ARCHITECTURAL DESIGN IV

Corporate Incubator Housing on Long Island: Affordable Living Space for the Next Generation of Workers

Studio Instructor: Joseph A. Betz
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Methodological & Theoretical basis for the Project:

READING 26

A Priori Knowledge and Heuristic Reasoning in Architectural Design

Peter Rowe

Rowe explores in this selection the nature of the design process in terms of the kinds of problems architects are expected to solve. Architectural problems are defined as "wicked" in that both the ends and means of solution are ill-defined; there are no clean starting or stopping points in the design process. He states: 'Tackling a problem of this type requires some initial insight, the exercise of some provisional set of rules, inferences, or plausible strategy, in other words, the use of heuristic reasoning." Rowe argues that initial ideas and concepts generated by the architect early in the design process will have profound effects on the final building solution, and the process itself should be seen as a co-mingling of problem-solving methods.

A distinction can be made in the world of problems between those that are well defined and those that are ill defined. [I] In solving the former kind the "ends" are known and one has to find the "means." In the latter kind, that includes most architectural design prob-

Source: Peter Rowe, "A Priori Knowledge and Heuristic Reasoning in Architectural Design," Journal of Architectural Education, 36. no. I (Fall 1982), pp. 18—23.

lems, both the "ends" and the "means" are unknown at first and one has to define the problem. Architectural design problems can also be referred to as being "wicked problems" in that they have no definitive formulation, no explicit "stopping rule," always more than one plausible explanation, a problem formulation that corresponds to a solution and vice versa, and that their solutions cannot be strictly correct or false. Tackling a problem of this type requires some initial insight, the exercise of some provisional set of rules, inference, or plausible strategy, in other words, the use of heuristic reasoning.

Design is often guided by heuristic reasoning involving solution images, analogies, or restricted sets of form-giving rules that partially and provisionally define the "ends" or solution state of a problem, i.e., what it should be like. Such heuristics, by virtue of the a priori knowledge that is incorporated, provide a framework for problem-solving behavior and exert a strong and dynamic influence over subsequent sequences of problem interpretation, solution generation, problem representation and solution assessment. During the course of designing one mode of heuristic reasoning may be found to be unproductive and give way to other kinds; co-mingling may even occur. As a result, design appears to be essentially an emergent phenomenon where new information about a problem is generated, evaluated together with a priori knowledge, and solution strategies amended accordingly.

TYPES OF HEURISTICS

Five classes of heuristics can be identified largely according to the kind of subject matter involved. They are: (1) the use of anthropometric analogies, (2) the use of literal analogies, (3) the use of environmental relations, (4) the use of typologies, and (5) the use of formal "languages." These classes were based on protocol analyses of architectural designers at work, mixed with some speculation. Each class is by no means exclusive of the characteristics of others, nor totally inclusive of the range of possible heuristics. Rather, the classification is one of practical convenience for grouping and discussing observations.

Anthropometric Analogies

The use of an anthropometric analogy employs a construct describing the physical occupancy of a space, with relational and metric qualities, that guides further design activity. This form of reasoning is often used by naive designers with little or no experience with other forms of heuristics. In one such case a person without any architectural background was observed producing a staircase design based upon imagining someone ascending through a room in a certain manner. The result was a graceful form for which the subject appeared to have no prior reference. Architecture may be peculiarly suited to this sort of process by virtue of the close correspondence that seems able to be attained between the act of visualization and the 3-dimensional artifact itself. Less naive designers may also resort to using this approach when others fail to yield satisfactory results.

Literal Analogies

This kind of heuristic incorporates borrowing of existing forms, or form-giving constructs, as a point of departure for structuring a design problem and for facilitating further information processing. They are literal analogies because in all cases the subsequent architectural forms that are derived match very closely the conformation of the physical analog. Here, a useful distinction can be made between iconic analogies and canonic analogies.5

The scope of references for the development of iconic analogies appears to be extremely broad. They can encompass objects from the natural world, or objects outside of architecture per se, such as LeCorbusier's admitted use of the shell of a crab for the roof of Ronchamp Chapel. [6]

They can also include imagery from some scene, painterly conception, or narrative account of real or imagined circumstances. Or they can incorporate, for their iconographic value, artifacts and elements squarely within the realm of architecture. The resulting analogy appears useful to a designer by virtue of its symbolic iconographical meaning, a meaning that is in some ways synonymous with an intention that, once realized, provides additional Structure to a problem from which other information can be organized.

