Fourth Edition

How Designers Think

The design process demystified

Bryan Lawson

Architectural Press

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Measurement, criteria and judgement in design

'She can't do Substraction,' said the White Queen. 'Can you do Division? Divide a loaf by a knife – what's the answer to that?' 'I suppose-' Alice was beginning, but the Red Queen answered for her. 'Bread-and-butter of course.'

Lewis Carroll, *Alice Through the Looking Glass*

There's no such thing as a bad Picasso, but some are less good than others.

Pablo Picasso, *Come to Judgement*

Measuring the success of design

In the last chapter we saw how a design solution is characteristically an integrated response to a complex multi-dimensional problem. One element of a design solution is quite likely simultaneously to solve more than one part of the problem. But how good a response is a design solution to its complex problem? How can we choose between alternative design solutions? Is it possible to say that one design is better than another and, if so, by how much? The question before us in this chapter, then, is the extent to which we can measure the degree of success of the design process.

It is far from easy to answer this question. In order to see how difficult it is, we shall consider the design of a garden greenhouse. There are a number of features of a greenhouse which can be varied. While the body of a greenhouse must inevitably be mainly glass, we have more choice when it comes to the frame. We might at least consider wood, steel, aluminium and plastic. The actual form of the greenhouse is even more variable with possibilities of domes, tent shapes, barrel vaults and so on. In fact there are many more design variables including the method of ventilation and type of door, the floor and foundation construction and so on. What the designer has to do is to select the combination of all these features which will give the most satisfactory performance. How then do we measure the performance of our greenhouse? The primary purpose of a greenhouse is clearly to trap heat from the sun, so we can begin by measuring or calculating the thermal efficiency of a whole range of possible greenhouses. Unfortunately, we are still some way from describing how satisfactory our greenhouse will appear to individual gardeners. They may well also want to know how much it will cost to buy, how long it will last, or how easy it will be to erect and maintain, and probably, what it will look like in the garden. The greenhouse then, must satisfy criteria of solar gain, cost, durability, ease of assembly, appearance and perhaps many others.

If we imagine that we want to assess a number of design solutions so that we can put them in order of preference we would need to begin by assessing each design against each of the criteria and then somehow combining these assessments. This leaves us with three difficulties. First, the various criteria of performance are not likely to be equally important, so some weighting system is needed. Second, performance against some of the criteria can easily be measured while in other cases this is more a matter of subjective judgement. Finally, we then have the problem of combining these judgements together into some overall assessment.

The problem of numbers and counting systems!

Of course what all this means is that measurement in design involves both quantities and qualities. Somehow, then, designers must be able to balance both qualitative and quantitative criteria in their decision-making process. We shall return to this again after a small detour to examine the range of systems available to us for recording judgements.

Quantities and qualities actually turn out not to be so different from each other as we usually assume. This is because it is not sensible to talk of a quantity as if that were a single concept. We normally measure and express quantities by counting using a numerical system. This leads us to believe that all numbers behave in the same way and this is quite untrue. Actually, we commonly employ several quite distinct ways of using numbers, without really being aware of the differences. This carelessness with numbers can be fatal if we are trying to make the sort of judgements needed in design. Numerical systems differ in the extent to which they impose rules on the way the numbers work as we move along the scale.

Ratio numbers

The numerical system which has the most demanding set of rules is known as the ratio scale. It is this scale which we tend to assume is in operation whenever we see a number, and it is the numerical scale with which we are most familiar (Fig. 5.1).

When counting objects we use this ratio scale of measurement which allows us not only to say that four is twice two but also that eight is twice four. So it is normal and correct to assume that a person on their twentieth birthday is twice as old as someone who is only ten. In turn a forty-year-old will be twice as old as the person celebrating their twentieth birthday. The scale or ruler offers us the most obvious form of ratio measurement, and we can see that the ratio of three centimetres to one centimetre is exactly the same as the ratio of six centimetres to two. This way of using numbers would thus be used in comparing the lengths or sizes of our greenhouses.

Interval numbers

However, not all the scientific measurements we could make on our greenhouse rely on ratio numbers. If we consider, not the amount of light allowed in, but the temperature inside the greenhouse we must be careful! On a sunny winter's day it might be reasonable to expect our greenhouse to achieve an indoor temperature of say

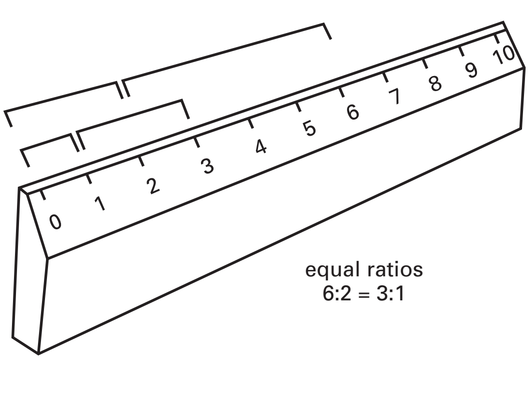

Figure 5.1
Distance is measured using the ratio numerical system

20 degrees centigrade when the outside air was only 10 degrees. Confusingly, we cannot say that the temperature inside the greenhouse is twice that outside (Fig. 5.2)!

