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Planning and Equipping Technical Institutions

A technical college is essentially an institution designed to teach students the applications of existing technological knowledge to the processes of industry. Its work involves not only teaching technician students the skills and principles underlying the production and manufacturing processes, but also those supervisory and management techniques and attitudes that are required in the industries served by the college. In the early stages of a country's industrialization a college may have to provide special courses for technologists and craftsmen as well as for the technicians required by local industry. There are advantages in this arrangement. But there are also dangers in that courses designed for technicians may have their integrity modified in order to provide a ladder to more academic technologist-type courses and qualifications. It is unusual to plan a college to provide courses for graduate or professional engineers at one end of the spectrum, for craftsmen at the other, and for the range of technicians in between. Nor is it normal practice for technician training institutions to provide resources for pure research, though there is a growing trend to include projects related to technician curriculum development, to special methods of teaching technician subjects, to the design and construction of teaching aids, to teacher and student textbook writing, to planning schemes of work, and to examination and testing techniques and course evaluation procedures.

Responsibility for initiating a proposal to construct a new technical college varies from country to country. In some countries it is done by the local education authority; in others by a state government or regional authority. In most cases the feasibility of the proposal is studied by senior executives of the authority concerned who assess the basis and validity of the arguments for providing a new college. For this purpose they require a full educational, economic, industrial and social justification of the scheme. This is usually undertaken by the sponsoring authority with the help of a policy planning committee which conducts forward planning for a period of about five years for the provision of

accommodation, equipment, and furniture, and of teaching and non-teaching staff.

The kind of data required by a policy planning committee includes:

1. A detailed analysis of the present and prospective technician student enrolment for existing and prospective technician courses in the region.

Different countries have different priorities in their technician manpower requirements. In the early stages of industrialization, civil, electrical and mechanical engineering usually have priority. The balance of teaching needs, the size of teaching groups, the teaching methods, the utilization of teaching staff, and the intensity of utilization of space and equipment, all influence the type and amount of accommodation and its design and layout.

2. Forecasts of the initial and annual intake of students and the long-term future demands for technician apprentices.

Such forecasts need to take into account technological innovations which can alter the mix of manpower required as a country develops. For example the proportion of technicians to technologists may rise and the proportion of craftsmen to operatives may fall. Much depends on the close collaboration of the manpower planning departments of the government, and on the active involvement of industry.

3. The anticipated needs for introducing new types of technician course, and for modifying existing ones.

4. The number of prospective technician students with the required entry qualifications.

It is desirable for planners to have sufficient information about the school population to enable them to correlate it with the proposed numbers of students who will enter courses for one category of technician or another for the next five to ten years.

5. The patterns of attendance to be adopted (e.g. full-time, sandwich, day release, and evening courses).

This is an important factor in planning teaching accommodation. For example, it may be possible to gain a more intensive utilization of buildings and equipment, and to increase the intake of technician students, if employers release students from industry in such a way as to achieve an even flow between work and college. In such circumstances the college may be able to organize a 48- or 50-week year.

6. A broad indication of the categories of accommodation to be provided.

Planning arrangements are most effective when the growth of student numbers and the provision of teaching accommodation are kept in step with one another.

7. An estimate of the expenditure required for building new accommodation and for adapting any existing accommodation that is to be retained.

New teaching accommodation should complement the old. Studies should be made to explore what can be done to make the best use of existing accommo-

dation by adapting it to new uses. New buildings should be designed to make good deficiencies in the old ones.

8. Estimates of the cost of external works.

These should take into account any special additional costs for which the need can be foreseen, as, for example, changes in labour and material costs, and any circumstances that could arise outside the terms of a normal contract necessitating the issue of a variation order.

9. Details of any proposed dual provision scheme for the provision of facilities for use by students and by members of the general public, including professional, commercial and voluntary organizations.

10. Sufficient evidence that the project makes proper provision for the number of technician students and courses proposed, that it can be achieved within the available expenditure and that it will be good value for money.

The policy planning committee should obtain the advice of a team of professionals. The team should include technical education planners and administrators, the senior staff who will direct and manage the college and organize and supervise the teaching, representatives of local and national industry, and (as soon as they are engaged) the architect, the engineers, consultants and quantity surveyors who will plan and design the whole scheme, and the builder selected to undertake the contract. This team should be given the fullest opportunities to be involved at every level and stage of planning and decision making. They can thereby ensure that the educational aims of the college, the pattern of the teaching, the social and administrative framework, the technician training programmes the utilization of buildings, equipment, furniture and fittings, and the landscaping, all contribute to an integrated whole.

The tasks of the policy planning committee will include making decisions about the kinds of technician education a new college will contain, about the accommodation that is wanted, and about the size, location and function of each of the buildings. The committee will also have to present the requirements in such a way as to avoid unnecessary duplication and make the maximum use of all available resources. If this is to be done well, the committee should consist of men and women who have the knowledge and experience to make the right decisions acceptable to the authorities. The goal is to plan and design a college that will efficiently and effectively serve the needs of staff and students for years.

One of the committee's first tasks is to select an architect so that he can be a working member of the project planning group. He should have successful experience in designing similar educational projects, an established record of achievement in accurately estimating costs, expertise in interpreting planning authority regulations, and a record of good relations with officials, fellow professionals, builders, and employees.

In work of this kind the architect has to take into account a very wide range

of ideas and expert opinions. He should therefore never have to resort to guesswork about such things as the educational aims, curricula, levels of course, student composition, teaching methods, and organization of the institution.

