Computers, design theory and the handling of the qualitative

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Although discussion of quantitative matters, ranging from the geometry of classical forms to the dynamics of thermal performance, has figured prominently in the literature of architectural criticism and practice from its earliest records, it has almost always been assumed by both practitioners and consumers of architecture that in the end it is the qualitative considerations, such as comfort, convenience, aesthetics, amenity and the expression of Man's spirit, that architecture is all about. Neither the 'form-follows-function' philosophical school, nor the 'dammit-the-place-should-at-least-keep-the-rain-out' consumer attitude, denies this assumption. Clearly there is a subtle relationship between the quantitative facts of a building's structure and the qualitative experience of living within it, but it is significant that architecture has been more often proclaimed Queen of the Arts than Father of Technology. It is therefore not surprising that one of the chief justifications claimed for computer-aided architectural design by at least some of those (1) who are trying to adopt it is that the computer could free the architect from burdensome preoccupation with (largely quantitative) chores and thus permit him to spend more of his time and energy on the handling of the (mainly qualitative) broader issues. If this aim is not close to the forefront of the consciousness of many of the people engaged in constructing CAAD techniques now, there are very good grounds for deciding that it should be so in the future. For one thing, there is growing public concern for the environment, the quality of life and the urban scene. For another, there is the sad fact that amongst large sections of the populations of urban societies the work of modern architects and planners is seen as unlovely, incompetent and de-humanising, if not actually baleful and repressive (2). Many will feel that the adoption of the computer as a tool by those architects and planners is as likely to
make things worse as it is to make them better. The present author believes that architecture "ought" to be about the quality of the built environment, he is committed to the development of computer aids, and here tests the (to him) vital hypothesis that CAAD permits the architect to improve his performance in the handling of the qualitative.

Direct evidence is hard to come by. There does not seem to be in the literature a single case of measurement being made of the proportion of time spent by an architect on qualitative and quantitative considerations respectively, or of the distribution of energy, skill or priorities between them. Even studies of the quality of building performance are rare. Where comparative studies have been made of projects conducted with and without computer aids (3) there is nothing to show whether in these cases the architect was able to devote more effort or less to the qualitative side, or whether the resulting designs were better or worse in qualitative respects. One is therefore forced to rely on the less direct evidence of the structure of the CAAD packages which are becoming available. Do they provide architects with the opportunity for handling qualitative considerations? Do they permit the completion of a design in fewer man/hours or at less cost, thus releasing time and/or money for devotion to the qualitative issues? Do they provide decision models for qualitative problems?

The third of these three questions is the most challenging, and requires some amplification. Can qualitative considerations be modelled at all? What do we mean by "qualitative"? The Shorter Oxford Dictionary defines qualitative as: "that which is concerned with degrees of excellence, relative nature or kind or character; as opposed to quantitative". The qualitative is thus that which is essentially relative, that is to say, that which has no fixed units of measurement. Beauty, comfort and convenience are examples of the qualitative. The author has argued in detail elsewhere (4) that although the qualitative cannot be measured on ratio scales or interval scales, like length or temperature, it can always be measured, in the strict meaning of that term, on ordinal or nominal scales (fig. 1). The term "measurement" means "the allocation of signs (usually numbers) to objects or events according to rules" (5). In the ordinal scale the numbers 1st, 2nd, 3rd, etc are assigned according to the rule that they have order but not magnitude. Thus we know at once that 2nd comes before 4th but we cannot tell whether the interval between 2nd and 3rd is greater or less than that between 3rd and 4th, or between 3rd and 15th, for that matter. We could just as well have used the letters of the alphabet, or triangles, circles and squares, instead of numbers, except that numbers are handier. It is important to note that the ordinary rules of quantitative arithmetic do not apply to the ordinal numbers. They cannot be added and subtracted, or multiplied and divided. That is not to say, however, that mathematical operations cannot be applied to ordinal information. On the contrary, the whole of the mathematics of inequalities, mathematical
non arbitrary zero constant unit

0 1 2 3 4 5 6 7

Ratio scale
eg. length

arbitrary origin unit assumed constant

0 1 2 3 4 5 6

Interval scale
eg. temperature

order no unit

1st. 2nd. 3rd. 4th. 5th.

