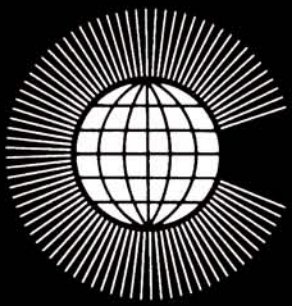

Commonwealth Secretariat

Educating and Training Technicians

EDUCATING AND TRAINING TECHNICIANS

A. MACLENNAN CBE BSc MEd

COMMONWEALTH SECRETARIAT

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Foreword

One reason why many developing countries show great readiness to spend a large proportion of their annual budget on education is that they hope educational expansion will eventually lead to a greater supply of manpower for national development. Over the years, many developing countries have experienced disappointment in the outcome of their educational programmes. In no field is this disappointment more acutely felt than in the field of technical education.

At the Fifth Commonwealth Education Conference many delegates referred to an acute shortage of trained technicians and other middle-level workers in their countries. While so much is spent on expanding and improving technical education, countries continue to rely heavily on expatriate technicians to support their industries. One of the recommendations of that conference was that the Commonwealth Secretariat should examine the problems of technician education and see how they could be solved through Commonwealth co-operation.

The Commonwealth Secretariat has already initiated a number of projects. It has, among other things, tried to determine the cause of the low status of technicians in many countries and made surveys of the progress of technician training in a number of countries in two regions, and it is preparing to make further surveys in this field.

It will be recalled that a specialist Commonwealth conference on technician training was held in Huddersfield in 1966. Many useful recommendations emerged, and the conference report contained many useful suggestions and much information which ought to be brought, once again, to the notice of everyone interested in technician education. Much of the material, however, is out of date and it was felt that the issues raised should be reviewed and presented anew, to ensure that the latest approaches and thinking are incorporated.

We have been fortunate in obtaining the services of Mr Alexander MacLennan to undertake this task. This volume is the result of many months of hard work which Mr MacLennan has put into the assignment which the Commonwealth Secretariat gave him. He has indicated in the introduction to the book some of the considerations which have guided him in his approach to the work.

Mr MacLennan has the academic qualifications, background and experience for this assignment. From 1946-1974 he was Director of the Huddersfield Technical Teachers Training College – College of Education (Technical) after 1964 – and he in fact took part in the 1966 conference on technician edu-

cation, both as a member of the British delegation and as the host to the conference which was held in his college. Moreover, Mr MacLennan has vast experience of technical education problems in most countries of the Commonwealth. He has advised a number of ministries in developing countries on technical teacher training, technical curriculum planning and development and technical college management. I have no doubt that for many years to come, in spite of his retirement, Mr MacLennan's advice in this field will continue to be sought by many countries.

The Commonwealth Secretariat deeply appreciates the conscientious work which has resulted in this publication, which we sincerely hope will make some significant contribution to technical education programmes and projects, especially in the developing countries of the Commonwealth.

S. J. COOKEY
Director
Education Division
Commonwealth Secretariat

Preface

The indispensable role and importance of technicians to a developing country cannot be over-emphasized. They are the middle-level manpower who exploit scientific and technical discovery; the people whose training and skill in industrial processes enable the material wealth of a nation to be built up. Their availability in the right numbers, at the right time, in the right place, and with the right balance of technical knowledge and practical skills, determines the pace and direction of industrial innovation and economic and social development.

Fairly recently, and fairly sharply, shortages of suitably-trained technical personnel have begun to be critical. As a result, plans for industrial expansion have been retarded and thrown off balance, and the import of expensive personnel from developed countries has had to be stepped up in an attempt to bridge the gap. In the long term, this cannot be allowed to continue or the developing countries will remain dependent on the developed world and will fail to realize the rates of growth – however modest – that they have set themselves. To remedy the situation, governments may have to make detailed forecasts of the needs for various categories of technician, and consider what modifications should be made in the existing education and training programmes to ensure that the needs are met.

In making plans for the future, many fundamental questions will have to be answered. For example, what is the technician's role in different kinds of industry expected to be? How can technicians best be recruited and selected for training? Where can the teachers be found, and how should they be trained? Are new technical colleges needed? If so, where should they be located, and how should they be designed, managed and administered? How can technician education programmes be evaluated, and the performance of the students be assessed and examined?

These are some of the questions that this book sets out to ask, and to some extent to answer. It does so in the form of six linked essays – on Manpower Planning and the Technician, on the Education and Training of Technicians, on the Selection and Assessment of Technicians, on the Supply and Preparation of Teachers, on Planning and Equipping Technical Institutions, and on Administration, Finance, Control and Inspection. The resemblance between these chapter headings, and, for that matter, the very title of this book, to those of *Education and Training of Technicians* – the Report of the Conference organ-

ized by the Commonwealth Education Liaison Council at Huddersfield in October 1966 – is no coincidence. For it was as a result of the Commonwealth Secretariat's invitation to me to review and up-date that Report that this book was originally conceived. In accepting the honour of undertaking its preparation, I must acknowledge with gratitude my indebtedness to the lead papers and other contributions made to the 1966 Conference, to the wide range of other published and unpublished material I have drawn on, and to the knowledge and experience of many colleagues throughout the Commonwealth. It is my hope that those who work with planning authorities, education ministries, polytechnics, teacher-training institutions, and technical colleges can all find something in this book which will be of use to them in their task of preparing the technicians of the future.

A. MacLennan, CBE BSc MEd
Former Director
Huddersfield College of Education (Technical)
June 1975

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Manpower Planning and the Technician

Manpower planning is an attempt to predict the role of the labour force in the achievement of the objectives of a national development plan. These objectives are matters of government policy, and reflect the kind of society that a country's rulers wish to create, establish and maintain. Though the priorities are a consequence of the political, economic, and social philosophy of the government, the main priorities are likely to be the provision of higher standards of living and an improved quality of life – particularly for the very poor, the undernourished, the badly housed, the socially ill-adjusted, the under-educated and the under-trained.

It is the function of industry to produce the national wealth required for these purposes. But in order to function at all, industry must have a productive work force. In other words, to obtain smooth, orderly progress towards the achievement of integrated economic and social objectives, industries need an adequate supply of the right kind of trained manpower, in the right numbers, at the right time, and in the right place. Technicians are an essential part of that manpower. Industries depend on them for the production of an increasing supply of goods which can be sold at economic prices in the competitive markets of the world, be delivered in first-class condition on target time, and be supported by efficient maintenance and back-up services.

The analysis of the role of the labour force in the achievement of economic objectives is an on-going activity both at government level and within the different sectors of industry. It identifies areas of the economy in which growth could be hindered by manpower deficiencies and imbalances, as for example between pure and applied scientists, professional engineers, technicians, craftsmen, skilled workers and operatives in industry and their equivalents in business, commerce and the government services. It yields essential data for planning the national and regional distribution and location of particular industrial projects. It is fundamental for planning the primary and secondary education on which

the speed and success of the further education, vocational training and supply of technician manpower depends. It provides information required for forecasting the numbers of different kinds of technician that will be required at critical points of time, and the specialist knowledge and skills which they must acquire to be productive workers in specific jobs in particular kinds of industrial organizations.

The effectiveness of manpower forecasting and planning depends on a high degree of expert technical collaboration between government, the national executive, industry and the education system working together to identify the nature of manpower priorities and to maintain the right balance between the overall development of a country's manpower resources and the usually narrower needs of a particular industry. This task is too complex and too vital to the economic strength of a country to be left entirely to local or private initiative and resources. In the case of technicians it involves isolating, identifying and analysing each category of job. When this has been done it is necessary to write each job description and specification, its constraints and its relationship to jobs of greater and lesser responsibility, its own requirement of specialist knowledge, skills, attitudes, and entry qualifications, and its own technical education and vocational training requirement.

Complete accuracy of job description and job specification is difficult. This is due to a universal shortage of specialists trained to analyse manpower requirements industry by industry and company by company. Consequently it is not yet possible to devise reliable job profiles as a basis for vocational guidance, for selection by an employer or a technical training institution, or for structuring the job evaluation criteria that define an individual worker's wages, conditions of service or status in the service of the government or an industrial organization. White collar jobs based on academic education have more status in industry and greater social prestige in society than blue collar jobs, regardless of the nature of the work, the level of responsibility, the skills or the personal qualities that have to be used. Parents and teachers therefore tend to encourage young people to become pure or applied scientists, technologists or professional engineers. Industry can absorb only a limited number of such people, and where there is also cut-throat competition for jobs in government service and education, unemployment can occur among university and other higher education graduates. In these conditions, status is not gained, but lost. Moreover, those who are unemployed lack the independence, the dignity of having a job and the salary they need in order to feel that they are responsible, participating, and significant worker-citizens in their community and society. On a large scale this may even lead to militant dissatisfaction, political confrontation and social conflict. At the same time there is a shortage of technicians who require in many cases to have theoretical knowledge not far below that of the professional graduate together with high-level practical expertise. This twofold problem could be overcome by having more effective education and vocational guidance programmes and more production industry-orientated edu-

cation courses with their own specialist occupational integrity. If these programmes and courses were to be coupled with an objective system of job evaluation and rewards, and reinforced by mass media education programmes to convince all members of society of their individual and collective dependence on the wealth created by industry, young people would more readily accept the career prospects, job satisfaction and material rewards that exist in the middle and higher levels of industry. The imbalance between unemployed and underemployed university graduates and the shortage of well-qualified technicians could then be corrected.