In preparing his designs, he and the policy planning committee must be aware that technical college buildings can in themselves contribute to outmoded educational processes, hierarchical structures, departmental segregation, and the uneconomic use of specialist teachers, expensive equipment, and accommodation. Alternatively the buildings can offer opportunities for meeting the occupational aspirations and social desires of the students and the community served by the college, and help to provide job satisfactions for the staff. The architect must therefore know whether the college is to develop as an integrated whole or as a number of separate departments, each with its own general and special accommodation. More will be said about these and related matters in the next section under the heading *Teaching Methods.*

Where they exist, town planning authorities should also be involved from the beginning of the exercise so that the college can be planned in relation to the surrounding area as a whole. The college is likely to be one of the largest local enterprises in terms of the number of people and the financial turnover involved. It may lead to a substantial increase of population in the area. Staff and their dependants will require housing, and will need to have access to the full range of public services and shops. Students are likely to require lodgings within easy reach of the college.

Teaching Methods

Plans for the teaching accommodation, equipment and staffing of a college should be as up to date and effective as possible. Nowadays the trend is away from teacher-centred methods of teaching to student-centred methods of learning. As a result there is a diminishing use of the formal lecture theatre with its emphasis on talking by the teacher and listening by the students, and an increasing use of multi-purpose rooms with movable wall divisions, chairs, tables and screens where seminars, tutorials, and various kinds of group work can be held, and where private study can be undertaken. In addition the present-day emphasis on laboratory workshop procedures creates a need for increased laboratory space as opposed to formal classroom teaching space. However, for modern technician courses the traditional concept of specialized, departmental laboratories is changing. Large fixed machines and free-standing equipment are being replaced by smaller, portable, trolley-mounted equipment. Though accommodation will continue to be required for some of the large equipment required for specialist work, and space adjacent to laboratory workshops will still be required for large-scale assembly and erection work, some of the space provided can be out of doors, and it can be shared by several departments if they co-ordinate their specialist needs. For example, mechanical and electrical engineering technician students can use the same facilities and accommodation for laboratory work in measurement and control systems; civil and mechanical

engineering technician students can share the same space and equipment for materials testing equipment; electrical engineering and building technician students have a common interest in electrical installations. In addition there is a growing emphasis on small-group inter-disciplinary project work in technician courses. These projects can be space-consuming for a limited period, making necessary the provision of movable equipment in laboratories and workshops and flexible space arrangements in general teaching accommodation. As a result, workshops tend to be less specialized, less formally laid out and less rigidly separated than in the past. There is less fixed benching and more clear floor space.

For the effective operation of a new college, the planners should ensure that the education and training of teachers of technician subjects includes in-service courses in the scientific principles underlying the design of modern industrial equipment, in its use and maintenance, and in modern methods of teaching special technician subjects. Training should also be provided in the writing of technical material for students, in the techniques of cumulative assessment, in testing and individual student record maintenance, in designing and producing teaching aids and programmed learning material, in counselling, and in techniques of self-assessment. For no matter whether the specialist technician teaching area is part of a large modern, open-plan laboratory, or a separate laboratory in a chain of specialist laboratories, the specialist technician teacher must have the knowledge and skills to be an effective and productive teacher. It is the responsibility of heads of departments to ensure that the specialist technician teachers to be employed in a new institution are trained to be effective in imparting the right level of technological knowledge and technical skill and that they are fully capable of the efficient and safe operation of laboratory and workshop equipment and teaching aids.

Central Time-Tabling

Central time-tabling is an essential feature of the effective management and maximum utilization of the total resources of a technical college. It involves breaking down departmental accommodation barriers so as to prevent excessive periods of under-occupation and unnecessary and wasteful duplication of equipment and staff. Details of lecture rooms and classrooms, assembly and general purpose halls, small rooms for seminars and other purposes, special purpose rooms (e.g. the computer room and the library), laboratories, workshops, etc. can all be put in a central pool. The rooms can then be classified according to their capacity, their services and facilities, and their location. Areas of full use and of under-use can be located, and a management group consisting of the principal, heads of departments and key teaching staff can consider what improvements can be made so as to maintain a constant level of use. For example, it may be possible to stagger lunch and coffee breaks. It may also be possible to restrict the number of subject options so as to maximize the use of accommodation and staff. The size of groups can be increased by bring-

ing together students from different departments for overlapping subjects which can be taught in common facilities. Particular areas need not be used exclusively for particular kinds of course (e.g. for management studies, higher degree or advanced diploma studies, or various kinds of industrial course). Instead, they can be used for other purposes as well. Increased use of college accommodation and resources can also be made in the evenings, week-ends and vacations.

Unless there is an overall plan for structuring the content, development and methodology of the technician curriculum provided by the college, and for the time-tabling of classes and accommodation, the individual teacher will be handicapped in his professional activities. He will not be able to fully contribute his technical knowledge, practical skills, industrial expertise and teaching experience to the achievement of the educational aims and objectives of the technician courses on which he is employed or to the college as a whole.

General Planning

The overall objective in planning, designing, staffing, equipping and furnishing a technical college is to provide the means for implementing appropriate vocational education and training programmes for the proposed number of students and courses. The physical development must serve the technician manpower education and training development plan, and give corporate meaning to the academic work and social life of the institution. Efficient planning is the basis of good design. It will result in accommodation which is functional, flexible, integrated, aesthetically pleasing, and economical to run, which gives good value for the investment, and which is completed on the target date. It will influence the quality of the total environment for learning, and the individual student's personal and social development. Planners and designers must therefore do all they can to provide adequate facilities and eliminate anything that can limit or inhibit the learning process.

Planning is influenced by many factors, of which seven of the most important are:

1. The economic needs and priorities of the country, state, region, and locality which the college is to serve.
2. The intended role of the college, the vocational education and training needs to be met, and the range of programmes to be provided. These matters will be influenced by existing and projected levels of industrialization, by the pattern and availability of general education (particularly at the secondary level) and by the scientific and vocational content of the secondary curriculum.
3. Whether the training of technicians should be carried out in a special institution or in one that provides training for various occupational groups at different levels.