Why this should be can be seen by using both our common temperature scales together. The outside temperature of 10 degrees centigrade can also be described as 50 degrees Fahrenheit, whilst the inside temperature of 20 degrees centigrade corresponds to about 68 degrees Fahrenheit. Thus these two temperatures give a ratio of 20 to 10 or 2 to 1 on the centigrade scale, but a ratio of 68 to 50 on the Fahrenheit scale.

This is because the zero point on these scales is not absolute but entirely arbitrary. The centigrade scale is actually defined as having one hundred equal intervals between the freezing and boiling temperatures of water. We could equally easily use the freezing and boiling temperatures of any other substance and, of course, any number of intervals between. These temperature scales are described as interval measurement. Although 20 degrees cannot be described as twice as hot as 10 degrees the difference, or interval, between 20 and 10 is exactly equal to the interval between 10 and 0.

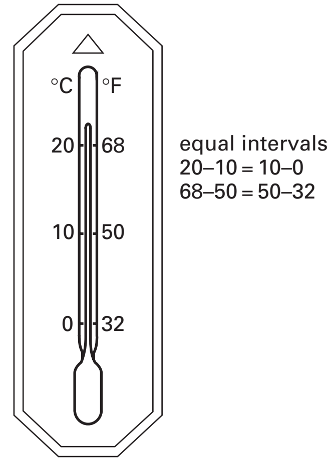

Figure 5.2
Temperature must be measured using the interval numerical system

Interval scales are frequently used for subjective assessment. Psychologists recommend that such scales should be fairly short, up to seven intervals, to retain the reliability of the interval. Thus to return to our greenhouse, we might ask a number of gardeners to assess the ease of assembly or maintenance on five-point scales. We must be careful to remember, then, that we are not justified in regarding a greenhouse assessed as four for assembly as being twice as easy to assemble as one assessed as only two.

Ordinal numbers

Sometimes we use an even more cautious scale of measurement where not even the interval is considered to be reliably consistent. Such scales are called ordinal, for they represent only a sequence or order (Fig. 5.3). If we take the final league table for the English Football league in 1930 (a year chosen purely at random!) we find that Leeds finished fifth, Aston Villa fourth, Manchester City third, Derby were second and Sheffield Wednesday were first. However, closer inspection reveals that the finishing positions of these teams, which are measured on an ordinal scale, are rather misleading compared to the number of points they scored, which are

FIRST DIVISION	P	W	D	L	F	A	Pts
1 Sheff Wed	42	26	8	8	105	57	60
2 Derby	42	21	8	13	90	82	50
3 Man City	42	19	9	14	91	81	47
4 Aston Villa	42	21	5	16	92	83	47
5 Leeds	42	20	6	16	79	63	46
6 Blackburn	42	19	7	16	99	93	45
7 West Ham	42	19	5	18	86	79	43
8 Leicester	42	17	9	16	86	90	43
9 Sunderland	42	18	7	17	76	80	43
10 Huddersfield	42	17	9	16	63	69	43
11 Birmingham	42	16	9	17	67	62	41
12 Liverpool	42	16	9	17	63	79	41
13 Portsmouth	42	15	19	17	66	62	40
14 Arsenal	42	14	11	17	78	66	39
15 Bolton	45	15	9	18	74	74	39
16 Middlesbrough	42	16	6	20	82	84	38
17 Man United	42	15	8	19	67	88	38
18 Grimsby	42	15	7	20	73	89	37
19 Newcastle	42	15	7	20	71	92	37
20 Sheff United	42	15	6	21	91	96	36
21 Burnley	42	14	8	20	79	97	36
22 Everton	42	12	11	19	80	92	35

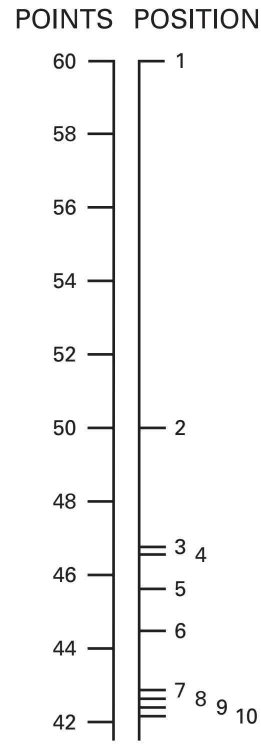

Figure 5.3
Rankings are an example of ordinal numbers

measured on a ratio scale. The third, fourth and fifth placed teams were only separated by one point, while Derby were three points clear of them, but Sheffield Wednesday were a massive ten points ahead of Derby. Regulations require that the materials used in buildings should not allow flame to spread across their surface in case of fire. Materials can belong to one of five surface spread of flame classes which range from class 0 to class 4. On this ordinal scale the higher the number the more rapidly flame will spread, but the difference between class 1 and class 2 is not necessarily the same as the difference between class 2 and class 3.

