Space planning and utilisation in tertiary education

Dr Raj Sharma, Planning Manager
Swinburne Institute of Technology

Abstract

Dawkins-initiated higher education revolution in Australia has not only induced major organizational changes through institutional amalgamation but has also strengthened rational resource planning and management. The relative funding model and the imminent release of a space allocation model by DEET are examples of such future directions. The formulation of space planning model for the Unified National System of Australian higher education in turn induces a need at the institutional level to develop appropriate decision support systems for the allocation of capital resources to academic organizational units in addition to the establishment of appropriate mechanisms for the monitoring and evaluation of use of existing spaces (utilization studies). This study reveals that space planning models can be constructed with built-in space utilization standards so as to not only permit more optimal space usage but also to provide a vehicle for the planning of the acquisition of additional building spaces and the relative priorities for the same across academic (and indeed non-academic) organisational units.

Introduction

Australia is moving towards a more rational basis for the planning and allocation of higher education capital resources. In this environment, it is important to analyse and develop various space utilisation and management techniques which can prove useful for purposes of capital planning in tertiary education.

In 1989, the Department of Employment, Education and Training (DEET), the Australian Vice Chancellor's Committee, Australian Committee of Directors and Principals and the National Board of Employment, Education and Training established a joint working party to develop an information management system for Space Planning and Management in Higher Education. DEET (1990) summarises the purpose of this system as follows:

- To facilitate institutions to maintain and analyse data relating to space management and planning for educational and support area needs.

- To provide DEET with additional information to develop a comprehensive picture of the type and quality of space within the higher education system and in assessing individual capital bids.

The aims of this paper are to examine the development of a space planning model in the Australian context and, to provide an overview of space management in overseas tertiary education institutions.

Space utilisation and allocation in overseas tertiary institutions

The United States

Much of the development work of space utilisation and space allocation in higher education was initiated in the United States (US). Doige (1974) notes that the first space utilisation studies dated back to 1916 in America when the University of Iowa reported that it could manage only 35 - 50 per cent utilisation.

Fundamental to the development of rational space management techniques is the maintenance of a detailed up-to-date space inventory. This seems to be accepted by many American Universities and

Colleges which hold fairly comprehensive space inventories as an adjunct to physical planning. Agro (1978) suggests that the existence of an adequate space management information system in the US may also be due to the initiatives of the US Office of Education which conducts surveys on institutional physical facilities through the HEGIS program.

The existence of a comprehensive and compatible data base in the US has generated inter-college exchange of space information. These inter-institutional comparisons have in turn provided a basis for the development of space standards relating space to programs. In its wider usage, space standards as applied by the American space managers refer to the following three parameters:

(a) The unit area assignment per student station.

(b) Room period utilisation which represents the percentage of hours each week a room is used in proportion to the total academic week.

(c) Student station utilisation which indicates the proportion of seats occupied when a room is in use.

A comparative space study by the University of the State of New York (undated) indicates a certain degree of uniformity in space standards across American tertiary institutions. This is evident from the following comparisons of standards for room availability (in hours per week) and percentage occupancy (prescribed student-station utilization) for selected room types operative in the states of Illinois, Indiana and Iowa (Table 1):

Table 1. Space Utilization Standards and Factors

Room type	Illinois		Indiana		Iowa	
	Hrs/week	% occ.	Hrs/week	% occ.	Hrs/week	% occ.
Class room	30	60	30	50	30	60
Laboratories:						
Agriculture	20-24	80	20	75	20	80
Engineering	20-24	80			20	80

Some US higher education institutions, particularly those in the state university system, utilize space standards on a formula basis to allocate institutional space resources (Agro, 1978). This begs a good question: what space allocation techniques are used in the US higher educational systems?

According to Wood (1970), the oldest and most elementary approach “was to ask the Dean of a college or Head of a department to estimate how much additional space would be needed for a certain increase in the number of students”. This method gave answers which were “obviously in error on the high side”.

A second “old method” is a statistical approach which is based on the number of assignable area per student needed for various room types. This method is subject to error too since it tends to perpetuate past errors and inefficiencies (Wood, 1970).

A more “modem” approach called the Drexel method was subsequently developed. it is a time-tabling system which firstly establishes the number of classes, frequency of meeting, and length of each meeting and then creates hypothetical room schedules. The major limitation in this technique is that it does not provide the educational administrator with a space allocation model but a simple centralized time-tabling procedure.

Another method for projecting physical facilities which was developed at the University of Illinois by Bareither and Schillinger (1969) is the “Numeric Method”. This space allocation model is more sophisticated and of greater utility than the previously discussed techniques for physical facilities planning.