Frequently technical colleges begin as multi-level institutions and, with expanding industrialization, develop into separate institutions each offering training within a more restricted range of levels. This is a good way to proceed. At the beginning the provision of different levels of training in one institution

makes it possible to have better accommodation, facilities, equipment and staff than would be obtained if resources were spread among several institutions.

4. The optimum size of the institution.

A minimum student population of about 750 day attendance is considered to be required to ensure the efficient utilization of facilities and staff. The support of industry is essential both for maintaining student numbers and for providing suitable employment on the completion of training.

5. The provision of adequate properly designed accommodation for administration, teaching, and communal activities.

The space allowances for non-teaching communal and administration accommodation are normally related to full-time and full-time equivalent students. The number of teaching spaces required depends on detailed studies of the kinds, levels, organization and duration of courses, and of student numbers, and cannot, as in the case of the non-teaching accommodation, be related to the actual number of full-time and full-time equivalent students. The size of classes rarely matches the recommended official size. The accommodation should be considered for the institution as a whole, in terms of total provision for the time that students and staff spend in the college.

It is normal for college planners and designers to have administrative freedom to distribute area allowances flexibly, provided that the educational aims of the scheme are met and the expenditure level is not exceeded. In the course of a normal week a student will spend part of his time in scheduled activities (such as lectures, seminars, tutorials, and practical work in groups of various sizes with members of the academic staff), part of his time in private study in the library or elsewhere, and part in social and recreational activities. The allocation of space depends on the particular circumstances and practices of the college. One factor to remember is that the number of students for each technician course is seldom the same from year to year, and it often changes drastically during the course. Another is that space that is suitable for one form of activity at one time may be equally suited for a different activity at another time. For example, different departments may be able to share the use of centrally timetabled classroom accommodation. They may also be able to share space that is closely linked with laboratories and workshops. Engineering drawing offices—provided they are equipped with dual-purpose furniture—are interchangeable, as are other kinds of general teaching space. An assembly hall with a flat floor can be used for large lectures, for theatrical performances, for concerts, dances and social functions, for students' union meetings and for other purposes.

6. The provision of educational data.

This is usually assembled in a recognized sequence: (a) a schedule of the proposed departments; (b) the number and duration of the courses to be followed; (c) the number of students and staff; (d) a list of general and specialized teaching accommodation and hours of use; and (e) a list of essential staff and student accommodation.

7. The provision of space standards.

These are needed for the preparation of preliminary sketch plans and circulation diagrams showing the relationship of rooms and their location for maximum efficiency and convenience, and for special features concerning the service, equipment and furnishing requirement of the rooms in each department. They provide the basis for the economic assessment of a college project.

Initial planning should be thorough and accurate to eliminate the need to change the plans after the working drawings have been completed. Each building should be planned and designed only after a detailed assessment of its functions has been made.

Also at the outset it is essential to identify priorities and establish clearly the sequence of events, the time scale, and the responsibilities of the main parties concerned in the planning and design process. Only plans for the immediate future can be drawn in detail. Others should be left until later so as to make allowance for compromise.

Flexibility in Planning and Design

The special nature of technician training and its relationship to scientific and technological development make it subject to change in content, in the balance of theory and practice, in teaching methods, and in the kinds of resources required. It is difficult at the initial project-planning stage to predict either the direction or the pace of change. As time goes by, the purposes that a building is called on to serve are less and less like those originally planned for it. The process of change is continuous. New teaching methods may result in heavier than expected demands on the library or the language laboratory. New subjects may be introduced, evening courses may appear or disappear, day-release courses may be replaced by block-release courses, and so on.

Planners should therefore regard nothing as permanent. They should aim at providing accommodation which, with minimum expense and interruption, can be adapted to serve new purposes over the years while keeping different types of accommodation in balance. They should consider using pre-engineered components to create flexible, modular, adaptable spaces which can be altered and rearranged as required to serve technician education and retard obsolescence. Inflexible, outmoded buildings can be a major impediment to innovation and change in the organization, management, supervision, and teaching methods in technician education.

The test of a successful development plan is its potential for future adaptation. The plan should be flexible enough to keep options open for as long as possible, and to accommodate unforeseen changes while providing adequate guidance to facilitate immediate decisions. Arrangements for future expansion must be envisaged at the initial planning stage. Where alternative lines of development are open, the options should be stated so that the physical development can include a contingency for each of them. Expansion at a later stage by means of upward extension is expensive and interferes with the normal activities of the college; provision for lateral expansion is greatly to be preferred. Building in

stages is a satisfactory solution to problems of future expansion provided that this is considered at all points in the project programme.

Teaching Accommodation

The teaching accommodation should be planned as a whole. It should be designed not to meet only the needs of separate departments but to allow for maximum pooling of accommodation and for the easy movement of students from one department to another. Good planning should enable the general accommodation allocated for lectures, for class work, for tutorial, seminar, and group discussion, and for small committees and syndicate work to be utilized for up to 80 per cent of a forty hour week. For specialized accommodation the figure may be closer to 70 per cent.* However, such high occupation rates can be obtained only where there is a close fit between sizes of groups to be taught and sizes of rooms available.