Ordinal scale
eg. preference

no order membership

+ No.1 + No.5
+ No.3 +
+ No.6 +
+ No.2

Nominal scale
eg. football players' shirts

Figure 1 SCALES OF MEASUREMENT

design building value use users'

DECISIONS PROPERTIES ATTRIBUTES OBJECTIVES GOALS

eg. dimensions eg. space eg. convenience eg. traffic flow eg. survival
dimensions eg. space eg. convenience eg. traffic flow eg. survival
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Figure 2 DESIGN AND FUNCTION
logic and decision trees are fully applicable to data measured on ordinal scales, as are the techniques and statistics of ranking (6).

In the nominal scale the cardinal numbers 1, 2, 3, etc are assigned according to the rule that they have identity but neither magnitude nor order. The numbers on footballers' shirts or on the route indicators of buses, tell us who they are, and whereabouts we are likely to find them, but no more. Nominal scales are the scales of taxonomy or classification. We cannot add, subtract, multiply, divide or even rank the numbers on nominal scales. We can, however, perform the operations of union and intersection, and and the other techniques from set theory, as well as their developments in numerical taxonomy (8). There are even a few statistical operations we can perform. The literature of the social sciences is packed with descriptions of techniques for handling qualitative information (7). There is thus no reason whatever why computer models should not be built for the handling of qualitative considerations in architecture. The widespread, fallacious and dangerous belief that information has to be in quantitative form for manipulation by computer has never been more debilitating for a field of applications development than it has here. The AND, OR and NOT gates, derived from set theory, and the GREATER THAN, LESS THAN tests, derived from the mathematics of inequalities, are far more fundamental to computer logic than the rules of arithmetic, which are themselves no more than special cases of general logic.

To track back through our nest of questions, we must ask again: Do the CAAD packages which are becoming available provide decision models for qualitative considerations in architecture? Very few of the packages described in the literature are real, or available, in the sense that any architect has much prospect of being able to design a real building with them in their present or currently planned state of development. Most are academic, in the sense that they are calculated mainly to advance knowledge, rather than practical, even in ultimate intention. According to a recent survey, (9) none has any capability for modelling the qualitative. To go back one more question: Do the emerging packages permit the completion of a design in fewer man/hours or at less cost, thus releasing time and/or money for devotion to the handling of qualitative issues by traditional means? In at least one case (10) time and cost advantages can be predicted, so here, at last, we find a positive indication. In this case, too, the structure of the package is such as to allow the architect to apply his sensibility to qualitative considerations when examining his own and the computer's drawings and tabular information, and to modify the design accordingly. In this particular package, the architect designs and the computer backs him up. Where the computer actually "optimises" the design under given constraints the architect may be at some disadvantage when trying to modify the design in the light of other, subjective, considerations (11). In either of these cases, one is dependant upon the willingness of the architect under all sorts of practical, economic and timetable pressures.
to use the found-time, and the over-ride facilities provided towards such ends. Human nature being what it is, for much of the time, he is likely to let things be. And herein lies cause for alarm. From the field of applications of computer-aided design in engineering there have been vociferous complaints (12) that in actual practice economic and timetable pressures do NOT permit designers to apply more, or even as much consideration to comfort, convenience, aesthetics, amenity and the expression of Man's spirit. Where economic pressures have made things de-humanised, baleful and repressive before, it is said, computer-aided design tends to make them even more de-humanised, baleful and repressive after. Is this going to be true of computer-aided architectural design as well? The answer lies as much in the state of the art of designing as it does in the science of computing.