The Numeric Method can be adequately illustrated by considering an example of one category of space, namely, classrooms. For example, suppose a hypothetical subject Education 1 with an enrolment of 100

students requires classroom attendance for 3 hours per week, then this generates 3 x 100 = 300 weekly student contact hours. Further, assume the following space standards for classrooms:

- Square metres per station = 1.5
- Hours per week classrooms are used = 30.0
- % of time each station is occupied when the classroom is in use = 60.0

Then the area required per weekly student contact hour is 1.5/(30 x 0.60) and hence the total area required as a result of enrolments in Education 1 is 300 x 0.0833 = 25 square metres. Such calculations can be performed and aggregated for all subjects offered by a teaching department to generate that academic unit's requirement for teaching space. A basic limitation of this method is that it does not specify the number and size of classrooms that should be allocated to the teaching department.

The US has undoubtedly been in the forefront in the development of space utilization and physical facilities planning models for tertiary education institutions. It will become evident in the subsequent consideration of building space planning models in the United Kingdom and Australia, that educational administrators in these countries have tended to adapt and build on the pioneering studies commenced in the United States.

The United Kingdom

Grace Kenny (1977) indicates that the impetus for space utilization studies in higher education in the United Kingdom began to gain momentum during the middle to the late 1960's when the universities and colleges came "under considerable pressure to accommodate the result of the postwar baby boom". Musgrove (1974) believes that this concern with space management in Britain grew to prominence in 1967 when the committee of Vice-Chancellors and Principals commissioned a space utilization study. This study showed very low utilization levels and a large variation in standards of operation at the 47 universities surveyed.

In the United Kingdom, the Department of Education has sponsored space utilization studies as a means to enhance effective management of institutional accommodation. Further, Rawlinson (1977) states that the UK Department of Education has been encouraging tertiary institutions to undertake their own utilization studies so that their proposals for new buildings can be supported by factual data. This poses the question: how is the actual institutional space requirement determined in the United kingdom?

The Department of Education and Science Design Note 8 (1972) details the space allocation "model" used to calculate gross floor areas required for the expansion of physical facilities in Polytechnics. The model for determining space requirements for Polytechnics is a simple one; it assumes that space allocation is a function of types of courses, numbers of students and space standards stated as an area allowance per full time equivalent student. This approach is, therefore, very similar to one of the "old methods" of space allocation utilized in the US, as discussed in the previous section.

Thus much work has been undertaken in the UK on aspects of space utilization in higher education. The British studies have largely been directed at increasing utilization of existing teaching space and not towards the development of more effective models for space allocation within institutions; only macro-models have been developed to enhance inter-institutional resource allocation with very limited capability for intra-institutional space allocation.

It is contended that this emphasis on space utilization may be misdirected since, a particular academic unit's under-utilized capacity could be due to declining enrolments rather than inefficient classroom scheduling. In this regard, space managers can be guided by the more balanced approach provided by the US specialist in the field to the two important dimensions of tertiary education accommodation planning.

Space management in Australian colleges

Sharma (1982) undertook a survey of resource management in the former Australian Colleges of Advanced Education. The following summarizes the salient results of the data analysis from that study on space planning.

Firstly, the analysis of the survey questionnaire indicated that between 1978 and 1979 approximately 59 per cent of the responding colleges experienced diminished capital funding, 27 per cent were in a stationary state and only 14 per cent enjoyed a real increment in their budgets for building projects. VPSEC (1991) study indicates a highly constrained resource situation in 1991 with "... an additional $320 million would need to have been invested in 1991 (in the state of Victoria) to accommodate actual enrolments in that year"; it is hence evident that a shortfall in higher education capital funds has continued in Australia.

Sharma's study, though dated, was undertaken at a time of highly constrained capital funding for Australian Colleges which is similar to the current situation. Despite this fact only five percent of the respondents utilized a rational approach to the allocation of teaching space. Nevertheless, many respondents have developed sound management principles and procedures to promote efficient utilization of existing institutional spaces. In fact, some institutions had made such progress that they were on the threshold of developing mathematical models to achieve a better internal allocation of spaces.

Table 2 indicates the degree of progress achieved by the former CAEs in the effective administration of institutional accommodation. The data shows that 82 per cent of the respondents annually review space requirements for their college. In times of severe shortages, such a regular assessment of the total accommodation needs of institutions become essential for survival. For instance, a variation in student composition over time could demand the readjustment between building space types. Further, such a review would assist colleges in the preparation of submissions to external authorities for additional funds for building projects.