The amount of teaching accommodation required is determined by: (a) the pattern and types of courses to be conducted, the subject matter to be taught, and the level of instruction required; (b) the number of students to be trained; and (c) the range of activities and the degree of specialization planned. Data derived from surveys should indicate clearly the number of working spaces of different types required for a given number of students to follow the particular kinds of courses to be offered. The spaces fall into three groups: (a) non-specialized general areas such as lecture theatres, classrooms, tutorial and discussion group rooms, seminar, small committee and syndicate rooms, drawing rooms, educational and training technology rooms; (b) specialized areas such as laboratories and craft rooms; and (c) workshops with associated service and storage rooms. Given this information the gross floor area can be calculated. This can then be translated into detailed descriptions of the accommodation required for the various departments and sectors of work. Normally not less than half the total will be teaching space. Half of this is likely to be of a non-specialist, general kind to be used by students from all departments. It should be planned and designed for intensive and economic use. Some of it should be

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*In calculating the utilization of space, two factors are taken into account. One of these is the frequency of use of rooms. The other is the extent to which they are occupied on occasions when they are in use. Utilization can then be expressed as a product of the two.

Thus in the case of a room with 25 seats used by a group of 20 students for 30 hours out of a possible 40-hour week:

$$\text{Frequency} = \frac{\text{room hours used}}{\text{room hours available}} = \frac{30}{40} = 0.75$$

$$\text{Occupancy} = \frac{\text{seats used}}{\text{seats available}} = \frac{20}{25} = 0.8$$

Utilization = Frequency x Occupancy = 0.75 x 0.8 = 0.6

Expressed as a percentage, the figure in this case is 60%.

open planned and allow for easy sub-division. The general teaching accommodation, together with the library, and the communal, catering and administrative areas, should be grouped for easy access on good circulation routes to all parts of the college. Where these facilities are incorporated in a single building, the ground floor should be reserved for activities producing considerable population movement, heavy floor loading (e.g. the library, the assembly hall, the auditorium, large lecture theatres, the gymnasium, heavy laboratories and workshops and the canteens).

General Accommodation

A Lecture Theatre

A purpose-built lecture theatre is costly to build, furnish and equip, so its level of utilization should be at least 50 per cent. Otherwise it is an expensive luxury.

Normally a lecture theatre will have accommodation for at least 50 and not more than 500 students. Its floor will be raked and its fixed seats will be tiered with provision for note taking. It should be well equipped for a wide range of demonstration purposes, including a fully-serviced demonstration bench with a built-in control panel for operating all services including those in the projection room and the boards, screens, and lights. The acoustic standards must be good, and a public address system should be installed if seating is provided for more than two hundred. Air conditioned, windowless lecture theatres are preferred. There should be an adjoining lounge, rest room, cloakroom, and small conference and seminar rooms.

The disadvantage of having a large raked lecture theatre with tiered seating is that it offers few possibilities for alternative use. It is not suitable for social activities, and it cannot substitute for an assembly hall or auditorium.

Classrooms and Lecture Rooms

These usually have a flat floor, and accommodate up to 50 seats with provision for note taking. The equipment includes a dais and demonstration table, visual aid equipment, appropriate lighting and services, a range of boards, and space for charts and exhibition material. The size of each room should be determined by the purposes to which it will be put. Usually classrooms of several different capacities will be needed.

The design of larger classrooms presents particular problems. They should have no columns to limit visibility. They should be located near ground-level entrances and exits, but not under laboratories having service lines for liquids. In general they should be a little longer than their width.

Specialist Accommodation

Laboratories

The education and training of technicians is essentially practical. Much of it takes place in laboratories containing special facilities and equipment, and often requiring close control over the environment in which the work is done.

In terms of cost per square metre, laboratories are among the most expensive

teaching areas to provide. They also present the most difficult planning problems.

It is logical to plan large open laboratory and workshop spaces for multi-purpose use. Barriers between technological disciplines are breaking down and common-core curriculum studies are being devised for the first two or three years before strict specialization starts. Inter-departmental collaboration and central time-tabling of laboratory space should therefore be undertaken for such subjects as physics, chemistry, the properties of materials, electrical engineering, hydraulic engineering, and control engineering. Although it is not always possible or appropriate to teach every branch of technician science and technology in a single laboratory, everything possible should be done to prevent laboratories from being tied irrevocably to one subject or to equipment-oriented spaces that cannot be adapted to fluctuating demands. Adaptability is essential because increasing industrialization creates needs for new types of technician who, in turn, require new types of laboratory training. This should be taken into account in planning. So should the need for growth which can be allowed for initially by surrounding each piece of equipment with plenty of space. In general, compromise has to be reached between providing special accommodation and facilities to meet the different training requirements, and avoiding unnecessary duplication. At the same time it is necessary to isolate certain activities and equipment within the larger space – for example, noisy machines, welding equipment, and delicate instruments.

When laboratories or workshops are on different floors of a multi-storey building, heavy reciprocating engines, shock-producing machines used in testing materials and structures, compressors, and equipment producing noise and vibration disturbing to others should be kept at ground-floor level and in a position to minimize transmission of sound and vibration effects through the steel structure of the building or the air ducts. They should be on anti-vibration mountings and have flexible joints for pipes and connections in order to confine the vibrations at the source. Special precautions may be necessary against flash interference, fumes, dust, excessive heat or damp.

It is unlikely that dual or multi-purpose laboratories can provide the appropriate facilities and environment in the later stages of technician courses, but it might be possible to fit some of the lower-level work into more advanced laboratories provided that the services to the work stations are suitably planned and designed. Small laboratories accommodating about 25 students can be planned without adding greatly to overall requirements or cost. They can be designed for multiple use as a changing curriculum requires.

Students, teachers and laboratory technicians working in established laboratories can be a useful source of information for laboratory planning. They can provide data about the nature of the activities in which they are engaged and about the constraints imposed by buildings, lay-out and services. By studying existing and past records and patterns of laboratory usage it should be possible to predict trends in requirements for the future, bearing in mind that patterns of technician education and training change so rapidly that precise long-term pre-

diction is not possible and that there must be adaptability in planning and design to accommodate changes.