We also get ordinal scales when we ask people to rank order their preferences. Thus we could ask our gardeners to place a number of greenhouses in order of attractiveness of appearance. Whether ordinal or interval scales of assessment are appropriate remains a matter of judgement but, generally, ordinal scales should be used where the assessment may depend on many factors or where the factors cannot easily be defined. Thus while it seems reasonable to ask our gardeners how much easier it is to assemble one greenhouse than another, it does not seem reasonable to ask how much more attractive it may be. Academic examiners may award marks out of one hundred for a particular examination, which is really an interval scale since the zero point is rarely used. Overall degree classifications, however, are usually based on the cruder ordinal scale of first, upper and lower second, third and pass.

Nominal numbers

Finally the fourth, least precise numbering system in common use is the nominal scale, so called because the numbers really represent names and cannot be manipulated arithmetically. Staying with our football example, we can see that the numbers on the players' shirts are nominal (Fig. 5.4). A forward is neither better nor worse than a defender and two goalkeepers do not make a full back. In fact there is no sequence or order to these numbers, we could equally easily have used the letters of the alphabet or any other set of symbols. In fact, some rugby teams traditionally have letters rather than numbers on their backs as if to demonstrate this fact. The only thing we can say about two different nominal numbers is that they are not the same. This enables the referee at the football match to send off an offending player, write the number in his book, and know that he cannot be confused with any other player on the pitch. It used to be the case that the numbers on football players' shirts indicated their position on the field, with goalkeepers wearing '1' and so on.

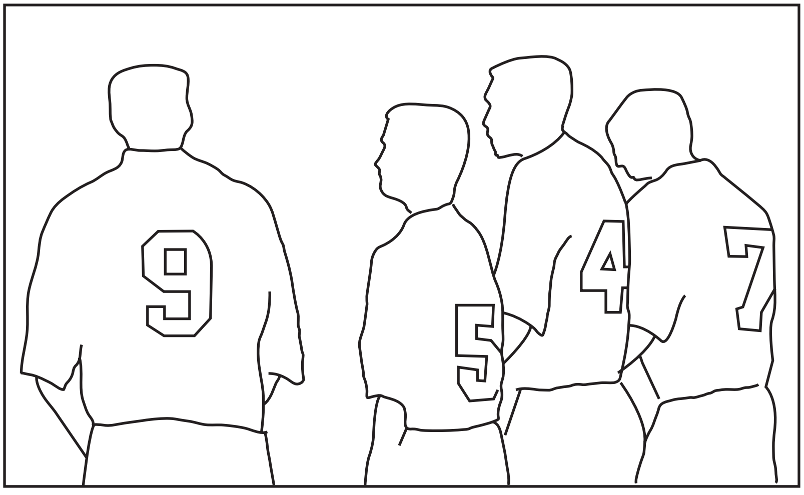

Figure 5.4
Numbers used as names – the nominal numerical system

The introduction of so-called 'squad numbering' removed this meaning from the numbers and was not surprisingly objected to by the traditionalist supporters.

Combining the scales

It is apparent, then, that only numbers on a true ratio scale can be combined meaningfully with numbers from another true ratio scale. We cannot combine temperatures from different scales, and certainly we cannot add together numbers from different ordinal scales of preference. Imagine that we have asked a number of people to assess several alternative designs by placing them in order of preference. These rank scores are of course ordinal numbers. We simply cannot add together all the scores given this way to a design by a number of judges. One judge may have thought the first two designs almost impossible to separate, whilst another judge may have thought the first-placed design was out on its own with all the others coming a long way behind. The ordinal numbers simply do not tell us this information. Tempting though it may be to combine these scores in this way, we should resist the temptation!

One of the most well-known cases of such a confusion between scales of measurement is to be found in a highly elaborate and numerical model of the design process devised by the industrial designer and theoretician, Bruce Archer. He, apparently somewhat reluctantly, concedes that at least some assessment of design must be subjective, but since he sets up a highly organised system of measuring satisfaction in design, Archer (1969) clearly wants to use only ratio scales. He argues that a scale of 1–100 can be used for subjective assessment and the data then treated as if it were on a true ratio scale. In this system a judge, or arbiter as Archer calls him, is asked not to rank order or even to use a short interval scale, but to award marks out of 100. Archer argues that if the arbiters are correctly chosen and the conditions for judgement are adequately controlled, such a scale could be assumed to have an absolute zero and constant intervals. Archer does not specify how to 'correctly choose' the judges or 'adequately control the conditions', so he seems rather to be stretching the argument.

