SECTOR

The space-time interface

A systematic approach to the problem of flexibility in educational buildings

Thomas W. Maver

The space-time problem

The concept of temporal variability in the spatial requirements of the users of buildings is enjoying unprecedented currency: no self-respecting architect would discuss modern design rationale without mention of 'flexibility', 'obsolescence', 'improvisation', 'indeterminacy' or one of the other current neologisms to describe his understanding of the concept or the account he takes of it.

Regrettably, however, the understandings seem to be individualistic rather than mutual and the account taken of them attitudinal rather than rational. This paper proposes neither a philosophical overview of the concept nor a catalogue of predetermined solutions; what it does attempt is an investigation of the space-time interface in a single building type in the hope that some useful insights into the problem can be deduced.

In educational buildings the temporal variation in spatial requirements is significant at two levels:

(a) within a single cycle of the educational timetable (which normally has a duration of one week but may be longer) a large number of disparate behavioural settings have to be accommodated; in a comprehensive school, for instance, every period of 40 minutes represents a unique configuration of spatial use

(b) as teaching methods, curricula and technology improve, the nature of the periodic activities which make up the educational timetable change; this change is not cyclic but progressive and has to be satisfied spatially.

The space-time problem in educational establishments is therefore one of designing a building within which a large variety of disparate activities take place cyclically (the space-time cycle), the composition of the cycle itself changing progressively over the lifetime of the building (the space-time progression). In every respect, therefore, the spatial problem is that of satisfying a dynamic system.

The space-time cycle

A 'snapshot' of an education establishment at any instant in time would reveal a specific set of behavioural settings: in a secondary school for instance (and this example will be used throughout, in view of the generality of our experience of such an organisation) the 'snapshot' could reveal 90 pupils engaged in the study of English (say in three groups of 40, 30 and 20), 72 pupils engaged in the study of Mathematics (say in four groups of 20, 20, 18 and 14), 53 pupils engaged in Gymnastics etc. A snapshot taken forty minutes later would reveal the same broad categories of activity – English, Maths, P.E., etc., but each involving perhaps a different number of pupils, differently subdivided, from the previous snapshot.

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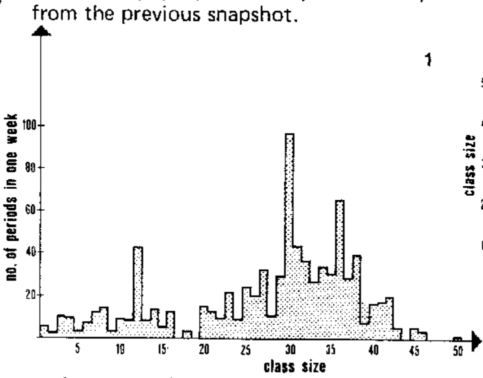
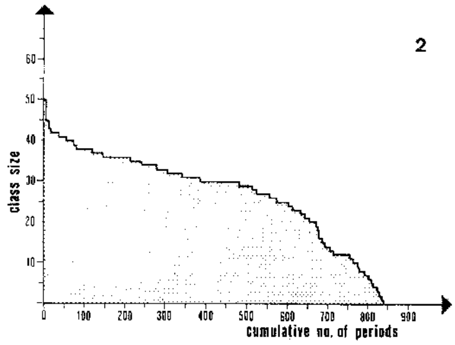
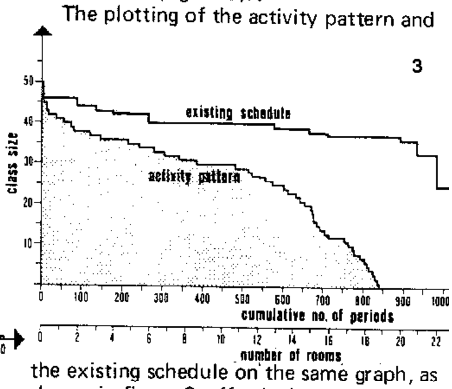