Workshop Accommodation

The purpose of the technician workshop is to provide the special off-the-job training and work-experience requirements of technician education and training courses where this is not possible or available on the job in industry. The aims and objectives of workshop courses should be described in detail before serious planning begins as these will determine the areas and spaces required, the equipment, tools and materials to be used, and the services to be installed. The objectives themselves will differ if the workshop is to be used for strictly vocational or for strictly non-vocational courses. Thus the main objective of a non-vocational course is to provide facilities and resources for students to be creative in an imaginative way not necessarily to meet the needs of productive industry. On the other hand, one objective of the strictly vocational workshop course is to familiarize higher- and middle-level technician students with the application of science and technology to industrial processes, equipment and procedures, and to introduce them to the manipulation of tools, machines and instruments. Another is to provide an environment in which junior technician students will learn to use tools and machines to manipulate materials and carry out the disciplined industrial processes of a trade with an appreciation of the technology underlying the strict procedures they carry out.

The total workshop area should be planned as a general purpose unit related to the technology laboratories, the general teaching accommodation, and the associated resources. Workshops should be grouped according to their relation to each other and be connected by covered walkways. They should also be flexible enough to meet different technician student needs. For example, partitions between workshops should be constructed in such a way that they can be removed and space arrangements modified as future circumstances warrant.

It is not possible to lay out a floor plan or to determine the equipment and facilities needed in a workshop or laboratory workshop without an understanding of what is to be performed there. Sometimes the chief determinant will be the number of students requiring space; sometimes it will be the shape, size and number of machines to be installed. Workshops should, where possible, be one storey in height to simplify problems of floor loading. There should be at least two doors, opening outwards, one at each end of each workshop. One of them should be larger than the largest piece of equipment to be moved in or out of the workshop. Open spaces should be provided near entrances and exits to eliminate congestion, and there should be facilities for the receipt of heavy and difficult loads adjacent to a good service road. There should be adequate headroom of about 5m (17 feet). The roof and ceiling construction should have the minimum of supporting columns. It should make provision for supporting a track or a hoist. The shop area should be rectangular in shape, with a width to length ratio from 1:1½ to 1:2. Easy-clean, minimum repair, non-slip surface floors resistant to oil

and water should be at one level and should be insulated to reduce noise in the shop and prevent transmission of noise to other shops. Any electric floor heating must avoid machinery locations. Floors round large equipment should be non-combustible. Sub-floors must be sufficiently thick to avoid vibration and to permit the ragging in of bolts for fixing machines. Walls, furniture, and equipment should be painted in light colours, and the floor and wall materials in workshops should be acoustically treated and be capable of being stained and restained.

Although natural lighting should be used wherever possible, windows alone are not adequate. Roof lighting is sometimes used to provide additional natural lighting, but it can cause problems and it is not always sufficient. Basically what is required is sufficient natural and artificial light to give a good, even spread over the whole floor area without creating shadows or excessive brightness or glare. Artificial lighting is conveniently achieved by fluorescent lighting with separate low-voltage lighting for each machine.

Noisy workshops such as diesel engine shops should be located in the noisy zone of the college so that they do not disturb other activities. Dust, smoke, fumes, gases, vapours and odours should be evacuated by mechanical ventilation designed to carry them away from other college buildings and adjacent private property.

Equipment, except for the portable type, should be fastened securely to the floor or other stable foundation. Machinery should not be mounted on columns or against pipes or air ducts if these will transmit noise to other parts of the building. Heavy equipment should be mounted on concrete bases projecting to the floor level and insulated from the floor slab and other structured members of the building. Larger machines that create a vibration problem may be mounted on rubber, adhesive, cushioning pads, but this method is not applicable in all cases. Machines around which danger zones exist should be adequately guarded, and lines should be painted in red or contrasting colours to indicate the danger zone. Built-in workshop benches with heavy wooden tops covered with heavy-gauge metal plate should be provided along most of the outer walls in the general engineering and automobile shops. Benches in the electrical engineering workshops should be similar but not covered with steel plate. Equipment and work stations should be placed so that there is no danger of interference with adjacent workers. Aisles not less than four feet wide should be provided for safety and free flow of student traffic between all points and areas of common usage.

Laboratory and Workshop Services

Where laboratories and workshops are planned as general purpose areas of unobstructed floor space allowing for a variety of arrangements and special needs, they require flexible services. These normally include: A.C. and D.C. electricity; heating, ventilating, and air conditioning; cold and hot water; drainage and waste disposal; compressed air; liquid fuels, gases, and steam. They need not all be installed at the outset – as this can result in unnecessary over-provision. However, sufficient space should be allowed for fresh services to be introduced as required,

and service runs should be easily accessible for the laying of new cables and pipes.

Localized mobile sources, which are either self-contained or modify the centralized distribution, enable special services to be made available in any location. Compressed air and vacuum can be supplied from trolley-mounted rigs so that problems of access do not arise provided that free circulation floor spaces have been planned at the design stage. Greater freedom of workshop and laboratory lay-out is also possible if movable benches or tables can be butted up to service bollards, or if services can be supplied from buzz bars, multiple voltage socket boards and overhead booms with flexible connections to the work place and movable bench-level channels into which free-standing sinks can drain.

Where battery supplies are considered necessary, special provision is essential for ventilation, the storage of acid, and the overnight charging and transporting of portable batteries. Facilities for the storage and handling of bottled gas, if it is needed, should also be provided.