Canonic analogies have as their basis "ideal" proportional systems usually manifested in the form of abstract geometrical patterns or shapes. Such configurations, like cartesian grids or platonic solids, are often employed as guidelines to give shape to design problems and to help ease transition into the realm of 2- and 3-dimensional design. In a less palliative manner, canonic analogies may be pursued almost as ends in themselves for the purpose of exploring possibilities for spatial organization and order.

Specific analogs are apt to possess simultaneously both iconic and canonic properties. For example, the architectural rendering of an essentially canonic form may itself symbolize iconographically a particular aesthetic position. [7] For some observers the ubiquity of the urban grid may be strongly identified with decentralized, non-authoritarian organizations, whereas for others the uniformity may symbolize control and oppression. However, the final distinction as to whether a particular literal analogy is iconic or canonic is both a matter of degree and a matter of the purposes to which it is put by a designer.

Environmental Relations

Here, use is made of a principle or set of principles, often derived empirically, that represents what appear to be appropriate relationships between man and his environment and between components of the building fabric. Typically, special information about behavior as a determinant of form, or the influence of other environmental factors, such as climate, physiography, materials and resource availability, are incorporated. Also included are principles describing the expected behavior of the material substance of the building itself. In many ways the typological class of heuristic, described in the next section, fits the same definition. However, the heuristic principles involved with environmental relations are not necessarily drawn from past building practice, do not necessarily represent "ideals" in the same manner as typologies, and the arguments inherent in the principles invariably reflect highly problem-oriented interpretations of the design constraints.

The logical structure behind the application of this kind of heuristic for solution generation seems to be: if problem "X" is encountered, then take formal action "Y," under conditions "Z." The principle involved, in effect, creates a bridge between a perceived problem and an ensemble of form-giving characteristics representing its potential solution. Alexander's "patterns" exhibit these properties, as do other relational constructs such as those dealing with structural behavior and "bubble diagramming" procedures that link preference information about physical adjacency to a 2- or 3-dimensional spatial arrangement.

Typologies

As heuristics, typologies allow one to make use of knowledge about past solutions to related architectural problems. Further, in a prototypical sense, they embody valid principles that appear to the designer to have exhibited constancy or invariance.

At least three sub-classes can be discerned.[9] First, there is the use of a building type as "a model," representing characteristics worthy of emulation, that seems to provide for the perceived needs, uses and customs found in a problem under consideration. Here, the symbolic meaning attributed to the type, "a model," is of as much importance as the organizational principles that are incorporated. Second, there is the "organizational typology" used primarily as a framework for solving problems concerning distributions of uses or conformation of functional elements. Third, there are "elemental types" representing prototypes for solving particular classes of problems that recur in different design situations; for example, the problem of "entry," methods of handling vertical circulation, and the problem of rendering the transition between the ground plane and a building.

In some ways this subclassification is arbitrary. A single building may incorporate all three dimensions and be "a model," an organizational framework, and provide a repertoire of solutions for particular kinds of sub-problems. However, it is not the completeness of the building type that is at issue here, but rather the purposes to which the type is put in order to guide problem-solving activity.

Most typologies implicitly possess iconic and canonic qualities in the sense discussed earlier in connection with literal analogies. The difference IS that the presence of these qualities in 'types" is confined to the realm of architectural expression, and that one of the intentions presumably behind the use of a typology is its quality of being "tried and true" in the formation of architecture. This property is not necessarily found in all literal analogies.

Formal "Languages"

In this classification the use of formal "languages" is a heuristic process where the content represents generalizations of the information inherent in other kinds of heuristics, particularly those involving typologies and man-environment relations. It is "languagelike" at least to the extent that the process's guiding structure imposes an internal consistency that allows for the meaningful ordering and "correct" functioning of formal elements. Explicit treatises on the "classical language," for instance, provide a repertoire of architectural elements, rules for their combination and transformation, and a prescription of the purposes for which various ensembles of elements are deemed most appropriate.10 The so-called "pattern language' is a no less deterministic method of reasoning, although ostensibly concerned in a different manner with architectural composition. No less highly developed "languages" may be idiosyncratic and derived from a constant way of doing things over an extended period of time. More often than not, this form of heuristic reasoning is to be found in the work of experienced designers.