By summating or "overlaying" these snapshots for the duration of the curricular timetable, it is possible to build up a histogram of the spatial requirements within any academic session. Figure 1 shows such a summation with class size recorded on the horizontal axis and frequency of occurrence, i.e. number of periods in the cycle (in this case a week), recorded on the vertical axis; in this example the summation has taken place over all years in the school and over all 'non-specialist' subjects. Immediately apparent from figure 1 is the variability in class size – from one pupil to 50 pupils – which is typical of secondary schools of comprehensive intake and structure. Somehow or other the spatial configuration in the school must reflect this variety in group configuration.

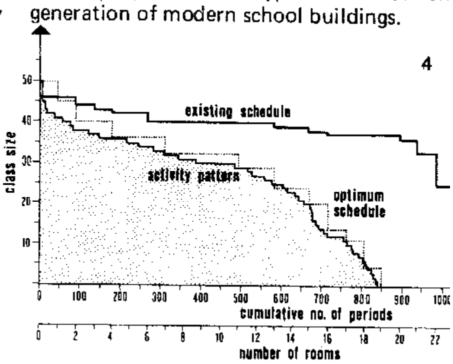


The matching of spatial provision to spatial need is promoted if both need and provision can be expressed in the same format. One way of achieving format compatibility is to reconstruct the data in figure 1 in the manner shown by the shaded area of figure 2, i.e. class size plotted vertically, number of periods plotted accumulatively on the horizontal axis, with the columns of data arranged in order of decreasing height. This profile, labelled 'activity pattern', envelopes an area proportional to 'pupil-periods' and thus represents the number of pupil-places required. It is not surprising, therefore, that by the simple device of dividing the horizontal axis by the number of periods in a timetable cycle (in this case 45), the existing schedule can be represented in the same format (figure 3).

The plotting of the activity pattern and



the existing schedule on the same graph, as shown in figure 3, affords the opportunity of determining the spatial overprovision or mis-match, as represented by the difference in area between the two profiles. The overprovision in this case (approaching 100%) is by no means atypical of the curren generation of modern school buildings.



A more efficient spatial solution is represented in figure 4, here the 'optimum schedule' profile matches the 'activity pattern' profile as closely as is feasible, given the constraints of modular decrements in class size. For a single activity pattern it is quite reasonable to generate the optimum schedule graphically; for a large number of activity patterns it is as well to use a computer to generate the optimum schedules and Table 1 shows the input

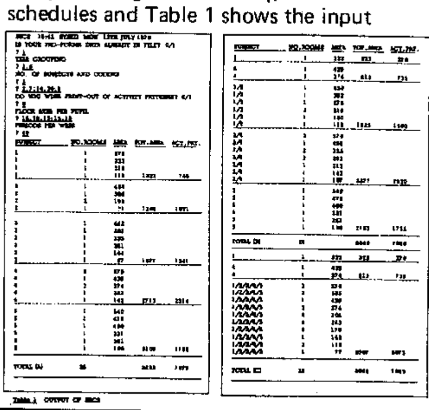


Table 1

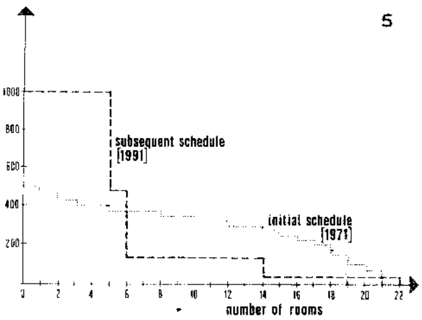
underlined) and output from such a programme (details of which are given in SECS: A programme package for accommodation scheduling in comprehensive schools).