Government regulations for building standards, services installation and safety requirements may have to be observed. Education planners have an obligation to ensure that they give architects and designers full and correct advice on these matters. Points to be borne in mind are: (a) a complete schedule of the safety precautions built into the service installations; (b) the accessibility of centrally supplied services; (c) the location of power and light controls, other services, and outlets for fumes; (d) special requirements for heating, ventilation, sound, anti-vibration, drainage, and rubbish disposal; (e) special finishes of flooring, walls, ceilings and screenings of windows for particular activity areas (e.g. in arc welding bays to avoid injurious effects to the eyes); (f) adequate lighting for general and special purposes; and (g) location of conspicuously-labelled fire extinguishers near danger points.

Communal Accommodation

Labelling the three main areas in a technical teaching institution as teaching, communal, and administrative is essentially a planning convenience. The teaching function cannot be confined to one area, and teaching programmes cannot be tailored to the administrative structure of an educational organization. The communal and teaching accommodation required for the occupational, employment, and social learning experiences necessary for training technicians must include integrated resources for large and small group instruction, general and special laboratory work, individual and team project exercises in workshops, and library assignments. Teaching staff and students also need to have easy access to communal areas such as centres for learning resources, audio visual aids, and closed circuit television.

Definition of the foreseeable educational and social objectives of the institution is essential before the communal needs can be assessed and planned. It is a complicated task to provide for all the various needs, and plan the communal accommodation so that it proceeds in step with the growth of the whole institution. Provision has to be made for changing emphases on the use of the library,

on small group and private study, on the growth of inter-disciplinary studies, and on links with the local community.

Communal accommodation resources should normally be provided centrally so that they contribute to the establishment of a social focal point for the institution. In bigger colleges the provision of limited, minimal communal facilities on a circulation route can be a convenience without unneccesarily duplicating the main central facilities. It is not essential to provide separate facilities for staff and students: shared facilities can encourage informal teacher and student contacts. Non-specialized communal areas are usually interchangeable with other functions. For example, a main hall can serve several additional purposes. Thus it can act as a college assembly and examination hall, a gymnasium, a dining room, canteen or cafeteria, a local community hall, or a theatre or cinema. It can be used for indoor games and sports, for social activities and for exhibitions and displays, or it can be partitioned into temporary spaces for seminar and syndicate activities. Indeed, its provision may be justified only when it can be used for community functions as well as for college purposes.

Library

The purpose of the library is to support the teaching programmes by providing a readily available selection of appropriate technical literature and a range of general educational publications to broaden the students' knowledge and interests. Planners have to ensure that the accommodation will be designed and arranged to permit and encourage maximum utilization by students and staff.

Provision should be made for three main areas: stacking and shelving for books, periodicals, and other reference material; reading and private study spaces; and administrative services. The size of each will depend on such factors as the proposed extent of student use of the library; the proportion of course time to be spent in supervised library assignments and in private study which requires ready access to the library; the kind of study spaces to be provided; the balance between open shelf and limited access; the types of material to be made available; and the amount and kind of stacking, shelving and storage required. Early decisions have to be made between central and departmental libraries so as to meet special needs without wasting staff or duplicating titles unnecessarily: the solution probably lies somewhere between complete centralization and complete dispersal. Decisions have also to be made about the location of stacks, bound volumes, and display racks for new books and periodicals; about whether there is to be a separate reading room for periodicals and journals; about the location and size of the offices for the staff; about service counter and catalogue areas; about space for the receipt and cataloguing of new books; and about the provision of a workshop for book binding and repair.

It is best to provide flexible accommodation, preferably on one floor, that can be modified to adjust to the changes and expansion which always take place in a new technical institution. The library in most technical institutions is not merely a dispenser of books and periodicals. It is a multi-media centre with abstracting,

photocopying, retrieval and storage services, and with facilities for microfilms, tapes, records, cassettes, and other audio-visual aids for class or individual use.

The library should be readily accessible from the main circulation routes in the college but removed from noisy communal accommodation. It should have easy access for delivery by road to a service entrance. Its location should make possible evening, week-end and vacation opening without creating problems of access, security or safety.

Catering

Catering arrangements can have a considerable effect on the planning and design of college communal accommodation. They must be decided at an early stage in the development of the design brief. To provide an efficient, financially-viable catering organization, it is essential to have expert advice. Designs should be based on flow diagrams of the logical sequence of activities from the delivery of food to washing up. They should take into account such matters as the range of food to be provided, storage (including refrigeration and cold storage requirements), food preparation and serving (whether by cafeteria or table service), the number of students and staff requiring meals at particular times, and the toilet and other facilities required by catering staff and customers.

Residential Accommodation

Many policy decisions have to be made before investing in traditional type hostel accommodation. These will be influenced by such matters as the preferences of the students, the cultural, social and family life of the country, the wishes of the parents, the age-range of the students, the geographical location of the college, and the degree of supervision that the college authorities are required to exercise.

Though hostels should be separate from the main college buildings, they should be within walking distance or be easily accessible by public transport so that students can use their rooms for private study in the day-time and use the college communal facilities in the evenings and at week-ends. Usually they should consist of single study-bedrooms grouped in family units with a common-room, small kitchen, utility room, and appropriate bathrooms, showers and toilets. Recreational facilities should be provided for the hostel as a whole. If hostels are to be built, they should be constructed at the same time as the teaching accommodation. So should staff housing if it is to be provided at all.

Administration

Though the accommodation to be provided for administration will vary with each project, space will normally be required for the principal and vice-principal, the heads of departments, the senior administrative officers, and the secretarial staff. These people and all the teaching and non-teaching staff (who include librarians, technicians, storemen, caretakers, cleaners, porters, gardeners, and catering workers) must have good working conditions, cloakrooms and toilet facilities. A number of general and special purpose spaces will also be required.