There is no less need to persuade most nations to intensify and accelerate primary and secondary education programmes. Such action is needed to increase investment in craftsmen and skilled workers from among the millions of children who remain uneducated or under-educated and whose abilities and talents remain unutilized for the common good. This is another element in manpower planning, and it must be admitted that complete accuracy in making valid judgements for more than one to five years ahead in technician manpower planning is difficult. It depends on many variables such as those that follow. They are not ranked in order of priority.

1. The level of industrial sophistication in a country's economic development.
2. The rate of growth in different sectors of the national economy.
3. The trend effect of industrial and economic growth in regional development projects.
4. The level of technological sophistication in a country, in different industries, in different companies.
5. The stage of scientific discovery, the rate of its exploitation by technological change and innovation in different industries and companies.
6. The lack of scientific techniques, reliable data, specialist expertise and experience to analyse the occupational, employment, and age structure of the national labour force.
7. The capital intensive or labour intensive organizations in industrial development.
8. Rate at which mechanization will reduce the number of semi-skilled and unskilled workers and increase the number of technicians and skilled workers required.
9. Frequent changes in traditional classifications of jobs and skills to meet future needs in different industries.
10. Modern technological developments that tend to create jobs which overlap traditional demarcations.
11. New skills that are required in modern design to make mechanical production and maintenance simpler.
12. A breakdown of clear-cut distinctions between occupations.

13. Availability of managers, technologists, technicians, craftsmen, skilled workers and operatives.

14. Introduction of organization and management techniques.

15. Attitudes of technicians to geographical, occupational, and social mobility.

16. Emigration; brain drain.

17. Immigration of technicians and skilled workers with technician potential for re-training.

18. The virtual impossibility of identifying in advance every industrial project and the kind of manpower that will be required to staff every projected factory, hospital, university, polytechnic, and school.

19. The movement of industrially qualified manpower to government jobs.

20. Changes in the armed forces and security forces due to increase in or relaxation of national or international tensions.

21. Unforeseen national catastrophes.

22. Premature retirements and deaths.

23. The fact that many well-qualified people leave an industry or a company because their knowledge and skills are under-used.

Despite the unreliability of the data available and the difficulties of guaranteeing complete accuracy it is still essential to have the best possible forecasts made by manpower specialists who understand the role of labour in industry. Such forecasts encourage a rational approach to matching manpower requirements, as predicted scientifically, with national economic and social planning requirements.

The Employment Structure of Industry

The work force in industry can be divided into six broad occupational categories:

1. Managers.
2. Industrial scientists, technologists, and professional engineers.
3. Technicians.
4. Craftsmen and skilled workers.
5. Semi-skilled operatives.
6. Unskilled labourers.

Manpower in business, commerce, and central and local government services could, in large measure, be fitted into the same categories, though the ratios between the categories will naturally vary.

Throughout industry there is no fixed ratio between the number of workers and the number of managers. Even in the sophisticated technology-based companies with massive investment in highly-trained manpower and equipment, the percentage of top-level managers involved in making and implementing policy is very small in relation to the total work force and to the number of middle-level departmental and line managers. The ratio between the numbers of

lower-level managers – including supervisors and foremen – is not specifically related to the numbers of technicians, skilled, semi-skilled and unskilled workers. Instead, it varies widely with the size, technological sophistication and consequent mix of the labour force. Even so, there does tend to be a relationship between the number of technologists, technicians, and craftsmen in industries or companies of the same type *and their efficient operation*. Thus in production engineering the ratio is about one technologist to five technicians and 25 craftsmen: in the chemical industry there may be as many as three highly skilled technicians to two technologists; a frequently quoted generalization is ten craftsmen to one technician.

Managers

The success of any company depends on the quality of its management. It must be efficient if the company is to contribute to the steady growth of the national economy on which full employment and social development depends. The top manager's function is to exploit all of a company's resources to maximize production in order to achieve the goals of the company and, more specifically, its profit targets. He is involved in policies of manpower planning, recruitment, selection, induction, placement, technical education, vocational training, and development. Though he is normally supported in his work by specialists, in the final analysis he is responsible for co-ordinating product design, development, field tests, manufacture, quality control, inspection, distribution and servicing; for planning and manipulating the use of space, equipment layouts and materials; and for devising systems, methods of work programmes, flow charts, and production time-tables. He has to implement the company's financial investment and resource development plans. This involves budgeting, cost control, value analysis, and diagnosis of deviations outside the financial parameters. He has to understand computer techniques for analysing data concerning ratios of profit to product turnover, turnover to assets, efficiency of purchasing, economic use of storage space, losses due to bottle-necks in work flow, cost of skilled labour turnover, speed of production-line problem-solving, efficiency of man management, and the quality and success of industrial and human relations in avoiding conflict and confrontation in the labour force. It is the efficient use of expensively trained manpower and maintenance of profitable, productive industrial and human relations which is the main and most difficult responsibility of a majority of managers.

Technologists

Progressive growth in national economy depends on industry having an adequate supply of industrial scientists, technologists and professional engineers whose education and training fit them to carry new industrial designs and processes from the research and development stage to the innovation of efficient and productive processes. They are required at the point of production for it is here that application of scientific knowledge and technological know-how can be most effective, and it is here that industry needs highly intelligent, person-

ally able, appropriately educated and trained men and women technologists and engineers. The capital investment at the point of production in trained, skilled manpower, in equipment, in materials, and in servicing is far greater than the investment in pure research and development. As time goes on, more and more technologists and professional engineers will be employed at the later stages of the production process. They will be employed in departmental and line management, as works and maintenance supervisors, and in co-ordinating technical processes, quality control, inspection, value, and cost effectiveness.

The technologist in a modern industrial organization needs to have the trained ability to deal with people as much as with things, to use data from computers and from operational research, to apply techniques of critical path analysis and work study, to innovate, organize, plan, direct and manage, to solve problems of product development, and to avoid shop floor production and industrial relations problems. Technologists and professional technical manpower whose education and training have been production oriented are required for economic and social development by every country needing a stake in world markets for the application of the technologies of life science, bio-engineering, medical sciences, nuclear power, petro-chemicals, data processing, ocean technologies, and the transformation of older industries such as ship-building, civil engineering, building construction, textiles, mining, steel manufacture, and transport.

Craftsmen

The craftsman is almost totally concerned with things and only marginally with data and people. He needs to have the right level and kind of manipulative skills together with enough knowledge of mathematics, science, drawing, technology, and communication skills to know how to use the tools, instruments, machines, materials and the special techniques required to practise his craft effectively. In some companies, if he is employed near the lower end of the technician function, he may need basic mathematics in order to use fine measuring instruments and gauges for setting machine speeds and feeds, and to calculate limits, fits, tolerances, clearances, quantities, capacities, task times and costs. He may have to learn to use simple formulae involving substitution and transposition. In a modern organization he is likely to have to learn how to use mathematical tables and calculating machines and materials suppliers' instruction handbooks. He is unlikely to need more than this, and training programmes should be structured accordingly. *At present there is evidence that craft apprentices and trainees are taught more mathematics than they are ever required to use on the job.* Many of them fail in the mathematics part of their technical education course. It is an unnecessary barrier to the recruitment and career prospects of many people who have the practical knowledge and skill to get and to give satisfaction in craft jobs.

The craftsman may do a better job if he has learned to appreciate the science and technology applicable to the basic design, use, care and maintenance of

tools and equipment, to the operations in a particular craft process, procedure or technique of production, construction or servicing, and to the properties and treatment of the materials he uses.

The craftsman is concerned with learning to produce a working drawing only to the extent that the knowledge will give him the practical skill to interpret a blue-print on the job in order to make a simple, step by step analysis of the sequence in which the individual tasks in a job have to be done, to mark out a job, to prepare a simple schedule of the materials required, to make a simple costing of the job, and to devise a tool layout and machine use programme on a simple time and motion, work study analysis so that he can complete the work within the prescribed framework of speed, accuracy, cost, and quality of workmanship.

The craftsman needs communication skills to understand and carry out the handbook and work schedule instructions for using the tools, machines and expensive equipment which have to be operated with maximum efficiency in order to obtain the full economic output to justify the company's investment in them. This involves understanding, interpreting and translating printed instructions into work procedures. It means understanding words which are within the range of his vocabulary, and being able to read them without difficulty. Any misinterpretation or confusion of the text can result in costly errors on the job. Modern instruction handbooks reduce the printed word to a minimum. The medium of communication may consist of the one-step-at-a-time, gradually built-up diagram of a technique or an exploded picture of a component assembly. It may contain graphs, charts, and tables giving data, for example on machine shop operations, heat treatment processes, engine service data, fitting electrical installations, and the scientifically correct mixes of materials to be used by craftsmen in different trades and on different jobs.

Technicians

It is difficult to establish acceptable criteria as a starting point for investigating the nature of occupations. There is no classification that covers every job. This is particularly true of the technician category where a wide variation in job functions exists even within a single technician group. The criteria used in arriving at the classification include the kind of work involved in the occupation (whether it is intellectual or manual, whether it deals with people or with things, and whether it is concerned with administration or with production); the educational qualifications required for admission to training; the profile of general intelligence, special aptitudes, and personality traits required for admission to training; the recruitment incentives and career prospects offered by employers; the wages paid; the factors which the individual workers in an occupation consider to be important; and the general interests of the workers employed at different levels of the occupation.

A great deal of research is being concentrated on investigating the possible psychological basis for occupational classifications. It could be many years

before such a classification becomes available.

The search for better ways of exploiting scientific discovery and technological innovation in order to obtain more rapid industrialization, higher productivity and more efficiently managed organizations has resulted in a changing of job functions in every manufacturing industry and business. A new occupational category of 'technician' has emerged. Technicians function between the technologist or professional engineer on the one hand and the craftsman or skilled worker on the other.