Assuming all the basic data on group sizes and frequency of occurrence has been fed into the computer, the designer specifies (by typing on the keyboard) which subjects he wishes to schedule and the corresponding pupil-space allocations. The computer outputs three alternative schedules: the first, summarised by TOTAL (A), treats each subject separately; the second, summarised by TOTAL (B), treats subjects in pairs; the third, summarised by TOTAL (C), treats all the subjects together. The totals, it can be seen are quite different, the 'individual' schedule being almost 10% more spacious than the 'joint' schedule. The reason for this disparity relates to the fact that in the joint schedule, maximum advantage has been taken of the diversity in demand for space over the cycle, i.e. the space-time interface has been optimised within the dynamic space-time cycle.

Use of such a programme for space-time interfacing can result in massive cost savings in the design of educational buildings. One pass of the programme (which takes about 10 minutes) costs approximately £5.

The space-time progression

The foregoing section has dealt with the dynamic nature of the space-time interface within one academic cycle. As already mentioned, however, changes in teaching methods, curricula and technology over the life of the educational building necessitate corresponding changes in the spatial environment if the provision/needs match is to be efficiently maintained.



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Assume that an optimum schedule has been generated, as already described, for a comprehensive school due to open in 1971; and that an optimum schedule, based on a hypothesised activity pattern pertaining to the year 1991, has been generated in a similar fashion. Figure 5 represents two such schedules.

Three design strategies are possible:

(a) demolish (or substantially remodel) the school designed to the 1971 requirements in the year 1991;

(b) initially provide redundant space, equal to the envelope of the two schedules; or

(c) inbuild, to the 1971 schedule, sufficient physical flexibility to allow it to transform into the 1991 schedule when required.

Physical solutions to the first two strategies are obvious; the determination of the optimum physical solution to the third strategy is of extreme complexity. Since comparison of the efficacy of the strategies depends on a solution to the third, however, a method has been devised and is now described.

In simple terms it is required to chop up the 1971 schedule into columns and to snip and glue these columns until the pieces can be combined to give the 1991 schedule. To do this most efficiently a method is required to determine the fewest number of 'snips' and 'glues' to achieve the reformation. Even a small problem tackled this way will drive the victim to drinking the glue and stabbing the nearest person with the scissors.

REQUIRED AREAS OF SUBSEQUENT SCHEDULE

EXISTING AREAS OF INITIAL SCHEDULE	1000	1000	1000	1000	1000	470	120	120	120	120	120	120	120	110	30	30	30	30	30	30	30
500	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
470	0	0	0	0	0	470	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
430	430	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400	0	400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400	0	400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
380	0	0	380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
380	0	0	380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
380	0	0	240	140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
350	0	0	0	350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
350	0	0	0	350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
340	0	0	0	160	180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
340	0	0	0	0	340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300	0	0	0	0	300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300	0	0	0	0	180	0	0	0	0	120	0	0	0	0	0	0	0	0	0	0	0
280	0	0	0	0	0	0	0	0	0	0	110	120	50	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0	0	0	110	0	0	30	30	30	30	10
240	0	0	0	0	0	0	120	120	0	0	0	0	0	0	0	0	0	0	0	0	0
200	0	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0	0	120	0	0	0	0	0	30	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	70	0	0	30	0	0	0	0	0
70	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PARTITIONS TO BE ADDED = 13
PARTITIONS TO BE REMOVED = 13
REMAINDER OF EXISTING AREAS = 0
REMAINDER OF REQUIRED AREAS = 20

Table 2

Again, however, a computer, ingeniously programmed, can undertake the task with equanimity by an iterative process of trial and error. Table 2 represents the output of one section in the package SECS, already mentioned: down the left-hand side of the table is a list of the existing areas in the 1971 schedule and along the top is a list of the required areas in the 1991 schedule. Entries within the table are the spatial allocations arrived at by the computer after a massive sequence of trial attempts.

With one exception, which will be mentioned later, the entries in each row sum to the total in the left-hand column; similarly the entries in each column sum to the total heading that column. Thus the required area of 1000 sq.ft. in column one should be created by combining existing areas of 500 sq.ft., 430 sq.ft. and 70 sq.ft. as indicated by the table entries; analogously an existing area of 240 sq.ft. in the 17th row should be split up into the required areas of 120 sq.ft. and 120 sq.ft.