These will include space for student guidance, counselling, and medical services, the student union officer, the mail room; public telephone kiosks; a book and stationery shop, an enquiry desk, cloakrooms and toilets, an exhibition area; and a porter's room to control the main entrance hall.

The entrance hall is the first point of contact for most visitors, and it should be planned as a pleasant focal area big enough to prevent congestion at peak hours, and with exhibition space and easy access to lifts and the main circulation corridors. The architect will need to have guidance about these matters and about the requirements for lifts. Designing the installation of lifts is a specialist's job involving decisions about their location, the floors to be served, and peak-period requirements.

Some of the policy decisions that have to be made may at first sight seem trivial, but their results can be sources of tension and acrimony among the people involved. Here are some examples. Who should be allocated private offices, how big should they be, and what furniture should they contain? Who should have a private secretary, and who should make use of the typing pool? Who should have a private telephone? Is it necessary to have a spacious, expensively-furnished, fully-serviced room to be used solely for very occasional meetings of the governing body, the college academic board, and special committees?

Planning office space to meet present and future needs is a complex task. Staff work-rooms can rarely be individual offices but they should provide individuals with secure and private desks and storage space. Those for departmental heads and teaching staff should be designed in conjunction with the teaching areas, laboratories and workshops in which these people work. Space (whether in a separate office or in shared accommodation) will also be needed for staff with special responsibilities, such as interviewing students, keeping academic and career development records of junior teaching staff, keeping cumulative records of students, drafting testimonials and confidential references, time-tabling, administering examinations, making arrangements for college visitors or part-time teachers, collaborating with industry, and organizing extra-curricular and other student activities.

Planning decisions have to be made about the location and organization of the central store and any other stores that are required. The tendency is to locate the central store in the main laboratory and workshop area where it can serve the students and the staff and be under the control of a chief technician storeman. It should have a receiving room with large outside doors and an unloading platform adjacent to an access road. It should be connected to the laboratories, workshops and other special areas by corridors wide enough and high enough to allow for the free movement of equipment on trolleys, rollers, or fork-lift trucks. Special storage may be needed for petrol, oil, solvents, hazardous chemicals, and perishable items.

Sub-stores, located in different work areas of the building, may be required for equipment and materials not suitable for incorporation in a laboratory or workshop, and for the storage of students' work while it is still in progress or

awaiting assessment. Other storage space will be needed for the caretaker's and cleaners' equipment, for linen stores, for the kitchen, for furniture, for wet outdoor clothing, for protective clothing, etc. That used for personal belongings should be easily accessible, capable of temporary expansion, and be located near to main circulation routes around the college.

Site and Location

When selecting a location for a college, several factors need to be taken into account. To begin with, surveys have to be undertaken to determine the needs of industry and the numbers and types of technicians that will be required in the region. Secondly, thought should be given to the location of the new technical institution in relation to an industrial centre so as to allow for close liaison with the companies and organizations that will send students to the college and employ them during and after their training. It is difficult, and expensive, to find a site near the middle of an established urban centre. Nor are near-by sites often available at the right time for phased development. Divided sites can create administrative and management problems, and, as a result, new technical colleges are more often located on estates outside the towns where new industry is springing up, where land is more easily available and less expensive, and where the college can become an integral part of the community. A well-located college can serve not only the needs of industry but also those of farmers and all those men and women who seek further general and specialist education and a social and recreational centre for themselves and their children.

The selection of a particular site for a college should be determined mainly by the functional requirements of the proposed institution and by the physical features of the sites available. The site should be reasonably level, and large enough for present and future needs. The subsoil should not be swampy or liable to flooding or subsidence. Land bought cheaply and requiring major site works should not be chosen even though modern civil engineering techniques can overcome apparently serious disadvantages. The price of the land is not the largest cost element in the plans for a new technical college.

The site should have good road access and easy public transport communications with the areas where students, teaching staff, and administrative staff live. Access to adequate mains supplies of electricity and uncontaminated water, to telephone services, and to a main drainage system are also important.

There is no simple formula for determining the appropriate area for an institution. It is usually good practice to select a single site that is larger than the estimated necessary area in order to leave the options open for development and expansion in the future. The density of the development is critical. Planning should aim at a compact, economical lay-out, and leave sufficient space for future expansion — taking into account the development needs of individual departments with specialized accommodation and with equipment that cannot easily be moved.

The possible types, shapes and sizes of the buildings are set by the parameters of the site. They can be built upwards or outwards, or be a mixture of both. A

single-storey building is economic to erect where land is plentiful and cheap and the building budget low. However for pipe runs and cables for services, for drainage and sanitary accommodation, and paths and covered ways, the costs are higher than in multi-storey construction. In addition, the long distances between buildings in a large one-storey college make it difficult to co-ordinate organization, management and resources into an efficient working unit. Often it is an advantage to arrange the accommodation in a quadrangle. This eases communication between various parts of the college, tends to bring students and staff together, and helps to encourage a corporate sense in the college.

Confined sites should be avoided. Multi-storey buildings may be inevitable in heavily populated areas, but they are expensive to build. Heavy floor loadings for upper floors result in high structural costs. Lifts, staircases, safety precautions, services, and drainage systems all become more elaborate and expensive as buildings increase in height. Many workshops, laboratories and other teaching spaces may require permanent supplementary artificial light, and supplementary mechanical ventilation or air conditioning may also have to be provided.

With a mixture of single and multi-storey buildings it is possible to get the advantages of both types of structure. The saving on site area may in itself be sufficient to offset any additional building costs. The upper floors of multi-storey buildings should be used for activities that require light structural loading and minimum services (e.g. classrooms, drawing offices, studios, light laboratories, offices), and the ground floor for activities where heavy equipment is in use (e.g. workshops, some laboratories, and the library). Single-storey buildings can be used for activities where noise can easily be isolated.