As the professional engineer and technologist become increasingly employed on research and development, design and industrial engineering, technicians have to take over some of the duties they formerly held. As a result, more and more technicians are required with the higher-level technical knowledge, the practical know-how and the necessary skills to build, install, and service sophisticated equipment and operate complex processes. They constitute the middle ranks of a country's highly trained skilled manpower. Unfortunately, the pace of industrial change has created a world shortage of technicians in every sector of industry and government service, which, in turn, has created a serious bottleneck in the implementation of the industrialization projects on which national economies depend.

There is a general consensus that the causes of the shortage, and its solution, lie in education. There is a shortage of secondary school teachers who are scientists, mathematicians or technologists with experience and interest in industry. This limits the scientific education of many pupils, and consequently their career choices and opportunities. In other words, the problem is not that pupils consciously reject technician occupations, but that the shortage of science and technical teachers, and the academic content and traditional interpretation of much science teaching, deny pupils an understanding of modern science and a technological job orientation. As a result they miss the opportunity to choose a satisfactory career in industry.

Clearly, if things are to improve, technological, industrial, and occupational changes should be reflected in the secondary curriculum. These changes will be far reaching. They will extend beyond the classroom to affect the kind of jobs pupils will do, the standard and quality of life their families will have, the kind of society in which they will live, and the level of job satisfaction they will have. Curriculum builders need to be more directly and personally involved in industry to understand the changes that are taking place in the employment and manpower structure in industry. The values and the general cultural climate predominating among the teaching staff in schools and colleges towards careers in industry can have a strong positive or negative influence on the attitudes of students when making job choices. It is socially sensible and educationally responsible that pupils in secondary schools should learn from their teachers that profitable industrial production is essential to sustain the healthy economic life and culture of their community with its commitments to the poor, the homeless, the sick, the aged, the oppressed and the under-privileged in all lands. They

should learn through social studies programmes and by direct participation in production work experience in their final years of secondary education that real wealth must be produced before it can be used. At the Conference on the Education and Training of Technicians held at Huddersfield in 1966, the view was expressed that to satisfy manpower needs, technician courses require roughly four times the financial provision of corresponding university courses, and that in hardly any developing countries is this ratio achieved. One difficulty is that in a developing secondary school system, the relatively few students who reach sixth form (or equivalent) level hope to go on to the university which, on its part, often encourages their entry because it has more places than it can fill. Many students at this level are on the Arts side. In few countries does the proportion of secondary school students oriented towards science, technology, business, or agriculture meet the needs of the economy.

At one end of the spectrum of technician occupations there may be little difference between the education, training, and responsibilities of a higher technician and those of a junior technologist or engineer. The higher technician uses his knowledge, ingenuity and technical judgement in solving the problems generated by the engineer's design. He has an understanding of the scientific principles of his work rather than an uninformed reliance on established practices or accumulated skills. He uses the same kind of knowledge, practices and skills as the junior technologist or engineer. Both function within a similar frame of decision-making and a similar pattern of relationships with people, and both work with data and people more than with things.

At the other end of the technician spectrum are the junior technicians who work more with people and things than with data. They are the nuts-and-bolts men. Their work is similar to that of higher-level craftsmen in that they use practical skills more than technical knowledge. They plan, control, and supervise processes and workers, and they service and maintain equipment at the point of production. In some companies they are responsible for the training of skilled workers and production line operatives. By applying their technical and operational knowledge and practical skills to the proper use of equipment and materials, junior technicians probably contribute most in a direct way to the quality, quantity, operational efficiency and profitability of the production process.

In between the higher and the junior technicians are the middle-level technicians whose technological education and training equip them to understand whatever innovations have to be implemented in design, building, manufacturing, production, and servicing processes as a result of the work of scientists and technologists. They are the technicians who play a strategic role in translating and activating ideas for new projects into plans and work schedules which they then interpret to shop floor supervisors, craftsmen and skilled workers. Depending on the organization or the company for which a middle-level technician works, he may be employed as an assistant designer, senior draughtsman, specialist tester, inspector, or supervisor in a factory, laboratory, hospital,

planning office, production line, or engineering construction site. He may be working under the direct guidance of a technologist or senior technician, or he may be working alone with sole responsibility for his particular operation. In short, technician functions differ. They therefore have to be identified industry by industry for individual organizations and companies.

The balance between theory and practice in the technician's training depends on the level at which he is to function in a particular working environment. This may change as technology develops and as a man moves from one level of employment to another. Upward movement usually requires upgrading of technical knowledge and special skills, and involves further vocational education and training.

At the present stage of industrialization the nature of the work a person does determines whether he is a technician or a technologist or a craftsman. There are many people in industry doing technician jobs without being labelled technicians and without having any recognized technical qualifications. They function adequately in their jobs. However, their number is likely to diminish rapidly as industrial processes become more scientific, more mechanized and more complex. To prepare the way for this development, more clearly identified job functions are needed. They could provide the data for writing more objective job descriptions and for compiling more scientific specifications from which to structure profiles of the general education, technical education, vocational training, and work experience suitable for admission to the technician grade of an occupation in a particular industry and organization.

The role of the Technician in Industry

A number of definitions have been accepted as a starting point for exploring the role of the technician in industry. The Institution of Electrical and Electronics Technician Engineers in its publication *The Education and Training of Electrical Technician Engineers* gives the following definition of an 'engineering technician' which has been accepted by the Conference of Engineering Societies of Western Europe and the United States and by the Commonwealth Engineering Conference:

> An engineering technician is one who can apply in a responsible manner proven techniques which are commonly understood by those who are expert in a branch of engineering, or those techniques specially prescribed by professional engineers.
>
> Under general professional engineering direction, or following established engineering techniques, he is capable of carrying out duties which may be found among the list of examples set out below.
>
> In carrying out many of his duties, competent supervision of the work of skilled craftsmen will be necessary. The techniques employed demand acquired experience and knowledge of a particular branch of engineering, combined with the ability to work out the details of a task in the light of well-established practice.
>
> An engineering technician requires an education and training sufficient to enable him to understand the reasons for and purposes of the operations for which he is responsible.
>
> The following duties are typical of those carried out by engineering technicians:

> Working on design and development of engineering plant and structures; erecting, and commissioning of engineering equipment and structures; engineering drawing; estimating, inspecting and testing engineering construction and equipment; use of surveying instruments; operating, maintaining and repairing engineering machinery, plant and engineering services and locating defects therein; activities connected with research and development, testing of materials and components, and sales engineering, servicing equipment, and advising consumers.*

The 1961 H.M.S.O. White Paper *Better Opportunities in Technical Education* states: 'The term "technician" is applied to a wide range of responsible jobs involving a higher level of scientific and technical knowledge than that needed by a craftsman but below that needed by a technologist.'

Another definition is given in *A Report on the Recruitment and Training of Technicians* (British Iron and Steel Federation.) This states: 'A technician is charged with the application and control of technical practices that have been defined by technologists. He should have practical knowledge and experience of the skills involved, combined with adequate technical and process knowledge and experience to enable him to diagnose problems, work out details of a task or operation, carry out the work himself, and in some cases to exercise supervisory or advisory duties.'

The report continues: 'Thus the technician does not require the more advanced knowledge of the technologist and only rarely will he have any responsibility for initiating new work. He is, however, distinguished from the craftsman by his ability to bring a greater theoretical knowledge to the solution of his problem than a craftsman normally requires.'

The technician functions between the technologist and the craftsman. The technologist is normally a university graduate who has the scientific and general educational background qualifications and the range of responsible experience to be given professional level authority in an industrial undertaking. He has been referred to as the commissioned officer in the industrial army. He functions at the higher levels of management and administration, applied research and development, design, production, planning and organization. The craftsman has normally completed an apprenticeship or equivalent training. He needs to have the theoretical knowledge to appreciate why he is using tools, instruments, machines, and materials in particular ways for specific jobs. This knowledge and a wider range of manipulative skills are the characteristics that distinguish the craftsman from the skilled workers and operatives who carry out specific operations on equipment (such as lathes and machine tools) or who control special equipment (such as the tower crane) or who carry out skilled operations in a foundry, a textile mill, or a factory making steel or chemicals. Although operatives do not normally serve an apprenticeship, they usually have special training varying from a few days or weeks to one or two years. Craftsmen represent over one third of industry's manpower. The estimated demand

*As reproduced in Booklet No. 9: *The Training of Technician Engineers.* Engineering Industry Training Board.

is for ten craftsmen to every technician. Although there is no fixed ratio of technicians to other categories of manpower, it is estimated that about five technicians are required for every technologist in industry.

Technicians constitute a wide range of personnel in a modern organization. Their use is increasing rapidly to accompany the accelerating pace of industrialization and technological change. They are employed by every major industry. Because of the variety of the jobs and the lack of precision of nomenclature in industry, the specialist technician is not always recognized and designated as a particular kind or grade of technician. The specific functions and skills vary widely in their nature and breadth of application, and have to be identified within individual industries and companies. The identification of the specialism in the functions of a technician activity determines the technician job title. It depends on the nature of the work he does in a particular company. Industries and companies vary in their recognition of the duties that are suited to a technician. In some cases a job is done by technologists who would be more profitably occupied on more intellectual tasks, and in others it is done inefficiently by craftsmen or skilled workers whose education and training is below the level needed to do the job. Identification and analysis of job functions and responsibilities is necessary in order to minimize waste of capital investment in education and training by the misemployment of specialist and skilled manpower. Analysis can provide the data for structuring job-oriented training and associated vocational educational courses. It can provide the facts on which to base selection, recruitment, and job placement procedures. It is required for vocational guidance, staff career development and counselling.