HEURISTICS AND DESIGN BEHAVIOR

In practice each class of heuristic is by no means self-contained. Some designers may habitually use a small variety of heuristics, while others may be broader in their applications. Heuristic search through a "problem space" essentially involves the generation of solutions in a sequence of stages with evaluations of interim solutions being made at each stage. The new information provided by the evaluation is combined with prior knowledge about the problem structure in order to guide further steps. It is unknown beforehand if a particular sequence of steps will actually yield a solution. Or, to put it another way, it cannot be ascertained if a proposed solution is really a solution until the complete proposal can be made. [12] The types of heuristics discussed so far were defined by the type of a priori knowledge that they furnished and, therefore, their generative role in solution generation and evaluation.

Designers may employ one kind of heuristic at the outset of a problem and later abandon it in favor of another type. A designer may also switch back and forth between heuristics at either end of an imagined "iconic—canonic" or "subjective—objective" spectrum. Essentially, the power of each class of heuristic derives from the ability of its application to furnish new information about problem constraints (e.g. criteria, goals, objectives, etc.), and for providing fruitful avenues for responding to constraints that are already established.

New Information

One positive outcome of an appropriate course of heuristic reasoning is that it throws the problem under consideration into a new light. Consequently, both the scope of the problem (i.e., constraints) and the promise of various solution methods (i.e., courses of action) can be reinterpreted. The process has the effect of providing valuable new information. The testing procedures involved, such as the use of a principle about man-environment relations or organization of "type," provide this new information in at least 3 ways. First, the test provides information regarding the conformity of the proposed solution with known constraints. Second, it provides information regarding progress towards the overall goal of a solution, i.e., does the strategy appear to be working. Third, the heuristic can provide new information regarding other constraints not so far considered, i.e., problem re-definition.

Referential Bases

At a general level, the logical structure of solution generation within each heuristic class can be represented by a statement with three parts: condition, action and intent. The statement is usually expressed in the following manner: if condition "A" exists, then take action "B," for intent of "C. [14] Clearly, generative procedures of this form will automatically satisfy certain problem constraints. The constraints are incorporated within the generator itself. The same sort of thing can be said about each class of heuristic from which a particular generative procedure may be drawn.

For example, certain kinds of constraints are implicit in the use of "typologies" that may not be present in the use of particular literal analogies, and vice versa. Further, essentially the same kind of constraint may be able to be articulated in a different way from one heuristic class to another, materially affecting the final outcome.

The referential basis for the form-giving power of a heuristic, like one involving an analogy, derives from the correspondence between an intention, prevailing conditions and formal action. Further, designers often seem to know of and express intentions through examples at hand. Actions and intentions may become intertwined to the point where they are largely synonymous, attention is shifted, and a transposition occurs in the logical structure of reasoning to: if action "X" (intention "Y") then condition "Z." Consequently, the process of solving the problem takes on a character of being "end-justified" i.e., re-definition of the problem conditions to fit a proposed solution. This may appear to be perverse, but when one remembers the under-constrained nature of most design problems it can prove to be quite a plausible and even necessary approach.

Each class of heuristic so far described has its own self-referential rule structure, if logically extended, that is largely governed by the incorporated subject matter. For example, in a proportional device such as a 3 X 3 cube there are many implied patterns of 011hogonal and diagonal subdivision that can be exploited to give rise to a building form. [15] However, the full implications, or consequences, of such a model may not be fully perceived by the designer when the heuristic is first employed. Discrepancies between the ultimate consequences and those initially perceived usually result in "back-tracking," where designers retrench their positions and change from one line of reasoning to another. It has been observed when such difficulties are encountered that switches among classes of heuristics are Often made in directions most dissimilar from the type of heuristic last employed.

Independent Qualities

As mentioned earlier, the applications of all heuristics are at least partially problem oriented, i.e., methods of generating and assessing solutions are assembled that incorporate and show cognizance of the problem constraints that are explicitly given. On the other hand, constraints may be independently supplied by the heuristic process. [16] Heuristic classes, in the manner described, latently incorporate a priori constraints consistent with the subject matter of the class. In a particular problem application, some of these constraints are likely to be autonomous, or independent of the problem as given. Moreover, this may be very positive in helping to re-define the problem in a more complete manner. However, should the autonomy of the constraints be extremely pronounced, or superficial, there may also be a high risk of arbitrarily "end-justifying" the solution.