Ease of movement is an important part of site planning. Because of the movement of equipment and supplies and the simultaneous movement of groups of people at set times, horizontal circulation is considered to be better than vertical circulation despite the difficulties of separating pedestrians and vehicles.

Car parking is a problem in most institutions. In some cases it may be possible to arrange for joint usage of public car parks. Where possible, staff and students should be encouraged to use public transport facilities, and special college buses can be arranged at strategic times.

A site development plan for a technical college can never be rigidly fixed. Decisions have to be reviewed in terms of technician manpower requirements, student numbers, courses, patterns of course organization, and unforeseen circumstances. Whatever type of institution is proposed for a particular region, planners and architects know that similar problems have been experienced elsewhere and that appropriate specialist information and expertise is available through governments and professional bodies.

Schedules of Accommodation

Preparing the initial statement of the schedule of accommodation requires close collaboration between the key teaching staff, the senior administrative staff, the architect, the planning committee and the appropriate government departments

for the whole planning period until the buildings are complete and taken over. It is essential that the exact responsibility of each individual concerned with making decisions or taking action should be defined. Otherwise delays can occur and costs can rise alarmingly.

The schedule of teaching accommodation is the first to be prepared. It is based on an estimate of the amount and usage of teaching accommodation arrived at by examining the schedule of courses, estimating the maximum student capacity, and analysing the space requirement for each subject and for each class within each course. The projected student population is the basis for estimating the required communal, administration and recreational areas. The amount, type and range of residential accommodation required is then determined, bearing in mind the amount, kind and range of provision required for communal, social and recreational accommodation and for areas such as stores, cloakrooms, toilets, and circulation.

If the project is to be phased, the schedule of accommodation should be compiled to ensure that the first phase will be able to function as an independent educational unit and fit with later phases to provide an integrated institution.

Costs

When the total floor areas have been planned and approved, the minimum cost limit can be calculated for a reasonable standard of building. Costing is a lengthy and detailed task involving co-ordination of the professional knowledge and expertise of several different kinds of specialist in order to produce the itemized costs for a total estimate. It includes, for example, the purchase of the site, the site development costs, the design fees, the building costs, and the cost of certain specified kinds of equipment and built-in furniture. It is not normal to permit variations, alterations, or changes of mind once building has commenced.

Design Brief

The design brief is the basis of the work to be done. A clear, logical statement of the planning committee's requirements is a prerequisite for good building. It should enable the architect to ensure that the parts of the design are always considered in relation to the whole so that the institution forms an educational and architectural entity. It should be compiled by the planning committee in association with the architect and his consultants and the design team appointed to do the job. The architect is best involved from the earliest stages so that he can understand what work will go on, the nature of the work flow, what is wanted in the building and its environs, what courses will be offered, the number of students expected to take each particular course, the pattern of student attendance, the organization and management requirements, and the special and communal accommodation that will be required. He will need to know how the teaching methods will affect the locations and relationship between areas, the frequency and intensity of occupation of individual spaces, the dimensions and shapes of different spaces, and the services to be installed. He will need to familiarize himself with the social structure of the entire institution, the probable

pattern of social life, the nature of small grouped units, and the use that students, staff, and the surrounding community are likely to make of the college facilities. He will also need to be able to allow for growth without disturbing the essential unity of the technician education and the design conception. He can then use his professional ability and experience in an imaginative way and not design yet another of those large box-like institutions made up of dozens of identical self-contained compartments which reinforce outdated, authoritarian ideas and hierarchical attitudes to the principles and management of technical education.

Spelling out the specifications in the design brief is a job for experts. Among the items are: (a) the site on which the institution is to be erected; (b) the materials of construction; (c) the accommodation to be provided; (d) the standards of space in different areas of the building; (e) the services required and the flexibility required in them; (f) the physical environment to be provided in various parts of the building; (g) the structuring of internal walls so that spaces can be reshaped; (h) the drainage and disposal requirements; (i) the entrances, exits, access roads, footpaths, and direction of traffic flow to and from different areas of the campus; (j) the pipe work, power cable, ducting and conduit requirements; (k) the location and housing of transformers, switch-gear, sub-stations, and maintenance arrangements; (l) the gas connections and meters; (m) the water tower, pump houses, meter, and fire fighting systems; (n) the storage tanks; (o) the position and maximum loads for lifting gear; (p) the position and dimensions of fitted furniture; (q) the location, type, and dimension of display areas; (r) the width and height of vertical and horizontal circulation routes; (s) the telephone and fire alarm systems; (t) access to light fittings for cleaning and relamping; (u) access for inspection, cleaning, repair, maintenance, and decorating; (v) the toilets, cubicles, fittings, wash basins, and hot and cold water supply; (w) the sports facilities; and (x) the car parking and bicycle storage requirements.

Often a consultant architect or surveyor is appointed as a project officer in the initial stages of planning. He attends meetings of the planning committee and planning groups so as to become familiar with all aspects of the building programme. One of his functions is to ensure that all essential data and technical details are available when required. In addition, he checks drawings submitted by the architect, consultants, engineers and sub-contractors to make sure that the requirements of the planning committee are being met. He has site consultations to ensure that the functional aspects of the building and the installation of services and equipment are progressing according to plan. He checks work in progress, and prepares reports on matters affecting the building programme. He does the planning for the installation of new equipment not being undertaken by sub-contractors.

Other important items in the brief are the date on which the building is required for use, the date for the submission of the preliminary sketches and the architect's report to the planning committee, the date for submission of the final sketch and the estimate of total cost, and the dates of going to tender, receiving tenders, and opening tenders.