Although a building is judged by its attributes, such as appropriateness of form, economy of construction, and so on, its embodiment consists in physical entities, and its conception comprises dispositions of information. The nature of these relationships is important (fig. 2). Design decisions will describe the geometry, dimensions and materials of the building and its components. These decisions are based upon the manipulation of information and are themselves information. The building itself will comprise physical entities, exhibiting properties, such as volume, weight, strength and cost. However, metres, kilograms and pounds sterling are neutral. They are neither good nor bad, economic nor uneconomic, in themselves. When we say the building is compact and convenient but expensive, we are attributing value-based qualities to it. Compact by what standards? Convenient in relation to what sorts of activity? Expensive as compared with what alternative? The qualities attributed to a particular building will depend upon the witness's objectives in relating with it. The developer will take one view, the purchaser another, and the occupant a third. The set of objectives which constitutes the basis for the architect's brief comprises the union of the sets of objectives of all the people who will have a say in the siting, construction and use of it. These objectives in turn arise from the pattern of goals and values of the people concerned. So far, almost the whole of the development of design theory and practice has concentrated on modelling the relations between design decisions and building properties. Apart from a rather limited concern with the geometry of good form, in either the classical or the Gestalt sense, there has been little effective work on the relations between the properties and value attributes (13). There has been even less on the relations between the attributes to which people attach value, and the objectives which they are trying to pursue. As materials and the methods of construction have proliferated, and as economic pressures have demanded closer and closer attention to the minimisation of redundancy in construction, so attention to the refinement of decision/property models has increased. The failure of the professions concerned to develop similar predictive models for the property/attribute relationships, or at the very least to
set up adequate ethical controls over the handling of them, is the root cause of public disenchantment with the professions' performance.

The absence of computer models for qualitative considerations is thus not so much due to uneven development on the computer side, as it is to uneven development in the underlying arts and sciences of designing. In a sense, however, this makes matters worse. If the underlying arts had been strong enough, traditional methods could have taken over for the handling of the qualitative, within the framework of a computer-aided activity, and/or computer techniques for the handling of qualitative matters could have been expected to emerge reasonably quickly. To be fair to the underlying art, it can be argued on the other hand that until the availability of low-cost aids in the manipulation of mathematical logic approaches the level of availability of aids such as scale-rules, slide rules, nomographs and adding machines in the manipulation of quantities, non-quantitative logic will remain behind. Computer people themselves have been slow to offer the advantages of computers in this respect. As it is, how does one expect the working architect, even if he has the wit, the will and the sensibility to do so, firstly to spend the time seeking alternative, qualitatively superior, solutions to problems he already has an answer for, and secondly to spend even more time persuading client, contractor and taxpayer that (say) design B is preferable to design A in qualitative terms, despite the instant, unequivocal and quantitative evidence produced by the computer that A is better the B in every other respect? The author is therefore reluctantly compelled to conclude that under present conditions CAAD does not permit the architect to improve his performance in the handling of the qualitative. Moreover, he suspects that unless something specific is done to prevent it, when the first generation of CAAD buildings is exposed before the critical gaze of the non-committed public, the occasion could be the signal for another outburst, more or less justified, of accusations of a further de-humanising of the built environment.

The next question is: What is to be done about it? It is suggested that the future development of CAAD should be constrained under four conditions, in descending order of priority. Firstly, and most importantly, the profession as a body should apply ethical controls to ensure that under no circumstances will the introduction of CAAD be allowed to reduce the amounts of time, money and effort which an architect is able to spend in dealing with the qualitative aspects of his designs, or to prevent him from over-riding and modifying machine-generated designs where his professional judgement demands this. In this respect the architectural profession is in a stronger position than the engineer, and this strength should not be wasted.

Secondly, every persuasion should be offered to those working on CAAD developments to include in the structure of their packages means for ensuring that the user architect has adequate time, information and control opportunities for handling the qualitative aspects of building design. This should apply to all packages currently under development.
Thirdly, those engaged in supporting or conducting research relating to design methods and management in architecture should give a high priority to studies calculated to raise the level of understanding of the property/attribute relationship nearer to the level reached in respect of the decision/property relationship. This would necessarily involve extensive field studies to improve the data base, fundamental studies on the mathematical modelling of qualitative relationships, the development of trouble-free everyday techniques, and, of course, the preparation of a great deal of teaching material. This recommendation relates as much to the improvement of manual practice as it does to computer-aided practices, and as much to non-architectural disciplines as it does to architecture.

Fourthly and lastly, a proportion of the effort devoted to CAAD should be directed towards the computer modelling of the property/attribute relationship. It could well turn out that the adequate integration of qualitative with quantitative considerations could never have come about without computer aids. If so, then the risk in the present situation will have been worth taking. There are many who feel that Man's relationship with his environment has reached a critical condition, in which the continued pursuit of past trends in technology, commerce and social organisation spell disaster. The case against computer-conducted, quantity-based, building design 'optimisation' is strong. Since charity begins at home, let us resolve to see that the ethical control over the direction of the development of CAAD begins here.
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