Having made the optimum allocation it remains to interpret what this means in terms of physical flexibility. Reverting to column one, three existing spaces have been combined to create one new space, i.e. two partitions require to be removed; analogously, in row 17, one existing space has been divided up into two new spaces, i.e. one partition requires to be added. In short, the number of partitions to be removed is obtained by taking, in each column, the number of *entries* minus one, summed over all columns; the number of partitions to be added is obtained by taking, in each row, the number of *entries* minus one, summed over all rows. The computer outputs these values as shown in Table 2, together with any required areas left over or existing areas un-created (see the last column to explain the remainder of 20).

In this example 13 partitions need to be added and thirteen partitions need to be removed to transform the 1971 schedule into the 1991 schedule. In other words, as a minimum, thirteen demountable partitions need to be incorporated when the school is built. If the analysis results in a disparate number of additions and removals, the maximum of the two is obviously required as a necessary provision; whether or not this minimum provision is sufficient is of course dependent on the subsequent layout configuration but this is no more true in the case of a 'physical flexibility' strategy than in the case of the two other strategies mentioned previously.

Two important points are worth stressing:

(a) application of the technique just described is not restricted to investigation of two points in time; a whole series of space-time progressions can be set up and computation carried out on the necessary and sufficient physical flexibility required to move from any two adjacent points on the progression, and

(b) application of the technique is not restricted to educational buildings but is relevant to any building type in which the spatial requirements vary progressively over time.

It is not appropriate in this paper to cover the algorithms embodied in the computer programme (one pass of which takes approximately 5 minutes at a cost of around £4); anyone who wants to find out how it works should consult the paper SECS. Alternatively, anyone with a week or two to spare can blow his mind searching for a more efficient solution to the given example.

A space-time paradigm

What has been discussed thus far are techniques for investigating the space-time interface in specific instances. The techniques, or variations on them, have a general relevance, however, to all building design problems in which spatial requirements vary over time.

The approach, then, embodies three paradigms:

(a) the ability to predict definitive futures of spatial requirements is not of vital importance provided one has a repeatable analytical mechanism (e.g. a computer programme) with which to test a large variety of alternative future postulations. In terms of our example of a space-time progression this means that we do not need to know, with a high degree of certainty, the exact nature of the activity pattern pertaining to 1991; what is important is to use the computer programme to test a variety of activity patterns in order to determine what level of physical flexibility will satisfy a wide range of possible futures. Current work at Strathclyde has shown, for instance, that provision of some fifteen ıountable partitions can allow ınsformation of an initial school schedule ıto almost any conceivable future schedule.

(b) it is mistaken to apply a particular solution strategy across the board: thorough analysis of individual problems, using the techniques outlined will indicate unique solutions, implying perhaps the initial provision of a wide variety of spaces, redundant spaces and physical boundary flexibility, in some unique combination.

(c) the analytical process should not be confined to what we currently understand to be the 'design stage': as the building is used, futures become less uncertain, other options are revealed and a process of continuing design or 'design-in-use' comes into operation. The analytical techniques developed for the initial design stage are equally relevant to the 'design-in-use' stage and take on the function of management tools. In the case of the school, for instance, the next session's curriculum can be input to determine the spatial implications; alternatively the programme can be used to explore the curriculum options which are feasible within the spatial constraints.

All of these paradigms can be summarised as follows: to achieve a 'robust' building design solution, where 'robust' implies a continuing match between provision and need at the space-time interface, we must concentrate our efforts towards the development of generally applicable design mechanisms or processes rather than towards definite solutions or plans. In short, to paraphrase McLuhan, *the plan is the process.*

References:

Maver, T. W. and Fleming, J. (1960) SECS: a program package for accommodation scheduling in comprehensive schools, ABACUS Occasional Paper No. 2, Department of Architecture and Building Science, University of Strathclyde, Glasgow, C.1