It is the ability to apply specialist knowledge and proven techniques to a specific job that makes the technician a valuable asset to a modern industrial organization. He uses greater theoretical knowledge than a craftsman normally requires in solving his problems. His level of craft skill varies according to the nature of his work. In production, construction, catering, or servicing it may be high. It will be minimal in research and development, performance analysis, jig and tool design, model testing, estimating, process and production planning, quality control, industrial engineering plant layout, work study, materials handling, electric power generation and transmission, or technical or sales representation. Even when he is concerned with the details of workshop or construction practice it is usually more important for him to have a fundamentally sound understanding of underlying principles than to be expert in their execution.

The education and training of the technician must be designed to equip him to adapt and develop his expertise to the changes in products, equipment, materials, and techniques that are characteristic of modern industry. The fundamental ability of the technician is of basic importance, but as processes, methods and techniques become obsolete he must accommodate himself to changing circumstances and be adaptable to re-training, up-dating and re-grading. As products and plants become more and more complex, the number and

variety of middle-level technician jobs increases, and the role of the technician becomes more clearly recognizable as being complementary to the professional engineer or technologist. He is a member of the research and development team. He analyses and interprets information from project and prototype experiments and makes evaluations upon which technical judgements can be based. Under the supervision of engineers he designs, develops or plans modifications of new products and processes. He may be a technical writer covering field tests for product performance or environment tests of mechanical, hydraulic, pneumatic or electrical systems. As the expert in the application of skilled techniques in a specific field he activates design or production policy decisions at drawing office or shop floor level. He prepares or interprets engineering drawings and sketches. He selects, compiles and uses technical information. He chooses tools and machines suited to a particular job. As a member of the production management team responsible for planning the efficient use of manpower, materials and machines he may be concerned with method and work study, inspection and quality control, rate fixing, and value analysis. He may be developing and supervising schedules which enable junior technicians, craftsmen or skilled workers to do first-line maintenance. Many are employed as supervisors or foremen. Many others work independently without direct supervision in the field as managers of small businesses, agents, contract managers, surveyors, senior estimators or buyers. Growing numbers are engaged in town planning, hospital administration and finance, mental health and social work, data processing, and transport.

The Status of Technicians

Most countries are facing the problem of establishing an understanding and appreciation of the work and status of the technician in industry and society. There is a consensus of opinion that part, but only part, of the reason for the universal shortage of technicians is this lack of a recognized status. The thesis is that the technician derives status from the nature and level of his responsibilities, from his indispensability, and from his contribution to the wealth-creating processes of the nation. It takes time for a comparatively new middle-level category to establish a status relationship with other occupations, particularly those which require the same standards of general education and vocational training and have similar financial rewards and conditions of service. Thus although the Industrial Revolution produced middle-level professional managers, accountants, and administrators over a century ago, they have only recently gained recognition and status in the community. More recently the technological revolution has produced the professional engineer and the technologist who have a recognized place and status in the top echelons of companies and an accepted status in society. At the other end of the scale the craftsman has a traditional status because of his apprenticeship and recognized skills, and his obvious contribution to production. But the work of new, emergent middle-level specialists who bridge the gap between the work of the professional

engineer and the craftsman has, in many cases, still to be identified, analysed, described, and evaluated in relation to the work of other more easily identified work groups. As we have seen, this lack of status affects recruitment, posing a serious problem to developing countries which need an adequate supply of technicians if their national development plans are to be achieved.

In the present state of industrial development, technicians are most commonly recruited from craftsmen or skilled workers. They undergo re-training to extend, up-date and up-grade their knowledge and skills to equip them for new tasks and work practices. This route should always be kept open for those workers who have the know-how, the abilities and personal qualities, the experience and on-the-job achievement to make a new kind of contribution in a changing industrial climate of scientific organization, logical planning, systematized functions and production management. The fact is that at every level of policy implementation people are needed who can adapt to change and innovation and who have sufficient mental flexibility to modify those traditional attitudes which lead to strict job demarcation and restrictive practices. But this form of recruitment is not the most effective way to obtain the specialist technician manpower needed to modernize industrial productivity and accelerate the achievement of national economic development plans. It identifies the occupational status of the technician with the craftsman or skilled worker. It perpetuates the shortage of recruits to technician education and training programmes. It discourages senior secondary school students of above average ability, with a good general education record and with technician potential, from choosing mathematics, science and the subjects on which to build the vocational education and training suited to a technician. It inhibits vocational guidance staff and teachers in secondary schools from advising students to look towards careers at the technician level in industry. It discourages parents who understand the occupational value and career opportunities of secondary education from recommending to their children technician jobs that project an image of manual labour with its dark shadows of insecurity of employment and lack of status in society.

Also to be deprecated is the method of recruiting technicians from among those who have failed to obtain a university or equivalent degree or a professional qualification. It lowers the prestige and adversely affects the status which teachers, parents and the community attach to the job of technician.

How could the attitudes of teachers and parents of children be changed? One way would be to devise special mass media communication programmes which stressed that the main purpose of universal primary and secondary education is to help each child, regardless of social, religious, racial and cultural factors, to build his personality and character and develop his intellectual and vocational potential as an individual human being in a society in which everyone is economically dependent on the combined work effort and shared civic responsibility of the whole. Another would be for the government to spell out the damage which the serious shortage of technicians is doing to its national economy, and make

whatever educational development plans and provide whatever capital investment resources are needed to remedy the situation. This programme would need the support of captains of industry who could explain how the lack of skilled manpower, and specifically of technicians, is retarding productivity. As things stand at present, most parents remain unconvinced by assertions that the technological revolution is changing the pattern of national employment structure and bringing about a breakdown of social divisions and barriers. Their experience of life has not encouraged them to believe in the blue collar revolution. They are very much aware that job and social status is highest in academic, white collar, government, non-manual and non-industrial occupations, and believe that it will remain so. They do not realize that status cannot remain static in a society which is changing its economic and social priorities, and its modernization and industrialization plans.

In the schools themselves, special information programmes are required. At present few students are motivated to learn about industry or about the jobs of technicians in industry. Like most of their parents and teachers and the politicians they do not have the foggiest notion of what a technician does for a living. However, if students are to learn more about these things and the realities of the industrial and economic world in which they live, the teacher training programmes must also be revised. Only in a few countries do primary and secondary teacher training deal with the national economic development plan, and the kinds of education and training that are needed to produce the skilled professional, technical and operational manpower to achieve its targets. Profound, penetrative, academic studies are not required. The need is for programmes to communicate basic knowledge to teachers about the government's philosophy of industrial development to match the national economic development plan, about the purposes, aims, objectives, social obligations, manpower policies, and employment structure of industry, about selection for employment, and about working conditions of employment. Such a programme would familiarize teachers with the meaning of industry and its importance to every individual in society. But is this sufficient? Should teachers not also have sufficient work experience to enable them to understand the work of technicians, and to learn what contribution it makes to raising the standards and the quality of living for everyone?

Lack of knowledge of the technician's work is more widespread than people realize. It is an unfortunate fact that few employers are much better informed than parents or teachers about the kind of work done by the technician. Yet it is the employer who determines the occupational status of an individual in an industry or company, and the employer who has the obligation to give the technician a career structure which adequately reflects the importance of his specialist knowledge and skill. Moreover, it is the responsibility of employers and governments to keep the general public informed about the value of particular categories and grades of technicians to industrial development and national economic growth. They need to ensure that educators in secondary schools are

equipped to advise students on the technician career opportunities available to them in a particular industry or company at a particular place and time. Careers advisers need to convince students and their parents of the job satisfactions which technician jobs offer to socially conscious young people, and employers and government departments need to give more than a label to a technician job when they seek recruits from among the good students in secondary schools. A label does not give status or convey the meaning of a job. It does not say what kind of work is involved, or what a technician is called upon to do. Young people need to know these things as much as they need to have details of the kinds of qualification required for admission to technician training, the duration and content of the technician's special education and training, and the standard and standing of the qualification awarded on successful completion of the training. They also need to know what they will be capable of doing on entering employment, and what their wages, career development opportunities and prospects will be. Students are aware that occupational and social status come from possessing a nationally recognized specialist qualification on top of appropriate general education qualifications. They are aware, too, that jobs that require the same general education and the same length of further vocational education and training and have the same salary structure and conditions of service are of roughly equal status. The education and training of technicians must therefore reflect their status in industry. The curriculum must clearly be quite separate from professional courses. It must have a distinct integrity of its own. Whether the terminal qualification be a degree, a diploma, or a certificate, it must have national standing in industry, in education and in society. Possession of the qualification should become a requirement for employment, and salary structures should reflect its worth. If the technician is to be accorded the recognition, status and rewards which it is claimed he deserves, the public and employers must understand how his activities fit into the overall technological pattern of industry. They must be convinced of the particular importance of his work and its contribution to the community.

Nevertheless, for the individual in an occupation, true status goes beyond the salary structure commensurate with the responsibilities of a job and the status symbols attaching to it. For him status comes from having his abilities absorbed to capacity and his ambitions satisfied at his level of employment and a feeling of having chosen to belong to an occupational group which has an ethos of its own.

2

The Education and Training of Technicians

Background

Planning for the education and training of an adequate supply of the right kind of technician manpower is an essential part of national economic development planning. The government decides the order of priority of national economic objectives, and the proportion of the national income to be invested in each area. Executive decisions are then made about how national resources are to be used to achieve the objectives, and a forecast is made of the total manpower required and of the mix of specialists within it. Ideally each industry and service identifies the jobs to be done, after which the tasks making up each job are analysed to construct a profile of the specialist technical knowledge, skills and attitudes involved in performing the tasks.