Order of Application

The sequential order in which various types of heuristics are brought to bear on the problem can materially affect the solution. Given the fair degree of problem independence in the constraint structure of each heuristic class, it probably makes a difference which kind of heuristic is employed in what order, and therefore the manner in which the problem becomes structured. The use of a particular heuristic, such as a building "type," will reveal the problem in a certain light, suggest solution strategies and tests, and consequently order the priority and scope of further problem-solving efforts. Furthermore, the residual effect of a heuristic strategy, long-since abandoned, is often manifested in the final solution.

Style

In the production of architecture, a major source of style is the design process itself,] [8] and hence the heuristic reasoning processes involved play a central role. Style is usually attributed to a building according to its features. As shown in preceding sections, these features, or final manifestations of a design process, are strongly determined by the classes of heuristics adopted, their use and interpretation, and the sequence in which the overall process unfolds. It is not only the structure of the process that is important but also the "object qualities" of the a priori "models" that are used.

Consistency in style among the output of particular designers can then be understood as a habitual way of doing things, of solving design problems. The tendency for this consistency to be most pronounced during particular times in an architect's career, say towards the end of stylistic episodes or "periods," is also understandable. A fluency in a particular way of designing and the consistency that comes with it are only reached from experience and constant development.

By extension, architectural style in the broadest sense may be regarded, in large measure, as being congruent with the collective adoption of certain design practices and forms of heuristic reasoning. When dominant forms no longer prove productive, they are replaced, and shifts in style can be observed. Undoubtedly social and cultural factors come into play and help shape and converge the design strategies that become commonly practiced. In fact, it is quite plausible that the individual discovery and sharing of information about the contemporary efficacy, or usefulness, of knowledge provided by commonly practiced heuristic types is the central mechanism in the process of stylistic change.

Role of Representation

The role of representation in heuristic reasoning cannot be underestimated. For it is through the reciprocity between mind and image involved in rendering a solution that judgements or tests are applied and new information generated. [19]

In this context, the act of drawing can be either a deductive or an inductive process. It is deductive in the sense of: "if this element is here and that element is over there, then under the current line of reasoning, this other element must be placed so." Under a particular heuristic mode, it essentially involves re-writing the problem from one state to the next. It is inductive in the sense of finding patterns among the "markings" representing an understood state of the problem that suggest other ways of looking at the situation,
i.e., that result in alternative lines of heuristic reasoning. Either way, drawing is a process of discovery: of becoming aware of formal arrangements and possibilities.

How a drawing is made, and therefore what view of the problem is offered, can either facilitate or inhibit the design process. Generally, in the course of design, drawing proceeds from referential sketches through consolidation in a "parti," or diagram, to more definitive drawings. Of relevance to heuristic reasoning are the data compression and referential aspects of drawings as portrayals of design ideas. In many cases these characteristics have quite a personal meaning to an individual designer, as evidenced by the difficulty of interpretation encountered when others try to redescribe the drawing in other than mundane terms. Clearly the scale and precision of a drawing reveals certain qualities of a design solution that renderings of a different scale and precision might not accomplish. However, regardless of scale and precision, there is good reason to believe that the very type of rendering itself strongly influences its referential significance. For it is the choice medium, and what can effectively be represented in that medium, that governs the possible interpretations that might be given a rendering and, therefore, the type of reasoning that might be further exercised.

A BRIEF CASE STUDY

A brief case study will serve to illustrate some of the prior discussion. This particular case study is drawn from a detailed protocol analysis of a student's work and is used because it seems to be typical of many such protocols. The program for the project called for a hotel and a comprehensive health facility. The site included a lake and an existing hospital to which the proposed building complex was to be connected. The following narration and accompanying illustrations are extracts from the protocol and describe some of the key attempts at solution generation and evaluation, 20The quotations in the text indicate direct narration by the designer.