In fact Stevens, who originally defined the rules for measurement scales, did so to discourage psychologists from exactly this kind of numerical dishonesty (Stevens 1951). It is interesting to note that psychology itself was then under attack in an age of logic as being too imprecise to deserve the title of science. Perhaps for this reason, many psychologists have been tempted to treat their data as if it were more precise than Stevens's rules would indicate. Archer's work seems a parallel attempt to force design into a scientifically respectable mould. Archer was writing at a time when science was more fashionable than it is today, and in a period during which many writers on the subject thought it desirable to present the design process as scientific.

Value judgement and criteria

It is frequently tempting to employ more apparently accurate methods of measurement in design than the situation really deserves. Not only do the higher level scales, ratio and interval, permit much more arithmetic manipulation, but they also permit absolute judgement to be made. If it can be shown that under certain circumstances 20 degrees centigrade is found to be a comfortable temperature, then that value can be used as an absolutely measurable criterion of acceptability. Life is not so easy when ordinal measurement must be used. Universities use external examiners to help protect and preserve the 'absolute' value of their degree classifications. It is, perhaps, not too difficult for an experienced examiner to put the pupils in rank order. However, it is much more difficult to maintain a constant standard over many years of developing curricula and changing examinations. It is tempting to avoid these difficult problems of judgement by instituting standardised procedures. Thus, to continue the example, a computer-marked multiple choice question examination technique might be seen as a step towards more reliable assessment. But there are invariably disadvantages with such techniques. Paradoxically, conventional examinations allow examiners to tell much more accurately, if not entirely reliably, how much their students have actually understood.

Precision in calculation

It is easy to fall into the trap of over-precision in design. Students of architecture sometimes submit thermal analyses of their buildings with the rate of heat loss through the building fabric calculated down to the last watt. Ask them how many kilowatts are lost when a door is left open for a few minutes and they are incapable of answering. What a designer really needs is to have some feel for the meaning behind the numbers rather than precise methods of calculating them. As a designer you need to know the kinds of changes that can be made to the design which are most likely to improve it when measured against the criteria. It is thus more a matter of strategic decisions rather than careful calculations.

Perhaps it is because design problems are often so intractable and nebulous that the temptation is so great to seek out measurable criteria of satisfactory performance. The difficulty for the designer here is to place value on such criteria and thus balance them against each other and factors which cannot be quantitatively measured. Regrettably numbers seem to confer respectability and importance on what might actually be quite trivial factors. Axel Boje provides us with an excellent demonstration of this numerical measuring disease in his book on open-plan office design (Boje 1971). He calculates that it takes on average about 7 seconds to open and close an office door. Put this together with some research which shows that in an office building accommodating 100 people in 25 rooms on average each person will change rooms some 11 times in a day and thus, in an open plan office Boje argues, each person would save some 32 door movements or 224 seconds per working day. Using similar logic Boje calculates the increased working efficiency resulting from the optimal arrangements of heating, lighting and telephones. From all this Boje is then able to conclude that a properly designed open-plan office will save some 2000 minutes per month per employee over a conventional design.

The unthinking designer could easily use such apparently high quality and convincing data to design an office based on such factors as minimising 'person door movements'. But in fact such figures are quite useless unless the designer also knows just how relatively important it is to save 7 seconds of time. Would that 7 seconds saved actually be used productively? What other, perhaps more critical, social and interpersonal effects result from the lack of doors and walls? So many more questions need answering before the simple single index of 'person door movements' can become of value in a design context.

Scientists have tended to want to develop increasingly precise tools for assessing design, but there is little evidence that this actually helps designers or even improves design standards. Paradoxically, sometimes it can have the opposite effect to that intended. For example, whilst we may all think daylight is an everyday blessing for each of us, not so when it comes to lighting calculations. A series of notional artificial mathematical sky models have been created from which the sun is totally excluded. The 'daylight factor' at any point inside a building is then calculated as the portion of one of these theoretical hemispheres which can be seen. Since the more advanced of the mathematical models do not define the sky as uniformly bright, the whole process involves highly complex solid geometry. In a misguided attempt to help architects, building scientists have generated a whole series of tools to help them calculate the levels of daylight in buildings. Tables, Waldram diagrams and daylight protractors, together with a whole series of computer programs have been presented as tools for the unfortunate architect. Now these tools all miss the point about design so dramatically as to be worthy of a little further study (Lawson 1982).

First, they all require the geometry of the outside of the building and the inside of the room in question to be defined, and the shape and location of all the windows to be known. They are purely evaluative tools which do nothing to suggest solutions, but merely assess them after they have been designed. Second, they produce apparently very accurate results about a highly variable phenomenon. Of course the level of illumination created by daylight varies from nothing at dawn to a very high level, depending on where you are in the world and the weather, and returns to nothing again at dusk. Thankfully the human eye is capable of working at levels of light 100,000 times brighter than the minimum level at which it can just work efficiently, and we make this adjustment often without even noticing! So the daylight tools indicate a degree of precision which is misleading and unnecessary. Third, the daylight tools are totally divorced from other considerations connected with window design such as heat loss and gain, view and so on as we saw in the previous chapter. Such a lack of integration makes such tools virtually useless to the design. It has been found, not surprisingly, that such tools are not used in practice (Lawson 1975a) but they are still in the curriculum and standard textbooks of many design courses.