This analysis is the key to structuring appropriate technical education and training courses for technicians. It is the basis for writing job content descriptions and for compiling job specification profiles of abilities, attainments and qualities required to train for the job. It can provide a structure for manpower selection, recruitment and job placement. It is the first stage in work study, job evaluation, wage and salary structures, conditions of service and occupational status. It can also provide essential basic data for vocational guidance and student counselling programmes, giving guide-lines for vocational subjects and industrial arts curricula in secondary education.

Interested groups in all countries are attempting to identify the appropriate roles of government, industry and the educational system in defining the nature of education for their particular kinds of society. The national system of general education is seen as a main contributor to a country's economic growth and social development. Technical education is an essential part of the general education system. It affects every individual's job and way of life. It is a need-satisfying and a need-creating institution. It has raised education in every country from being a privilege for a social and professional élite to being a top

priority economic investment. It has produced a restructuring of educational systems and a lengthening of school life.

Though there are fewer financial and social barriers to primary, secondary and tertiary education than there used to be, social factors still strongly influence educational and occupational opportunities and contribute directly to the shortage of technician manpower. The child from the large family of an unskilled labourer living in a poor part of a town is likely to have minimum, if any, full-time education. His school is likely to be old and run-down, be staffed by teachers having minimum professional qualifications, and be operating an out-of-date curriculum. His job aspirations are likely to be conditioned by the traditional attitudes of his parents and the neighbourhood towards the value of education and by the need to earn a wage as soon as possible. This is a tragic situation. The fact is that semi-skilled and unskilled workers could learn more, achieve more, contribute more, and reach higher occupational levels if they had better opportunities in their early life.

In a world of technician and skilled manpower shortage, wastage of this sort cannot be afforded. Countries can no longer allow the mass of semi-skilled and unskilled industrial workers in developing countries to remain illiterate. Their productivity is too low to give them a recognized place in the labour market and to give their countries a place in the economic markets of the world. Education and training must therefore prepare people to enter technician jobs having increasing intellectual and less manual content. The result will be a better standard of living and improved status at work and in the community – conditions which should appeal to those people and parents who are able to forgo some initial income in order to train for technician occupations that later on in life offer bigger rewards than semi-skilled or unskilled jobs.

To help to create a climate of acceptance of technician occupations, schools should undertake two tasks. One is to provide an education that will fit the individual for the kinds of job that exist or will exist in his society and from which he will get and give satisfaction. The other is to foster the social importance and worth-whileness of industrial technician occupations, and extend vocational horizons and interests beyond academic, white collar, administrative, office and desk jobs. It is true that the first of these tasks involves matching the secondary curriculum to the projected manpower needs of the nation, but this need not and should not become a mechanistic process. The school must never become the laboratory for exercises in social engineering to suit the purposes of politicians or industrialists. The preservation of human dignity and individual personality depends on government, politicians, executives, planners and educationists formulating a long-term humanistic view of the kind of society and way of life that they are helping to shape or create. Developing countries possess a sufficient range of middle-level occupations to be able to offer young people a wide, flexible choice with ample opportunities for the pursuit of personal aspirations and considerable scope for career development. What is essential is that secondary school curriculum builders exercise their

expertise to make modifications to syllabuses, adapt schemes of work and review teaching staff qualifications so as to incorporate the new knowledge, skills and teaching methods made necessary and possible by scientific discovery and technical development.

Aims in Technician Education

The main purpose of technician education is industrialization and modernization, thereby strengthening and sustaining a healthy, growing national economy by helping industry to be more effective in the achievement of its main objectives of producing the national wealth, creating employment, and providing an adequate standard of living in nutrition, health, housing, welfare, education, and an acceptable quality of life for everyone. Technician education produces the manpower resources that make industry more productive, increasing the volume and improving the quality of production of goods and enabling them to be sold at more economic prices in home and foreign markets. Technician education can also narrow the gaps between the rich and poor countries of the world and between the haves and have-nots within individual countries.

Industry can only be successful when it is technically and economically efficient. This requires the effective use of manpower, equipment and materials to produce the profit which makes the difference between success and failure. It is evident from national manpower surveys that as the economy of a country develops there is a demand by industry for relatively more technicians with specialist kinds of production knowledge and skills. The demand for technicians, and with it the demand for technical education, is a key growth point in industry, government and the social services. Success depends on developing more fully the human resources of the country, on educating and training the enterprise and ingenuity of all national talent, and on reducing the time between discovery and exploitation in the physical sciences, technology, and behavioural sciences. The pace of industrialization, innovation, and modernization in every sector from small-scale farming to nuclear power development is quickening in every country whether its philosophy of economic development is capital intensive or labour intensive. The technical education of technicians must equip them to anticipate change rather than have to adapt to change after it has overtaken them.

Education and training policy has been much influenced by pundits' assertions about the relation between education and the economy. However, the facts show that though technical education and training, especially of the adult population, is the most important material investment, it cannot be undertaken without a sound basis of primary and secondary education. The problem in many developing countries is to make universally available the secondary education which is at present only available to the minority. This means universal primary education; more and better-managed primary and secondary schools; more secondary school teachers qualified to teach mathematics, science, language, technical and vocational subjects; more modern equipment for better

teaching and for accelerated, higher quality learning; modernized curricula; more expert professional guidance; and greater opportunities for teachers to attend in-service courses. It also means changing the emphasis in secondary schools where at present the great majority of students take academic courses and as a result leave school unequipped with marketable knowledge and skills for industrial employment. This creates a waste of intelligent manpower which could be productively employed in the middle ranks of industry, and leads to unemployment among school leavers, and even among university graduates.

A country's social and economic development can become out of balance unless technical education and training is related in a flexible way to the kind of manpower planning which can give early warning that too many people are being trained in a particular technology, career or occupation. Manpower surveys, forecasting and planning to match planned targets are made from an analysis of the different sections of the national economic development plan for which the programmed investment allocations have been made. The aim is first to provide a model of the mix of trained manpower likely to be required at various levels in the different occupations at any particular time, and then to design an education and training strategy to match and phase the trained manpower required to produce the planned rate of economic growth. It is true that scepticism exists about the feasibility of any government being able to produce a valid national manpower development plan which can look further ahead than two or three years. Statistics are rarely completely accurate, data-collecting instruments and processes are not always scientific, planners can make errors of judgement and prediction, computers are fallible, and new jobs appear and existing jobs disappear with new technological developments. Despite this, there is an urgent need for technical education planners to identify groups of occupations within which there is sufficient common ground of knowledge, skills and attitudes to enable people with diverse qualifications and experience to move from one occupation to another through re-training, up-dating or re-grading programmes when changing technologies and economic conditions make such movement necessary. The goals of technical education and training are not solely those of increased productivity, economic development and progressive improvement in the rate of growth of the gross national product. They are as much concerned with objectives that are socially worth achieving – objectives such as higher standards of living, a better quality of life and more responsible citizenship. In other words, the goals should be concerned with cultural and social development no less than with the fashioning of materials and with manufacturing processes. The realism of economic objectives and career motivation need not necessarily be educationally restrictive or inhibiting to total social, cultural, spiritual and individual development. For the technical teacher the student is always first and foremost a human personality to whom he wishes to impart his specialist knowledge and skills so that the student will learn to use them with flexibility of mind and imagination and to adapt them to technological change and innovation to make himself an independent, personally

adequate, useful, self-supporting, socially responsible worker and citizen in his community.

Technician Courses

Only comparatively recently have workers been recognized and labelled as 'technicians' by employers. Until the world-wide demand arose for enormous supplies of consumer goods, production depended mainly on craftsmen. Traditionally these people learned their skills and technical know-how by observation and by word of mouth. They were trained on the job in a father-son or master-apprentice relationship. Then came the development of mechanization bringing with it a demand for specialist technicians in the middle-level occupations between the professional engineer, the technologist and the craftsman.

Today's technicians need to have an understanding of the fundamental scientific and technological principles underlying the purpose, design, construction, operation, and maintenance of the tools, machines and other equipment they use or for which they are responsible. They need to apply their knowledge of the properties of the materials which they use or which are manipulated by the skilled workers they supervise. They need to understand how to use working drawings, assembly diagrams and process charts. Those who are to become foremen or supervisors need to acquire a sufficiently high standard of specialist technical expertise and inter-personal skills to sustain productive shop-floor industrial and human relationships.

The broad spectrum of special technician occupations which involve special kinds of work are necessarily paralleled by an equally broad range of scientific education and training courses. They are near professional at one extreme, and near craft at the other. However, they must all have their own integrity and reflect the separate identity of the technicians as a particular category of employee.

Although the basic elements in technician courses are much the same everywhere, the specific subjects, and the mix and depth of treatment of topics, may differ from one country to another depending on the stage of development and industrialization, the need for particular kinds of technicians, and the systems of educating and training technicians. Different sectors of industry have different needs in the field of technician education and training. So have industries at different points along their evolutionary path. Nevertheless, course planning tasks remain the same. These are, first, to identify the occupations requiring the knowledge, skill, and personal qualities appropriate to technicians; second, to arrange specific procedures for the recruitment of young people with suitable profiles of general intelligence, special aptitudes, general educational attainment (specifically in mathematics, science, and use of the mother tongue), appropriate vocational interest patterns, and qualities of temperament; and third, to ensure that recruits receive appropriate practical training (preferably in industry or alternatively in a properly equipped and managed training centre) and complementary technical education that meets their special needs and equips

them for immediate and suitable employment as technicians in industry.

Technician courses must have an integrity of their own. They should be structured round national, regional and local industrial technician occupations. They should not form part of a planned progression to professional engineer or technologist status, and should be distinct from the courses given to craftsmen. They are intended neither for a superior tradesman nor for a depressed technologist.