Table 2. Space Management in Australian Colleges

Annually Review Space Needs	82%
Maintain a Space Inventory	86%
Regularly Monitor Space Utilization	70%
Centralized Time Tabling	
- of all teaching space	50%
- for lecture space only	17%
- other teaching spaces	29%

Since 1978, the then Tertiary Education Commission began an annual collection of space inventory information from Australian Colleges. Therefore, it was not surprising that 86 per cent of respondents maintain a space inventory. However, it seems that the stationary state funding situation prevailing at the time had induced many colleges to monitor and increase the utilization levels of their building spaces. For example, 70 per cent of responding colleges had engaged in a regular monitoring of institutional space utilization whilst 96 per cent employed some form of centralized time-tabling system for teaching spaces. The significance of a time-tabling system is that one of its major aims is "to improve utilization of general teaching spaces" (Rawlinson, 1977). In addition to the implementation of a time-tabling system for teaching spaces, the respondents indicated the employment of the following management control devices in an attempt to increase the overall utilization of the building spaces:

(a) Increasing after hours space usage.

(b) Annual review of space utilisation.

(c) Promoting off-campus studies.

(d) Analysing request for specialist space in terms of the department's utilization of existing space and rejecting requests where low usage of similar facilities exist.

(e) Retaining central control of general purpose teaching spaces.

(f) Spreading classes as evenly as possible throughout the week.

(g) Consolidating of small classes.

(h) Encouraging students to use under-utilized teaching spaces for private study during times when the rooms are vacant.

(i) Encouraging extra-curricula community activities on campus.

(j) Spreading load to evening sessions for part-time students.

(k) Conversion of specialized space which is under-utilized to other space types which are in demand.

Since only a small proportion of respondents utilized a rational approach to the allocation of college building space, it would be informative at this juncture to consider some of the correlates of colleges' accommodation. In. addition to collecting data on staff and student statistics, Sharma's survey questionnaire sought the net assignable instructional area (in square metres) from each college. Table 3 specifies the Pearsonian Coefficient between net institutional spaces and such variables as student enrolments and staffing for responding colleges.

Table 3. Correlates of net building space (m^2) in CAEs

Building space	**r^2**	**r**	**N**
Instructional area			
And EFTS enrolment (internal)	.699	.836	12
And Academic staffing	.749	.866	12

According to this tabulation, the net instructional area is strongly correlated with Equivalent Full Time student (EFTS - where full time students count as one and part-timers as a half) Enrolment (r = 0.84); it is even more closely associated with the total academic staffing of the colleges (r = 0.87). However, in view of the association between these three variables it is necessary to test, by the application of multivariate statistical analysis, whether a spurious element exists in the correlation matrix. Computation of Partial Correlation Coefficients indicate that the correlation between net instructional area and academic staffing is true. The correlation between net teaching area and student enrolments is, however, spurious.

Although further research appears to be necessary to investigate the problem of "multicollinearity" between these variables, the Pearsonian and Partial Correlation Coefficients between student enrolment (x), staffing numbers (y) and institutional building space (z) suggest that the empirical model of association is probably x -> y -> z.

More recently, Lagunzad (1990) has indicated that "the available (Australian) literature on facilities utilization measurement is relatively sparse". There is a need for greater institutional research efforts in Australia within the field of tertiary education space planning and management. Lagunzad has shown that the space planning techniques developed in the higher education sector are equally applicable to the TAFE sector (the AAIR which represents interests across the whole spectrum of Australian tertiary education be it TAFE, polytechnics, colleges or universities will try to fill the gap of this area of institutional research). Clearly, institutional researchers within the Australasian region need to make greater efforts in not only undertaking developmental efforts in the area of space planning and management but also disseminate the results of their investigation through paper presentation and publication. The Lagunzad study further suggests that Sharma's study is of contemporary interest to tertiary education resource planners.

Development of models for the allocation of teaching space resources

The empirical study of Australian colleges revealed a general lack of utilization of comprehensive analytical techniques for planning institutional resource allocation (Sharma, 1982). Similarly, the study of resource management techniques used in overseas tertiary education organizations, revealed some methodological flaws; for example, the models utilized in these institutions were often disjointed and lacked adequate integration. Even DEET's space planning and management system appears to be heading in the direction of a highly aggregated macro model which will simply allow a certain assignable area per equivalent full-time student units by discipline. Whilst such a model should prove useful in establishing inter-institutional priorities for space allocation within the Unified National System of Australia's higher education, it is unlikely to be suitable for intra-institutional building resource planning. The present section aims to traverse these problems, by developing a more comprehensive physical facilities resource allocation model in respect of teaching units.