The danger of such apparently scientifically respectable techniques is that sooner or later they get used as fixed criteria, and this actually happened in the case of daylighting. Using statistics of the actual levels of illumination expected over the year in the United Kingdom, it was calculated that a 2 per cent daylight factor was desirable in schools. It then became a mandatory requirement that all desks in new schools should receive at least this daylight factor. The whole geometry of the classrooms themselves was thus effectively prescribed and, as a result, a generation of schools were built with large areas of glazing. The resultant acoustic and visual distraction, glare, draughts, the colossal heat losses and excessive solar gain in summer, which were frequently experienced in these schools, eventually led to the relaxation of this regulation. In many areas, programmes were then put in place to fill in windows to reduce the negative effects of such a disastrous distortion of the design process.

Regulation and criteria

Unfortunately, much of the legislation with which designers must work appears to be based on the pattern illustrated by the daylighting example. Wherever there is the possibility of measuring performance, there is also the opportunity to legislate. It is difficult to legislate for qualities, but easy to define and enforce quantities (Lawson 1975b). It is increasingly difficult for the designer to maintain a sensibly balanced design process in the face of necessarily imbalanced legislation. A dramatic example of this can be found in the design of public sector housing in the United Kingdom.

The British government had commissioned an excellent piece of research completed by a committee chaired by Sir Parker Morris into the needs of the residents of family housing. The committee worked for two years visiting housing schemes, issuing questionnaires, taking evidence from experts and studying the available literature. This was to be a most thorough and reputable study which proved useful in guiding the development of housing design for several decades (Parker Morris, *Homes for Today and Tomorrow* 1961: 594, London House). The final report was in the form of a pamphlet containing over 200 major recommendations. Some of the recommendations were later included as requirements in what became the Mandatory Minimum Standards for public sector housing. It is interesting to see just which of the original Parker Morris recommendations were to become legislative requirements and why. Consider just three of these recommendations made in connection with the design of the kitchen:

1. The relation of the kitchen to the place outside the kitchen where the children are likely to play should be considered.
2. A person working at the sink should be able to see out of the window.
3. Worktops should be provided on both sides of the sink and cooker positions. Kitchen fitments should be arranged to form a work sequence comprising worktop/sink/worktop/cooker/worktop unbroken by a door or any other traffic way.

(Parker Morris 1961)

All these recommendations seem sensible and desirable. However, it seems a fair bet that most parents would rate the first as the most desirable, and probably most of us would sacrifice some ergonomic efficiency for a pleasant view. However the third recommendation is the most easily measured from an architect's drawing, and only this last recommendation became a mandatory requirement (Fig. 5.5). Thus it became quite permissible to design a family maisonette or flat many storeys above ground level with no view of any outside play spaces from the kitchen, but it would have the very model of a kitchen work surface as may not be found even in some very expensive privately built housing. It is worth noting that this legislation was introduced during the early period of what has now been called first generation design methodology. Thankfully these Mandatory Minimum Standards were later withdrawn. In a way this was also a pity as they contained other, far more sensible, requirements!

Design legislation has now rightly come under close and critical scrutiny, and designers have begun to report the failings of legislation in practice. In 1973 the Essex County Council produced its now classic *Design Guide for Residential Areas*, which was an attempt to deal with both qualitative and quantitative aspects of housing design. Visual standards and such concepts as privacy were given as much emphasis as noise levels or efficient traffic circulation. Whilst the objectives of this and the many other design guides which followed were almost universally applauded, many designers have subsequently expressed concern at the results of such notes for guidance actually being used in practice as legislation. Building regulations have come under increasing criticism from architects who have shown how they often create undesirable results (Lawson 1975b) and proposals have been put forward to revise the whole system of building control (Savidge 1978).

In 1976 the Department of the Environment (DoE) published its research report no. 6 on the *Value of Standards for the External*

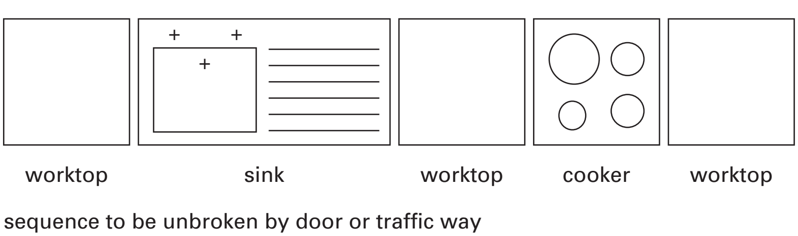

Figure 5.5
The Parker Morris recommended kitchen layout which became mandatory

Residential Environment which concluded that many currently accepted standards were either unworkable or even positively objectionable. The report firmly rejected the imposition of requirements for such matters as privacy, view, sunlight or daylight:

> The application of standards across the board defeats the aim of appropriately different provision in different situations.