Course Planning: Some Principles

The first objective of a technician's course is to equip the student to be immediately productive in his first job. This means that he must have learned to the appropriate level the principles underlying the tools, machines, and materials applicable to the processes and operations of his industry. For example, he should be able to select, treat, fashion and fabricate materials in the most economical way to produce the best job within specified conditions. He should also have confidence in his skills and his knowledge – the confidence that comes from knowing what he is doing, what is happening, and why. For these things to come about, his teachers must know what job he is being prepared for, what tasks he will have to do, what knowledge he will need, what skills he will have to apply, and what attitudes will assist him to be productive on the job. They can then determine the orientation of the teaching, the mix of subjects, the time to be spent on each subject, the salient information to be learned, the kinds of teaching required, and the techniques of cumulative assessment and examination of student achievement. To take one example, industrial technicians – who are nearer the point of production, construction, installation and servicing than other engineering technicians – will need less mathematics and more practical experience in industrial processes, production methods and maintenance skills. Their course will also be shorter in length – perhaps less than two years in duration.

Too often there is a difference between what the technician is taught in college and what he needs to do in a job. Instruction can be too theoretical and too imitative of university degree course work, and time can be better used in helping the technician to gain practical understanding of the applications of basic scientific principles to industrial processes and practices. For example, the science he learns should be related to his practical training. Similarly, his drawing-board training should equip him with the knowledge of the drawings he will require on the shop floor in industry. Thus he must be able to read a working drawing, to mark out and plan a job, and, often, to extract quantities of materials and cost the job. Under some circumstances he will be expected to make a job analysis, a time analysis and a work progression, and give detailed guidance about tools and other working equipment. For the design or drawing office draughtsman, drawing is not just a series of skills to be acquired by copying drawings or practising the standard exercises in textbooks. The student has to understand the principles of constructing a drawing in the accepted

form, and to learn to make the drawing intelligible to the people who will have to interpret the information for various purposes. The drawing becomes the technician's way of communicating ideas as well as the form in which instructions are communicated to the person who will perform the specific operations. A knowledge of the modern industrial structure and its requirements is the only basis for teaching technician drawing, yet it is one subject in which inadequate critical attention is directed when planning schemes of work and teaching methods.

In mathematics commendable teaching techniques are being developed which cut out a great deal of 'theory'. Teaching aids are available which illustrate the truth of theorems, relationships, and formulae. They can help the technician student to learn a mathematical procedure by rule of thumb rather than confuse him with the theory behind the rule. What he needs to be able to do is to identify a problem, analyse it, choose the correct formula to solve it, and know what tables and calculations to use to cut down time and eliminate error in computing the answer. The use of logarithm tables is an example. Few technician students understand the theory of logarithms and there is no sensible reason why they should. Similarly, technician students often spend too much time on the detail of constructing and drawing graphs when it is more useful for them to learn how to interpret the story told by a particular graph and to extract the precise information they require from it. Trying to understand the theory may even create a barrier against learning the mathematical techniques that will be needed on the job, on the site, in the workshop, or in the drawing office. It is not going too far to say that the only valid reason for teaching theory in vocational education and training is to advance understanding of vocational practices. Teaching unnecessary, irrelevant theory makes the wrong use of student time.

The syllabus is blamed, and often rightly, for being overcrowded, for having too much theory built into it, and for being inadequate in the selection of the material to be taught. These faults most often arise from a failure to enunciate clear aims and precise vocational learning objectives. In addition, priorities are not allocated, and the sequence of instruction is not always based on student ability and needs.

Initial courses must be based on a sound grounding of scientific principles in order to give the student a good foundation knowledge of his chosen industrial field and enable him to understand the basic principles of design, construction and production. For the period of transition from school the pattern should be general. It should then become more specialist in nature, being directed to the development of scientific vocational competencies. Though the technician's value and strength lie in the possession of an intensive knowledge of specialized techniques, his initial training should be sufficiently wide to act as a springboard to a first specialism. Progressive specialization can be added by further courses as his choice of career and his capacities become evident.

Another factor to be taken into account is that because technological

innovation is a continuous process in industry, the course structure must be capable of responding to change rapidly and efficiently. It should enable the range of existing knowledge to be extended without necessarily raising the level of subsequent specializations; it should make provision for up-dating courses throughout an industrial career; and it should incorporate special bridging studies where needed at particular transfer points.

To summarize, it may be said that no single initial course can impart all the education and training a technician needs for a lifetime or even for more than a few years. Much of what is taught is out of date in a relatively short time. For this reason, the subject matter and structure of technician courses needs to be kept under review. The basic principles and their applications are indivisable, and form parts of an integrated whole. Subjects are not narrowly-defined, highly-specific disciplines within separate departments. Instead, the lines of demarcation are so vague that specialist administrative department and subject barriers are often irrelevant and a hindrance to inter-disciplinary studies and to course integration. Thus in the case of science, the teaching should be precisely directed to developing the technician's knowledge of the applications of scientific principles to industrial equipment and processes, and to enabling him to select the right principles to enable him to overcome day-to-day industrial problems. It should develop his mental skills, his diagnostic, analytical and logical ability within the established, proven procedures in his chosen field of employment. The requirement for manual skill varies according to the nature of the work. In production and servicing it may be high. In design, quality control, work study, it will be minimal. In workshop practice and construction practice it is more important for the technician to have a sound understanding of principles than to be expert in their skilled application.

Course Planning in Practice

The technician must be identified in the first place by the functions he performs. The job label is not enough: it is the nature of the task which distinguishes one job from another. A precise, objective, and clear job description is therefore required. It should be industry-based and deal in detail with the range of tasks which make up the job. It may require a team of analysts using sophisticated measuring skills to isolate the important elements and collect and systematize the significant data. But when all is done, the result is only a snapshot of a job at a particular time. It can be useful only for a relatively short period in an era of rapid technological change and innovation when existing jobs disappear and new ones arise.

There are many reasons why jobs having the same title are done differently in different situations. Among them are the size and location of the organization, its attitudes to modernization, the quality of its management, the size and balance of its manpower, the sophistication of its equipment and processes, and the way it views a job within its manpower structure. The detailed knowledge, skills and attitudes which are required or which have to be acquired for a

specific job need to be analysed and identified. The resulting information is essential as a basis for planning, building and establishing the depth, scope and precise nature of the courses to be provided by vocational education and training courses. The specialist tasks in technician course planning include:

1. A profile of the job functions, tasks, and duties.
2. A profile of the kind of person required to do the job in industry.
3. The aims of the course and the vocational objectives to be achieved. These depend on precise identification of particular kinds of technician and on an analysis of each element of the job for which the course is required. Broader vocational education objectives depend for their achievement on the total learning environment, on the philosophy and attitudes of teachers and employers to work, on the students, and on the civic community. It is by example from teachers and employers rather than by precept, that students acquire constructive attitudes towards life-long willingness to learn; towards occupational, geographical and social mobility as a feature of modern society; towards working in specialist groups and teams; towards old-fashioned attitudes and restrictive practices; towards changes in occupational status; towards social and civic commitment; and towards life and living in a changing, shrinking world.
4. The vocationally salient information, facts, ideas, principles, processes, techniques, skills that students must learn. This is a process of selection. The essential elements and the emphasis to be accorded to each of them are difficult to assess, to weave into a cohesive pattern, and to put into practice.
5. The units or modules in the course.
6. The main vocational topics to be taught in each unit of the course.
7. The appropriate sequences of teaching each unit of the course, and of teaching each topic in each unit.
8. The learning objectives to be achieved in each main vocational topic.
9. The associated vocational subjects and the learning objectives related to each main vocational topic.
10. The total course time and the time allocation to each unit and to each topic. This involves defining who is to learn what, considering how technician students learn particular vocational knowledge, skills and attitudes for a particular kind and level of job; assessing individual differences within the group, and deciding which factors most influence the rate and quality of technician student learning.
11. The methods of teaching to be used for each topic (e.g. lecture, lesson, individual or group project, laboratory or workshop or library assignment, role playing, case study, team teaching, discussion group, tutorial, seminar, organized industrial experience, or special visits).
12. The teaching aids to be used in each topic (e.g. chalkboard, magnetic board, felt board, prepared diagrams, charts, progressive demonstration of basic scientific principles and their industrial applications, models, components, mock-up of assemblies and processes, pictures, slides, film strips, films, over-

head projector transparencies, learning programmes, learning packages, closed circuit television).

13. The private study, further prescribed reading, and homework to be assigned for each topic.

14. The devices, techniques and methods to be used for assessing and recording individual progress.

15. The levels and standards to be achieved by students in each unit of the course.

16. The preparation of student and teacher programmes and time-tables.

17. Methods of evaluating the content, planning, structure, organization, management and quality of the course, and also the quality of the output evaluated specifically in terms of performance on the actual job.

18. The organization and machinery for progressively reviewing course objectives, content, structure, management, staffing, assessment processes, equipment, and accommodation.

19. The total resources required to mount and conduct the course.

20. The mix of teachers to provide the required range and level of teaching qualifications, experience, and expertise; and the ancillary staff and other assistants required.

21. Special capital equipment and consumable materials.

22. Accommodation (e.g. specially equipped lecture rooms, classrooms, tutorial rooms, laboratories, workshops, educational technology rooms, library, private study rooms, offices).

An important measure of the efficiency of the educational management in a college is the degree to which the professional hierarchy succeeds in making the fullest use of costly investment in accommodation and equipment and in getting an economic return on educational plant – particularly their success in making the most effective use of expensive teaching manpower in achieving national education productivity targets.