Initially, for planning purposes, the program was divided into the two parts just described, with a third element housing functions that were shared in common. The design process then proceeded from an intention . . . "to address and preserve the lake" . as a major part of the scheme. Here, the first move was to create a . . . "formal space next to the lake but to shield the space from the outside" . . or northern portions of the site. A "classical" building type served as the point of departure for linking the two major program elements (Figure 26—1). This choice was made because of the apparent correspondence between the example type and the problem at hand: location on the water, symmetry and formality, and the presentation of a rusticated facade protecting the public side of the site. However, there also appears to be simultaneity in the adoption of the type and the initial intention of enclosing a space by the lake, The intention derived as much from the example as it did from a study of the site without considering the type. In any event, the location of a formal space between the building and the lake edge, a continuing theme throughout the design, clearly derives from adoption of the particular reference.

Problems were immediately encountered with this arrangement due to the overpowering presence of the two program elements on either side of the central feature, namely the hotel and the health facility (Figure 26—2). As a consequence, the initial arrangement was generalized into a semi-circular plan for the hotel (Figure 26—3), with the structure . . . "defining a circulation path through the pieces at the base" and thus, "having

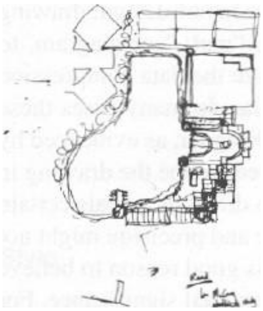

Figure 26—1 [Used by permission of Peter G. Rowel

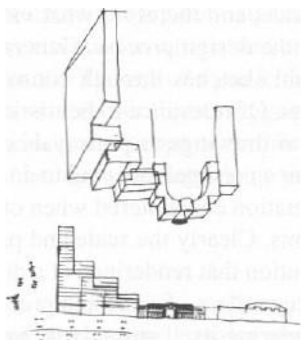

Figure 26-2 [Used by permission Of Peter G. Rowe]

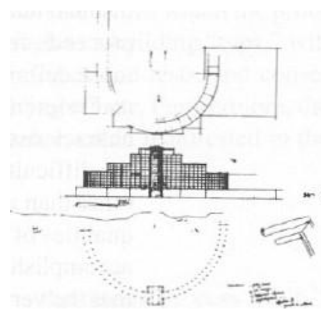

Figure 26—3 [Used by permission of Peter G. Rowe)

an ordering impact" . . . on the scheme. An attempt was then made to reconcile the asymmetrical program with the symmetrical spatial conception by elongating one arm of the composition and shifting the inward lakefront focus around to the eastern edge of the site.

Evaluation of the scheme at this stage revealed problems with the scale and shape of the hotel, and a lack of formal difference between the major functions of the health facility and the service functions of the hotel . . . "It was a problem with thinking of it (the health facility) just as a piece in a formal arrangement, so I started analyzing it as a separate piece" . . . Here, a shift occurred in the type of heuristic employed from a pre-occupation with formal composition derived from a building type to a concern with the geometry of structural bays and abstract functional arrangement of required facilities... "Basically I was trying to take a structural diagram, a functional diagram and a circulation diagram and combine them". . . (Figure 26—4). The result was an alternation of large and small structural bays within which circulation and functions of various sizes were appropriately accommodated. The same strategy was used to plan the service functions of the hotel . . . "Working strictly in sort of square bubbles, and (within) an understanding of proximity requirements, I tried to arrange the pieces so they would make sense". . .

With these problems at least partially resolved attention was again shifted to the overall plan of the complex . . . "The problem of bringing in an axis (with the symmetrical form) was that it had no relationship to everything else that was going on. If I was going to do this I would have to develop a relationship . . . so then I went back to looking at the whole site" . . . An axial composition then evolved with a progression associated with arrival from the main entrance to the site through to the lake, with the buildings distributed symmetrically about the axis. This also led to a realization that a formal outdoor space was required where you arrived at the building complex for functional reasons and in order to complete the composition. Further, . . . "I now felt that I was dealing with 2 major spaces: one at the end of the axis when you arrive, the other facing the lake . . . (also) . . . now I have a formal public arrival space and a more informal space facing the lake" . . .

However, the problem now became one of deciding which way the curvilinear form of the hotel should face "I realized I was trying to use the hotel piece to solve all problems and was having difficulty with this" . . . In fact, at this stage experiments were made with many different plan shapes (Figure 26—5). Ultimately, a decision was made to use a more simplified form of the hotel as a straight slab running across the site. This arrangement finally resolved the overall "diagram" or formal scheme of major elements in the project (Figure 26—6).