This report seems to sound the final death knell for legislation based on the 1960s first-generation design methodology:

> The qualities of good design are not encapsulated in quantitative standards . . . It is right for development controllers to ask that adequate provision be made for, say, privacy or access or children's play or quiet. The imposition of specified quantities as requirements is a different matter, and is not justified by design results.
>
> (DoE 1976)

Sadly, since this time legislators have not learned the lessons from their mistakes with daylight and kitchens. Legislation continues to be drawn up in such a way as to suit those whose job it is to check rather than those whose job it is to design. The checker requires a simple test, preferably numerical, easily applied on evidence which is clear and unambiguous. The checker also greatly prefers not to have to consider more than one thing at a time. The designer of course, requires the exact opposite of this, and so it is that legislation often makes design more difficult. This is not because it imposes standards of performance which may be quite desirable, but because of the inflexibility and lack of value which it introduces into the value-laden multi-dimensional process which is design.

Measurement and design methods

Reference has already been made to Christopher Alexander's famous method of design, which perhaps exemplifies the first generation thinking about the design process. We no longer view the design process in this way and in order to see why we shall pause here to fill in some detail. Alexander's method involved first listing all the requirements of a particular design problem, and then looking for interactions between these requirements (Alexander 1964). For example in the design of a kettle some requirements for the choice of materials might be as follows.

Simplicity: the fewer the materials the more efficient the factory.
Performance: each function within the kettle requires its own material, e.g. handle, lid, spout.
Jointing: the fewer the materials the less and the simpler the jointing and the less the maintenance.
Economy: choose the cheapest material suitable.

The interactions between each pair of these requirements are next labelled as positive, negative or neutral depending on whether they complement, inhibit or have no effect upon each other. In this case all the interactions except jointing/simplicity are negative since they show conflicting requirements. For example while the performance requirement suggests many materials, the jointing and simplicity requirements would ideally be satisfied by using only one material. Thus jointing and simplicity interact positively with each other but both interact negatively with performance.

Thus a designer using Alexander's method would first list all the requirements of the design and then state which pairs of requirements interact either positively or negatively. All this data would then be fed into a computer program which looks for clusters of requirements which are heavily interrelated but relatively unconnected with other requirements. The computer would then print out these clusters effectively breaking the problem down into independent sub-problems each relatively simple for the designer to understand and solve.

Alexander's work has been heavily criticised, not least by himself (Alexander 1966), although few seemed to listen to him at the time! A few years later Geoffrey Broadbent published an excellent review of many of the failings of Alexander's method (Broadbent 1973). Some of Alexander's most obvious errors, and those which interest us here, result from a rather mechanistic view of the nature of design problems:

> the problem is defined by a set of requirements called M. The solution to this problem will be a form which successfully satisfies all of these requirements.

Implicit in this statement are a number of notions now commonly rejected (Lawson 1979a). First, that there exists a set of requirements which can be exhaustively listed at the start of the design process. As we saw in Chapter 3, this is not really feasible since all sorts of requirements are quite likely to occur to designer and client alike even well after the synthesis of solutions has started. The second misconception in Alexander's method is that all these listed requirements are of equal value and that the interactions between them are all equally strong. Common sense would suggest that it is quite likely to be much more important to satisfy some requirements than others, and that some pairs of requirements may be closely related while others are more loosely connected. Third, and rather more subtly, Alexander fails to appreciate that some requirements and interactions have much more profound implications for the form of the solution than do others.

To illustrate these deficiencies consider two pairs of interacting requirements listed by Chermayeff and Alexander (1963) in their study of community and privacy in housing design. The first interaction is between 'efficient parking for owners and visitors; adequate manoeuvre space' and 'separation of children and pets from vehicles'. The second interaction is between 'stops against crawling and climbing insects, vermin, reptiles, birds and mammals' and 'filters against smells, viruses, bacteria, dirt. Screens against flying insects, wind-blown dust, litter, soot and garbage'. The trouble with Alexander's method is that it is incapable of distinguishing between these interactions in terms of strength, quality or importance, and yet any experienced architect would realise that the two problems have quite different kinds of solution implications. The first is a matter of access and thus poses a spatial planning problem, while the second raises an issue about the detailed technical design of the building skin. In most design processes these two problems would be given emphasis at quite different stages. Thus in this sense the designer selects the aspects of the problem he or she wishes to consider in order of their likely impact on the solution as a whole. In this case, issues of general layout and organisation would be unlikely to be considered at the same time as the detailing of doors and windows. Unfortunately the cluster pattern generated by Alexander's method conceals this natural meaning in the problem and forces a strange way of working on the designer.