Course Content

Irrespective of whether the philosophy motivating the technician course is authoritarian or democratic, the administration autocratic or consultative, the teaching methods traditional or modern, the ultimate measure of the success of the course is how effectively the technicians who complete it can apply and use their knowledge and skills on the job to improve productivity and increase production. Direct occupational relevance is the main criterion of what technicians should learn. The technological principles should be confined to those most likely to affect the work of the technician. Some examples are:

1. The tools, instruments, machines, skills, working drawings, and processes involved in machine shop engineering, pattern making or foundry work, and the servicing and maintenance of air conditioning systems, aero engines and earth-moving equipment.

2. The technology, techniques, and skills of the building construction trades.

3. The specialist and technician technology and skills required in the servicing and maintenance of modern public and private service vehicles.

4. The specific knowledge and skills required for a particular level of design or drawing office employment.

In every country the practical requirements of the industrial job define the practical training and thereby the content of the supporting technical education course. The data from expert analysis of a wide range of technician occupations shows that the spectrum of functions has more zones of common knowledge than sharp lines of difference. Each zone represents a cluster of activities demanding varying degrees of the same knowledge and skills according to the nature of the design, production, and construction work within the organization. An inadequate analysis of work functions and tasks can lead to fragmentation of courses and uneconomic use of expensive resources. Large areas can be covered, particularly in the early stages, by a single common course with a core curriculum and core subjects giving an early general foundation which can be followed by further stages of progressive specialization as required. What difference there is between the kinds of technician course in a single occupational field is chiefly a difference in the mix and specialist orientation of common elements, with near-professional courses being characterized by a higher proportion of technical and technological theory and a lower proportion of operative skills than the near-craftsman courses. It is this mix, with its characteristic balance between theory and industrial production, that has special relevance to the needs of the technician. A frequent balance for the higher technician is three quarters theory and one quarter practical, and for the junior technician two thirds theory and one third practical. Depending on the level and stage of the course 25% to 50% of the time is spent in the laboratory or workshop or practical room, particularly in the early stages. The purpose of practical and laboratory work is to elucidate fundamental facts and principles and link the information with industrial practice, to explain and demonstrate essential practical operations, to show that properly planned and sequenced basic operations can be assembled together to produce a successful product, to show that information from study linked with industrial experience can solve unfamiliar problems, and to demonstrate that team-work and organization are necessary to ensure economy of time and effort and create productive efficiency.

Most courses include technical education theory, technological theory, technical and technological skills, general education, and the mother tongue as a technical subject and as a communication skill. As the elements of the first four of these are sometimes grouped under different titles, a brief résumé of their content may be useful at this point.

Technical education theory is usually the framework of a first-year foundation course including mathematics, science, engineering drawing, workshop

technology, workshop training, and materials. There is a relatively high allocation of mathematics and science which form the essential ground-work for most of these courses.

Technological theory is directed to the principles of construction, use and maintenance of equipment, and to the techniques which the technicians most commonly use. Job-oriented theory can be learned with greater retention and used more effectively in practical situations if the student understands its applications to the design features, the purposes, the capacity and limitations of the tools, machines and equipment he uses, and if it helps him to acquire the range of techniques he must develop.

Technical and technological skills is a training element concerned with the actual equipment to be used and the techniques to be exercised on the job. It covers the skills of which the technician must have mastery – whether manipulative, conceptual, evaluative or of judgement.

General education includes studies designed to broaden the social, cultural, and occupational understandings and competencies of the technician and make him aware of the social and economic framework within which he functions. Important aims are to encourage the technician to understand himself and other people; to appreciate the personal relationships and problems of those working in associated occupations; to develop positive attitudes towards proficiency on the job; to understand the need for financial and accounting procedures and controls; and to accept new ideas in organization, planning and management.

The main problem is to co-ordinate the elements and subjects in an integrated whole. Its solution lies in better planning and use of modern education management techniques, and in more effective analysing and controlling of the technician education and training process. It requires more productive communication between government, industry, education administrators and planners, curriculum builders, college principals, heads of departments, and teachers. It needs more efficient techniques for defining the occupational objectives of a specific course and the elements and subjects within it, and for fashioning the particular activities and topics of the syllabus in a logical fashion. Better methods are required for objective, progressive assessment of student learning and target achievement for qualified technician status. Teachers must learn to see a course as an integrated whole rather than in subject divisions, to develop inter-disciplinary attitudes, and to co-ordinate their work. Heads of colleges and departments need to strike a balance between their administrative duties and their curriculum co-ordinating functions, and key teachers need to exercise more positive and better quality day-to-day control over the co-ordination, direction, integration, progress and control of student activity.

Project work is a long established method of organizing learning so as to encourage co-ordination of subject areas and produce an integrated whole. But it has not been accepted with enthusiasm by the majority of teachers in technical education institutions. Many reasons are given for resistance. The most common one is that not all teachers are willing to accept organizational changes

and work innovations that can affect their traditional role of unquestioned authority.

Some modern course regulations and syllabuses are making project work compulsory, particularly in the final year of technician education and training. The stated aims include designing the course for close co-ordination and integration of theory and practice to give a more practical basis to student learning and produce a more practical technician; giving students access to a wider range of industrial techniques and experience than is possible in a teacher-centred, subject-oriented, classroom-constrained organization of learning activities; giving greater flexibility to the order in which topics are treated whilst retaining planned, co-ordinated links with other parts of the course; and encouraging students to learn to work individually and in groups. Some subjects can be covered entirely by practical project work. Others cannot and must be supplemented, to a greater or lesser degree, by formal classroom work.

Integrated project work organizes learning so as to take account of those differences in abilities, attainments and educational background that affect the motivation and ability of individual students to learn particular, progressively more demanding aspects of theory, technology, and associated subjects and skills. All technology subjects lend themselves to rational learning as opposed to rote or rule-of-thumb learning; to an ordered, logical methodology which encourages analytical thinking; to practical, industrial problem-solving; and to a critical approach to tests and procedures used on the job under normal – and particularly under abnormal – conditions. The project method, in common with other student-centred techniques, helps to develop planning and decision-making skills as, for example, in identifying the critical points in producing a piece of equipment, a component, a model of a process, or a solution to a production or industrial relations problem. The possible options must be identified, the cost and benefits of each have to be evaluated, and the probable and associated results predicted. Projects can be devised that simulate industrial conditions. Examples are a task involving the interpretation of a design; interpreting and using a working drawing and blue-prints; using measuring instruments and mathematical tables; determining the production techniques to be used; choosing tools, machines and materials best suited to the job; deciding the sequence of work to make the most economical use of manpower, equipment and materials; and listing safety precautions for each stage of production.

Project work and less formal teaching methods are appropriate techniques for use in extension, up-dating, re-training, and up-grading courses for adults who have had experience in industry. For example, technicians who are being trained as a group for supervisory duties, involving man management of junior technicians, craftsmen, skilled workers, and operatives, have a wealth of first-hand on-the-job experience on which they can draw. This experience needs distillation, formalizing, and putting into a frame of reference of established management principles and practices at the supervisory level. In devising a course incorporating this experience, some of the questions and consequent studies

that arise are:

1. What does each job to be supervised involve in terms of special knowledge, skills, attitudes, methods, times, and costs?
2. What exactly does each worker do? (This leads to a job and task analysis.)
3. How does he do it? (This leads to a skills analysis, and to a time, method and motion study.)
4. What are the common errors? (This leads to an analysis of errors and to safety precautions.)
5. How are they ranked and evaluated? (Studies of cost, time value analysis.)
6. How, when and why do they occur? (Studies of safety precautions.)
7. How can they be anticipated? (Studies of boredom, fatigue; work study.)
8. How can they be avoided? (Studies of organization and management.)
9. How can they be remedied?
10. What problems affect groups when they are working on particular jobs in industry? (Studies of inter-personal relations, group dynamics, conflict situations.)
11. What are the causes of work relationship problems within a group? (Studies of job definition and description, lines of responsibility, channels and techniques of communication.)
12. What are the signs of latent problems? (Studies of accidents, damage to equipment, spoiled jobs, wasted materials, drop in production, absences, and psychosomatic illness.)

Other matters to which thought should be given include:

1. Human factors; personal relations; industrial relations; industrial sociology and psychology; techniques and quality of communication.
2. Formal and informal advice, help, guidance and coaching.
3. Close liaison during on-the-job training with company specialists to examine current problems.
4. Job rotation during training to broaden knowledge and experience of company activities.
5. Relevant principles of management and supervision through studies of actual situations including confrontation situations.
6. Relevant legislation concerning work, working conditions, and employer-employee relations.
7. Job evaluation, and evaluation techniques.
8. Personal on-the-job target achievement.
9. Personal career development plans, including the knowledge and skills needed, compared with those possessed, and the further training required.
10. Promotion criteria for employees.

To show how these considerations have been taken into account in existing curricula, here are three examples of course planning. The first is an analysis of the work of technician engineers. The second consists of abridged details of the full-time college-based course for the Ordinary National Diploma in Technology (Engineering). The third is a City and Guilds scheme of part-time study for the Mechanical Engineering Technicians Certificate.

*1. An Analysis of the Work of Technician Engineers**

Paragraph 10

An analysis of the work of technician engineers indicates that there is sufficient common ground between the skills and knowledge used by them to make this the basis of identification. Six main abilities appear to be demonstrated to a greater or lesser degree by all technician engineers in whatever branch of the engineering industry they may be working. These are:

(a) The ability to use and communicate information.

(b) The ability to measure or make use of measurements which involve a variety of tools and/or instruments.

(c) The ability to choose materials and components and understand processing of materials.

(d) The ability to understand manufacturing activities and the general commercial organization and practice of their companies.

(e) Diagnostic ability.

(f) The ability to organize (but not necessarily supervise) and give direction to the work of others.