Within this framework, solutions to more detailed problems were developed. The open-ended expression of the primary circulation corridor, defined by the columns of the hotel slab, was terminated at the junction with semi-public functions in the form of a circular alcove (Figure 26—7). The columns themselves, and the section through the base of the hotel, were specially articulated to give a sense of grandeur to the public entry space (Figure 26—8), and to allow for a view through the building to the lake (Figure 26—9). The façade on the northern public face of the building was composed from a proportional grid with intervals determined so as to diminish the apparent scale of the building (Figure 26—10). This façade was further divided into a distinct "base," "middle" and "top," no doubt as an outgrowth of the classical references used earlier. A more informal textural treatment was proposed for the southern façade (Figure 26— I l), although again the organization properties of a grid are evident . . . and so the process continued. The only subsequent modifications to the formal arrangement of the plan arose through attempts to extend the already successful strategy of expressing site constraints. Several

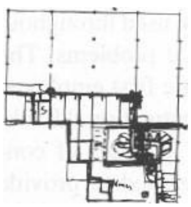

Figure 26—4 [Used by permission of Peter G. Rowe]

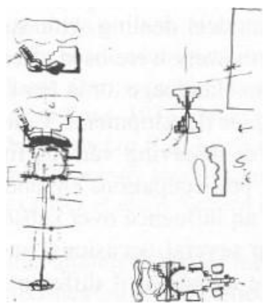

Figure 26—5 (Used by permission of Peter G. Rowel

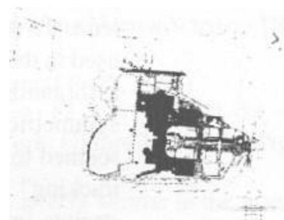

Figure 26—6 (Used by permission of Peter G. Rowe]

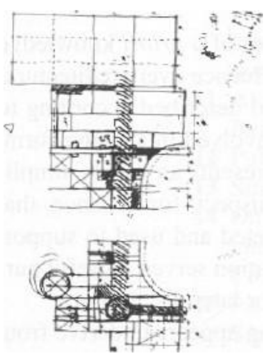

Figure 26-7 [Used by permission of Peter G. Rowe]

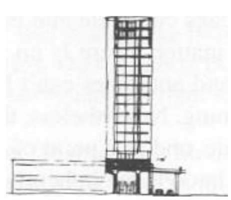

Figure 26—8 (Used by permission Of Peter G. Rowel

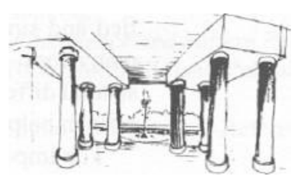

Figure 26—9 (Used by permission Of Peter G. Rowe]

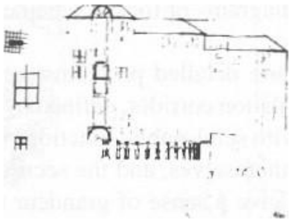

Figure 26—10 [Used by permission Of Peter G. Rowe]

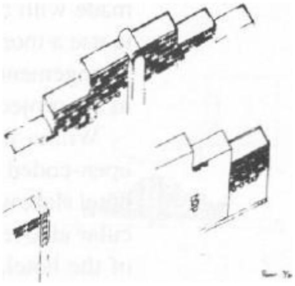

Figure 26—11 [Used by permission Of Peter G. Rowe]

lines at 45 degrees were introduced, relating the existing hospital with the building complex, with an additional purpose of helping organize a greater informality in the architecture along the lake front.

In this case several distinct lines of heuristic reasoning, where a priori knowledge was used to control the decision-making process, can be identified. The use of a specific building type, although more as an iconic analogy than as a typology, gave initial form to the project. Relational models dealing with structural organization and expressed preference for functional proximity were used effectively to solve specific layout problems. To some extent a formal language, or at least a set of "elemental typologies," was used in the sectional and facade developments. Canonic analogies were used throughout as organizational devices for resolving various functional and formal problems. The symmetrical compositional preoccupations engendered by the heuristic first employed seemed to persist, exerting an influence over subsequent lines of investigation. "Backtracking" could be seen on several occasions, and the independent qualities Of constraints introduced with the adoption of different heuristics often seemed to provide fruitful points of departure for subsequent design.