Value judgements in design

Because in design there are often so many variables which cannot be measured on the same scale, value judgements seem inescapable. For example in designing electrical power tools, convenience of use has often to be balanced against safety, or portability against robustness. Although it may prove possible to measure designs on crude scales of satisfaction for each of these factors, they remain difficult to relate. Thus a very lightweight lawnmower while being easy to manoeuvre and push might also prove to be noisy and easily damaged. For such an item there is no one right answer since different purchasers are likely to place different values on factors such as manoeuvrability or reliability. The sensible manufacturer of such equipment will produce a whole range of alternative designs each offering different advantages and disadvantages. The problem of relative values, however, becomes much more critical when design decisions are being taken for large numbers of people who may not have the choice available to the purchasers of new lawnmowers. Examples of such design problems include public sector housing or a new school, the routeing of new roads or the siting of factories. Inherently, such projects involve varying degrees of benefit to some and losses to others. A new motorway may well save a long-distance motorist's time and relieve congestion in nearby towns but, unfortunately, it may also subject local residents to unwanted noise and pollution.

The attraction of a common metric

An attractive way out of all the difficulties we have seen in this chapter would be if we could reduce all the criteria involved in design to some common scale of measurement. Cost-benefit analysis relies upon expressing all factors in terms of their monetary value, thus establishing a common metric. Attempts have been made to apply cost-benefit analysis techniques to the kinds of design problems where there are both gainers and losers. Unfortunately, some factors are rather more easily costed than others. This is perhaps best illustrated by reference to one of the most well-known applications of cost-benefit analysis, the Roskill Commission on the siting of the third London airport. After a number of preliminary stages during which some seventy-eight sites were considered, the commission narrowed the choice down to four sites at Cublington, Foulness, Nuthampstead and Thurleigh which were then compared using cost-benefit analysis. Even the grossly simplified diagram reproduced here gives some idea of the complex array of effects which the various interested parties could be expected to have on each other as a result of such a project (Fig. 5.6). In fact there are many other much wider effects not shown which include such matters as the distortion of the national transportation network resulting

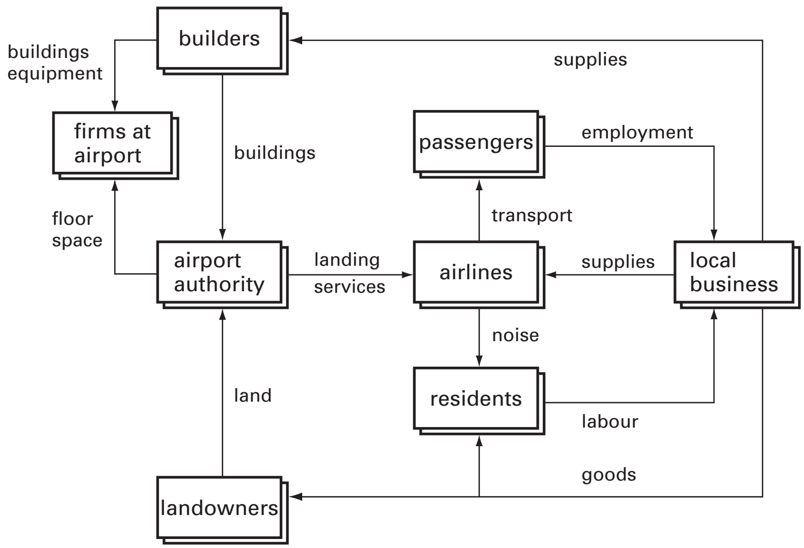

Figure 5.6
A simplified diagram of the interactions between the parties involved in a new airport

from the provision of new forms of access to the chosen site. For example, the opening of an airport at Cublington would have resulted in the closure of the existing Luton airport which would have been too close for air traffic control procedures.

Many of the benefits of the airport in terms of the profits to the various transportation authorities and other companies were reasonably easy to calculate for each site and could be set against the profits lost from the existing use of land. The costs of providing the access transportation to each site and the costs in terms of journey time were also fed into the equation. Losses in terms of reduced amenity, however, proved more difficult to assess in purely monetary terms. These effects range from otherwise unwanted expenditure resulting from people having to leave their homes, through such factors as the depreciation in value of property in the surrounding area to the noise annoyance caused by the operation of the airport.

Such a public use of cost-benefit analysis revealed many of the real dangers involved in basing decisions on the quantification of qualitative factors such as the amenity of an environment. Obviously the success of such a process is contingent upon the assumption that all the costs of amenity loss have been correctly valued. The real difficulty here is that such valuations are unlikely to be arrived at by consensus in a pluralistic society. This was demonstrated when the RIBA publicly expressed its concern at the valuations placed on both gains and losses and pointed out the many minor losses not costed which might have a large effect cumulatively:

> An hour lost by an air traveller is valued very generously, taking into account business overheads as well as salary, but an hour of sleep lost by those living outside the area of major impact is given no value whatever.
> (RIBA 1970)