In addition to clearly indicating the inter-relationships between pertinent variables, the resource allocation model should exhibit the following characteristics:

(a) The model should be simple, resulting in broadband grants to teaching departments/faculties. This is dictated by the need to devolve decision making to the lower levels of the organization.

(b) The model should be based on statistics which are accurate and valid in terms of indicating comparative demands for resources. Since a primary function of higher education is to provide tuition to students, the class contact hour would be a fundamental measure of resource demand; space related to other missions such as research would need to be identified separately.

(c) The model should take cognizance of as many of the real variables of the teaching process as possible.

(d) The model should incorporate a feed back process which will permit assessment of the efficient utilization of. resources and promote accountability to the taxpayer; in actuality this is not a characteristic that can be designed into a mathematical model, but is really a part of the management information system of the institution.

College students and staff require adequate accommodation in order to participate in academic activities. The large capital investment by the public in providing the requisite site and buildings necessitates a sound basis for establishing the demand for institutional space and its efficient utilization. This section describes such space projection models which integrate with student forecasting techniques as part of a comprehensive institutional decision support system.

As indicated earlier, one of the most sophisticated space allocation technique constructed and utilized in overseas institutions is Bareither and Schillinger's "Numeric Method". To achieve a more generalized statement of the techniques and its effective integration with a possible student projection model developed by the institution, the Numeric Method is reformulated as follows:

Let the number of weekly student contact hours generated by enrolments in subject i be $WSCH_i$ and denote the pertinent space standard for the programme by s_i (m^2 per station), hours per week the room is used by H and the percentage occupancy of the station when the room is utilized by O; then the total usable floor area required to teach all subjects offered by the department is given by

$$A = \sum_i \frac{10^2 WSCH_i S_i}{H O} \qquad 3.1$$

The Numeric Method of teaching space allocation has several limitations which diminish its utility. Firstly, the technique does not explicitly provide for the differing spatial requirements for the variety of teaching modes use in tertiary education. Further, academic activities often demand ancillary functions which are not considered in the above model; for instance, chemical laboratories require additional space for the

storage of equipment and consumable material. Anderson and Hoadley (1973) recognizing these problems effected appropriate refinements to the model; it will be useful at this juncture to consider this revised Numeric Method. Denoting the parameters as follows:

P_m = Percentage of total departmental weekly student contact hours taught in space type m
a_m = ancillary space factor for space type m
S_m = space standard (m^2 per station) for space type m
H = total hours per week the room is available
f = percentage of room periods utilized (frequency factor)

then the total net area required by the academic unit of space type m is specified by:

$$A_m = \sum_i \frac{10^2 \, (WSCH_i) \, p_m a_m s_m}{H \, f \, O} \qquad 3.2$$

The above models promote efficient usage of building space by incorporating assumed utilization levels.

Although the Anderson and Hoadley model provides significant improvements over the Numeric Method of space allocation, it has certain constraints. Firstly, the technique assumes that the percentage of teaching carried out in a particular space type is stable from one year to the next and can, therefore be estimated from historical data. In practice this room loading factor is likely to vary with. changes in curriculum and teaching mode employed by the functional unit. Further, both the Numeric Method and its above variant do not output the actual physical facility required in terms of number of rooms of certain capacities. These difficulties are surmounted in the space allocation system developed below (Sharma, 1982).

As indicated earlier, any resource allocation technique should recognize that the number of teaching groups is not continuous but integral. Thus, denoting the enrolments in subject i by SE_i, optimum class size for teaching model m by c_m and weekly prescribed contact hours for subject i under teaching mode m by wp_{mi}, then the number of m type instructional rooms of size cm required is specified by[1]

$$N_m = \frac{10^4}{H \, f \, O} \sum_i \left(\frac{SE_i}{cm}\right) wpmi \qquad 3.3$$

In general N_m will not be a natural number but will have an integer component, I plus a fractional component d, that is,

$$N_m = I + d \qquad 3.4$$

Therefore, the institution is faced with the following practical alternatives: either (a) allocate (I + 1) rooms of type m to the teaching unit, or (b) allocate I rooms of space type m to the functional group and permit it to share its fractional requirement d with other units which have the requisite under-utilized capacity. The net total area of space type m allocated to the academic unit is given by

$$Am = N_m p_m a_m s_m / 100 \qquad 3.5$$

where a_m and s_m have the same physical meaning as in equation 3.2 above. Algorithms 3.3 and 3.5 together with a student load planning model represent an integrated model for allocating building space to the teaching units in order to permit them to execute their necessary academic programmes.