SUMMARY

The central thesis of this paper has been that the various classes of a priori knowledge incorporated in heuristic reasoning processes exert a strong influence over architectural design activity. Various types of heuristics were identified and described according to the type of knowledge that seemed to be most immediately involved in shaping form. This classification is by no means complete and probably represents an overly simplified and singular view of the matter. There is no reason to suspect, for instance, that many form-giving principles and analogies can't be multifaceted and used to support several different lines of reasoning. Nevertheless, the classification served a useful purpose in helping present the topic, and as a point of reference for later discussion.

The importance of a priori knowledge in heuristic reasoning appears to derive from the directness with which partial solution states of a problem can be provisionally specified, and thus orientation given to subsequent problem-solving activity, and from the independent qualities of the constraints that are offered. In architectural design a certain amount of "end-justification" and autonomy of constraints beyond the immediate problem context appear to be both unavoidable and necessary. However, misunderstanding of the consequent conditions implicit in following a particular line of reasoning can easily result in arbitrariness and capriciousness within the final design. Furthermore, superficiality in the number, type and complexity of constraints can also have disastrous effects on a solution. Finally, initial ideas, and the order in which various kinds of heuristics are employed, seem to have residual effects that strongly influence the degree to which "backtracking" and problem re-formulation can be satisfactorily accomplished.

NOTES

1 Herbert A. Simon, Allan Newell, and J. C. Shaw, "The Processes of Creative Thinking," in Contemporary Approaches to Creative Thinking, ed. H. E. Gruber and M. Wertheimer (New York: Lieber-Atherton, 1962), pp. 63—119; and Herbert A. Simon, "Structure of Ill-structured Problems," Artificial Intelligence 4 (1973),pp. 181—201.

2 C. West Churchman, "Wicked Problems," Management Science 4, no. 14 (1967), pp. 141=42; and Horst W. J. Rittel, "0n the Planning Crisis: Systems Analysis of the First and Second Generations," Bedriftskonomen, no. 8 (1972), pp. 390—96.

3 G. Polya, How to Solve If (London: Anchor Books, 1957).

4 The protocol analyses involved extensive interviews with designers conducted at various stages during a design problem. During the interview, the subjects were asked to reconstruct, with the aid of sketches, how they solved the problem. This narration was tape recorded and copies made of the salient drawings.

5 Geoffrey Broadbent, Design in Architecture: Architecture and the Human Sciences (New York: John Wiley & Sons, 1973), chapter 2.

6 LeCorbusier, The Chape/ at Ronchamp (London: Architectural Press, 1958).

7 Alan Colquhoun, "Typology and Design Method," Perspecia 12 (1967), pp. 71—74.

8 Christopher Alexander et al., A Pattern Language (New York: Oxford University Press, 1977).

9 This classification, although derived for different reasons, is very similar in the manner in which characteristics are distinguished to the five-class system proposed by Vidler. Anthony Vidler, "The Idea of Type: The Transformation of the Academic Ideal, 1750-1830," Oppositions 8 (1977), pp. 95-115.

10 A. Palladio, I Quattro Libri Dell'Architettura (London: Ware Edition, 1738); JeanNicholas-Louis Durand, Precis des Lecons d'Architecture Donnees a l'Ecole

Polytechnique, 2nd ed. (Paris, 1813); and John Summerson, The Classical Language of Architecture (Cambridge, MA: The MIT Press, 1979).

11 Alexander et al., A Pattern Language; and Christopher Alexander, The Timeless Way of Building (New York: Oxford University Press, 1979).

12 Polya, How to Solve It.

13 Simon, Newell, and Shaw, "The Processes of Creative Thinking."

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18 Ibid. and E. H. Gombrieh, Art and Illusion: A Study in the Psychology of Pictorial Representation (New York: Pantheon).

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20 The case study used to illustrate this paper is drawn from the work of Elizabeth Rupp, a recent graduate student at the School of Architecture, Rice University.

Author's Comment: The term "a priori knowledge" as used in this essay simply means knowledge acquired before tackling a particular design problem, rather than an attempt to become involved in the broader philosophical question of innate or empirically derived knowledge.