The costing of noise annoyance or the value of quiet had proved difficult enough for the Roskill Commission, but when considerations of the conservation of wildlife at Foulness were introduced to the argument the whole decision-making process began to split at the seams. Cost-benefit analysis was clearly incapable of developing one equation to balance the profits of an airport against the loss of a totally unproductive but irreplaceable and, some would say, priceless sanctuary for birdlife. The Roskill report itself recognised the futility of attempting totally objective judgement in comparing the Cublington and Foulness sites. The choice was between the damage to the value of Aylesbury and the loss of a fine Norman church at Stewkley or the ruining of the Essex coastline and probable extinction of the dark-bellied Brent goose:

> As with much else in this inquiry there is no single right answer however much each individual may believe there is. For us to claim to judge absolutely between these views (the importance of conservation of buildings or wildlife) is to claim gifts of wisdom and prophecy which no man can possess. All we can do is respect both points of view.
> (Roskill Commission Report)

Even the costings of the more ostensibly easily quantifiable factors proved extremely debatable. For example the cost-benefit research team itself revised the assumptions on which total construction costs had been based. This change proved so drastic that Cublington moved from being the most costly to the least costly of the possible sites in this respect. The inquiry proceeded until it gradually became apparent that many of the fundamental underlying assumptions necessary for the cost-benefit analysis could similarly be challenged. The indecision which resulted at least in part from the discrediting of the technique led to many years of procrastination before an airport was finally built at Stanstead. Perhaps the last word here should come from Professor Buchanan, a member of the Commission who became so concerned that he published a minority report:

> I became more and more anxious lest I be trapped in a process which I did not fully understand and ultimately led without choice to a conclusion which I would know in my heart of hearts I did not agree with.

Recently there has rightly been more emphasis placed on the ecological implications of design decisions. Most of the energy consumed in the developed countries is connected with the manufacturing and use of products. A very high proportion indeed is connected with the construction industry. Similarly, levels of pollution and atmospheric emissions are heavily influenced by the decisions of industrial designers, architects and town planners. All this leads us to want more information on the true impact of design decisions, not just at the stage of constructing but in terms of the full life cycle. Again legislation is increasingly setting, and then changing, limits on energy consumption and pollution. Most designers are probably very conscious of the need to improve our world in this way, but find it extremely difficult to incorporate findings and recommendations into their design process. The findings and data are seldom clearly expressed in a form which a designer can make sense of. Just as it is increasingly difficult to know what it is safe and healthy to eat, so designing in an ecologically sound way is surrounded by myths, campaigns and, sometimes, deliberately misleading data. In all this confusion, however, designers cannot usually procrastinate as did those deciding on the third London airport. They simply must get on and make the decision in as integrated and sensible a way as they can. Their decisions then remain very visible and easy to criticise as data becomes more clearly available!

Objective and subjective decisions

In the final analysis it seems unreasonable for designers to expect to find a process which will protect them from the painful and difficult business of exercising subjective judgement in situations where both quantitative and qualitative factors must be taken into account. The attempt to reduce all factors to a common quantitative measure such as monetary value frequently serves only to shift the problem to one of valuation. The Roskill Commission on the siting of the third London airport provided one further lesson of importance here. Designers and those who make design-like decisions which profoundly affect the lives of many people can no longer expect their value judgements to be made in private. Such large-scale design processes must clearly invite the participation of all those who will be substantially affected. However, we must not expect the design process to be as clear, logical and open a process as the scientific method. Design is a messy kind of business that involves making value judgements between alternatives that may each offer some advantages and disadvantages. There is unlikely to be a correct or even optimal answer in the design process, and we are not all likely to agree about the relative merits of the alternative solutions.

References

Alexander, C. (1964). *Notes on the synthesis of form*. New York, McGraw Hill.

Alexander, C. (1966). 'A city is not a tree.' *Design* **206**: 44–55.

Archer, L. B. (1969). 'The structure of the design process.' *Design Methods in Architecture*. London, Lund Humphries.

Boje, A. (1971). *Open-plan Offices*. Business Books.

Broadbent, G. (1973). *Design in Architecture*. New York, John Wiley.

Chermayeff, S. and Alexander, C. (1963). *Community and Privacy*. Harmondsworth, Penguin.

Lawson, B. R. (1975a). Heuristic science for students of architecture. University of Sheffield Department of Architecture.

Lawson, B. R. (1975b). 'Upside down and back to front: architects and the building laws.' *RIBA Journal* **82**(4).

Lawson, B. R. (1979). 'The act of designing.' *Design methods and Theories* **13**(1).

Lawson, B. R. (1982). Science, legislation and architecture. *Changing Design*. New York, John Wiley.

RIBA (1970). 'The third London airport: choice cannot be on cost alone says RIBA.' *RIBA Journal* **77**(5): 224–225.

Savidge, R. (1978). 'Revise the regs: the plan revealed.' *The Architects' Journal* **167**(14).

Stevens, S. S., Ed. (1951). *Handbook of Experimental Psychology*. New York, John Wiley.