational system for design is the "better" to the extent that it increases the number of students who attain this view of architecture.

NOTES

7. For industrial design, such a system has been worked out in painstaking detail by L. Bruce Archer, SYSTEMATIC METHODS FOR DESIGNERS (London: Council of Industrial Design, 1965). From the standpoint of engineering design, such a procedure is presented in the article of J. Ch. Jones in J. Ch. Jones and D. G. Thornley (eds.) "Conference on Design Methods" (Oxford: Pergamon Press, 1963). Almost any textbook on systems analysis or operations research contains in one of its first chapters at least a crude enumeration of steps to be taken in a design problem.

8. SOCIAL TECHNOLOGY is the title of a book by Olaf Helmer (New York: Basic Books, Inc., 1966). Here, the term is used to designate methods of obtaining expert opinions about future technological, political, and social developments. In the context of this paper, the term is used in a wider sense, including all methods, techniques and tools which can be deliberately applied to accomplish specific, goal-directed modes of social behavior.

9. For a comprehensive analysis of the various forms of display and their uses, ef., C. W. Churchman, "The Use of Research in the Preparation of Decisions," pp. 255-270, in H. Krauch (ed.), WISSENSCHAFT UND POLITIK (Studiengruppe fur Systemforschung: Heidelberg, 1966). This essay emphasizes "dialectic display" as a most appropriate device "to make sure that the decision maker has the opportunity of scanning the most plausible alternatives in a forceful manner."

From Education for Technology. Report of a Conference at the School of Architecture, Washington University, St. Louis.

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READING LIST FOR AN INTRODUCTORY COURSE IN DESIGN METHODOLOGY

This is the reading list for Professor Rittel's course, Architecture 130, at Berkeley. It is in this course that the philosophy described in this article is presented to architecture students. This course has been a vital influence in the thinking of many students studying design methods at Berkeley.

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