It is contended that the above room/space allocation model overcomes some of the problems inherent in the Numeric Method and its variant. However, the former model has certain limitations which need to be

[1] This of course assumes that rooms corresponding to the optimal class size will be provided despite the fact that actual class size may fluctuate about this figure in accordance with subject enrolments.

counteracted. The basic problem with the technique developed here stems from the fact that the weekly prescribed contact hours wp_i for each subject generally represents staff/student contact time only. Therefore the room/space allocation system developed above does not make any provision for non-timetabled[2] student load. This difficulty, however, can be surmounted by including the non-timetable contact hours in the Subject Master File, as separate and distinct figures from the actual staff/student contact data; equations 3.3 and 3.5 may then be applied to this information to output the space requirement generated by non-timetable student load.

The above model development specifies the timetabled and non-timetabled teaching spaces requirements of academic units. However, in practice the organizational units make other demands for building spaces including higher degree, staff research and staff accommodation. These matters are considered below.

Higher degree research students require space equivalent to the staff offices (in addition to learning spaces identified above); in general, what is required is a private study carrel for students. In some cases, such stations are provided in a central library but in others, the academic' organizational unit needs to provide the required area within its own space allocation. Space standards for this facility tend to vary but my experience at RMIT indicates that 5.5 metres per EFTSU would appear satisfactory.

In practice, academic organizational units have a research mission in addition to teaching. Such space needs to be planned on some rational basis. A method using either area per higher degree research student or per academic staff member could prove useful. For instance, when I was working at RMIT, it was assumed that approximately half the full-time academic staff will be active in research and an area allowance of 10 square metres per active staff member was made for purposes of personal applied research or staff development activities.

Staff accommodation also needs to be provided for academic organizational units. Most academic staff office planning models use a student/staff ratio model to estimate projected needs for equivalent full-time academic staff and other staff requirements for teaching units. An area allowance per staff member is then used to quantify the staff accommodation requirements of the academic organizational unit. Most such models are variable in nature, that is, they assume that the staff accommodation area is directly proportional to full-time equivalent staff. However, the RMIT model has both a fixed and a variable component to it. It provides a fixed area of 35 square metres per academic organizational units for purposes of provision of reception area and the like for the teaching unit and as associated with the establishment of the office of the Head of Department. It is further noted that the RMIT staff accommodation model provides 3 square metres per full-time equivalent staff for purposes of ancillary spaces (such as required to house staff equipment and storage requirements).

In non-academic organizational units, the space needs arise from essentially staff related activities including office requirements, associated storage space and area required to house office equipment. Staff accommodation can be estimated in a similar manner to that described above for academic staff. Storage and equipment requirements can best be established by interviewing the head of management units and making a satisfactory provision for such activities. Ground rules can be developed for the latter, for example, at one tertiary institution a standard three square metres was permitted for each personal computer station in an office.

Conclusion

Recent environmental pressures facing Australian Higher Education will mean increased need to plan the allocation of building spaces more effectively as well as, carefully monitor the utilization of existing spaces. With the advent of the DEET Space Planning and Management Statistical Collection, there is increased accountability by institutions to the Federal Government on building space resources. In recent times the growth in student load in Australia has increased much more rapidly than the available spaces in tertiary

[2] This arises in situations where students are required to undertake essentially non-supervised activities in addition to normal staff/student contact hours. For instance, students may require computation rooms to complete assignments or projects.

institutions. This together with the over-enrolment situation in most higher education institutions in 1991 means that greater pressure will be exerted on the existing building space available to institutions.

The DEET Space Planning and Management Model (SPAM) will only provide a macro decision support system - one which is applicable only at a broad level and for purposes of inter-institutional comparisons. However, such a model is not comprehensive enough to guide space allocation within a particular institution. For instance, it is unlikely to output the usable floor area required for staff and accommodation, research, teaching spaces by type, non-timetable spaces and ancillary space for each academic organisational unit. Therefore, institutions will need to develop a more comprehensive model for the allocation of building spaces to the academic and administrative organizational units. The work undertaken in such decision support systems in the United States and at RMIT will provide significance guidance in this matter. Further, model refinements made in this paper should also be of assistance in particular, permitting institutions to convert area requirements into the number of physical rooms required for teaching and research purposes.

Future investigation of space planning models include empirical studies to establish space standards for the research mission of higher education, demands for non-timetable spaces and studies which assist in further refining decision support systems for the allocation of non-academic space. Given the diversity of research efforts by members of the Unified National System and the advent of DEET's SPAM efforts, there is an urgent need to investigate space requirements associated with higher education research. Such research should be undertaken as a matter of priority so that the proposed DEET space allocation model can be discussed with adequate rationality.

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