To develop these abilities the average entrant needs training in breadth and depth towards a particular specialization. He will require complementary further education to a level within the range of the Full Technological Certificate of the City and Guilds of London Institute and Higher National Certificate or Diploma in engineering subjects.

Paragraph 11

The figure [Figure 1 on page 32] illustrates a number of areas of activity of technician engineers and gives an indication of the degree to which these abilities are required.

2. Abridged details of the Ordinary National Diploma in Technology (Engineering)†

This is a broadly based course with a strong vocational bias deliberately planned for two years' full-time study extending over at least 70 weeks, divided equally between the two years. The course is for the college-based student who has not committed himself to a particular firm or to a particular branch of engineering technology and it is intended specifically to avoid too early commitment, as a positive preparation for the making of an informed decision.

The educational aims and objectives of the course are:

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*Extracted from Booklet No. 9 *The Training of Technician Engineers* (Engineering Industry Training Board: London).

†Summarized from *Notes for Guidance*, O.N.D. in Technology (Engineering). Joint Committee for Ordinary National Certificates and Diplomas in Engineering. London, January 1972.

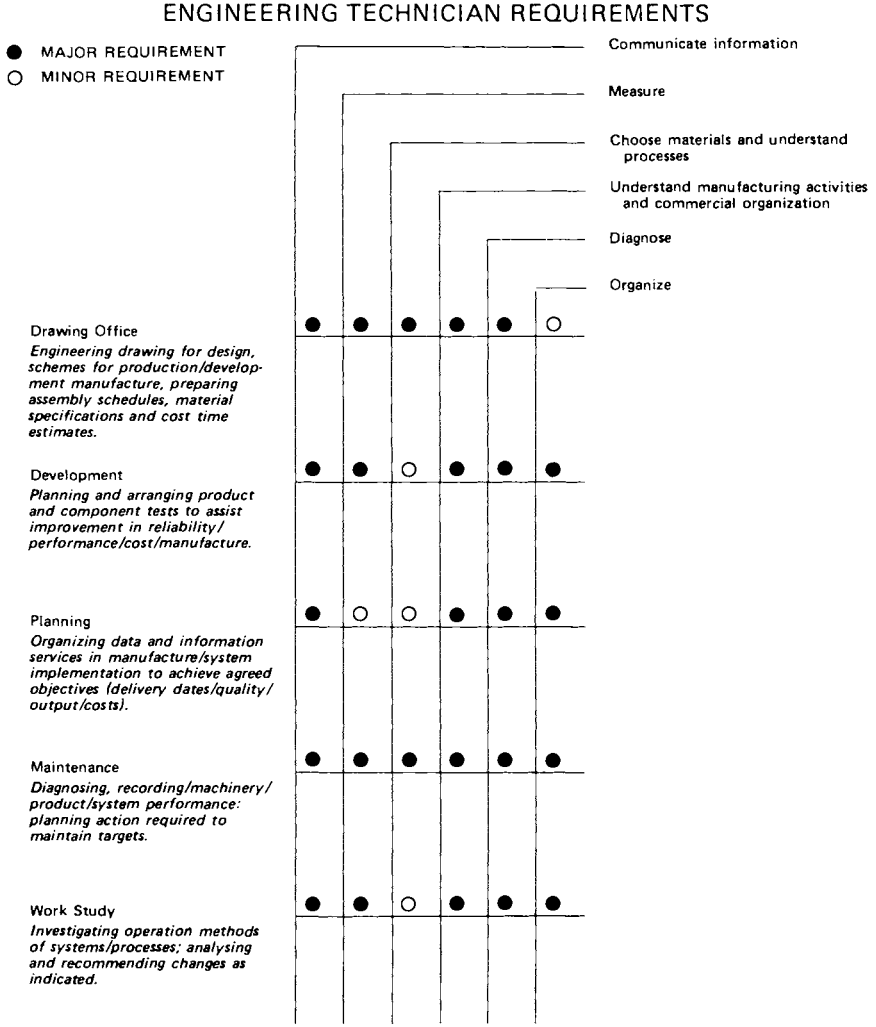

Figure 1

(a) To provide a two-year full-time technological course of study for the 16-19 year age group in further education which is a sound preparation for more advanced studies and meets the academic standards required for entry to higher courses such as degrees, Higher National Diplomas and Higher National Certificates.

(b) To provide an educational course which is sufficiently broadly based to enable students to make an informed choice of the discipline in the general field of engineering technology which they may ultimately wish to follow.

(c) To give students an appreciation of technological problems and some idea of the industrial scene in as many fields as possible.

Time allocation:

Principles of technology	1030 hours
Mathematics	300 hours
Communications	200 hours
Complementary studies	170 hours
Project work and private study	400 hours
	2100 hours (including tutorial time)

Admission qualifications:

A minimum of 4 G.C.E. 'O' levels one of which must be mathematics and one a suitable science subject (e.g. physics, physics with chemistry, general science).

Division of marks in the final year

Examination	
Principles of technology (3 papers)	300 marks
Mathematics (1 paper)	100 marks
Course work	
Technology and mathematics	200 marks
Communications and complementary studies	200 marks
Project	200 marks
	1000 marks

Award of the Diploma requires an aggregate of 500 marks subject to a minimum examination mark of 40% in each of the two examination subjects and a minimum course work mark of 40% in each subject. A minimum attendance of at least 75% is required over the two years.

By the end of the course it is hoped that students will show that:

(a) they can use and apply knowledge they have gained;

(b) they are able to communicate this knowledge clearly by written, oral and graphic means;

(c) they can translate from one mode of communication to another;

(d) they have analytical ability;

(e) they have the ability to synthesize;

(f) they have the ability to evaluate a situation and make value judgements;

(g) they possess some creative ability.

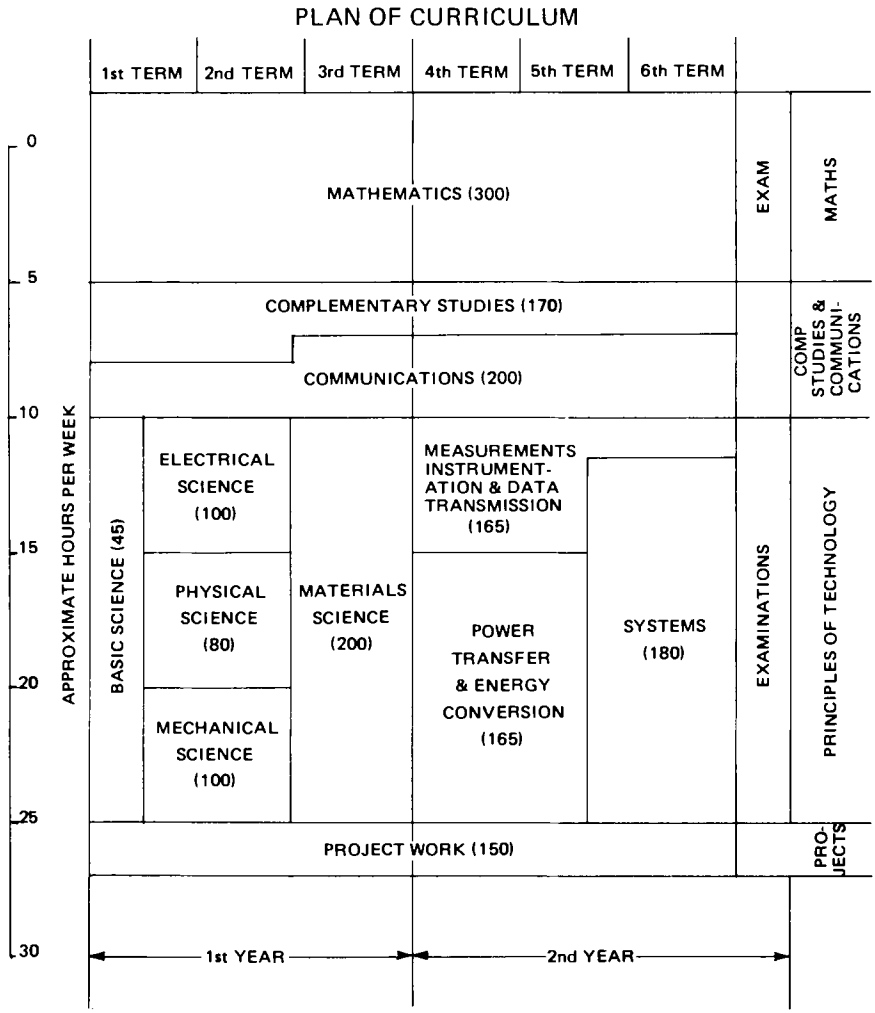

Figure 2

It is recognized that some of these attributes are difficult to define in precise terms and even more difficult to measure, but the right learning environment can help a great deal towards achieving these abilities and the right sorts of examination or test can provide an acceptable means of assessment. Project work features strongly in this.

When planning the teaching of the course the staff should bear in mind the following five general aims:

(a) to stress the teaching of basic principles;
(b) to teach methods of inquiry and of problem-solving thinking;
(c) to teach students to become competent in independent study;
(d) to inform students progressively of the standards they must attain;
(e) to keep the instruction on a personal basis.

Good teaching produces a situation in which there is every encouragement for a student to find out things for himself, to read, to make use of the library facilities and to utilize to the full the tutorial periods. The private study element of the course should take the form of individual directed studies. The lecture should be used with caution and the tutorial should be used as an essential complementary function in which the powers of the students themselves to apply, analyse and synthesize should be developed. Due attention should be paid to the integration of the learning experiences and the syllabus content, bearing in mind the opportunities and facilities available to the staff of the college in deciding the teaching method or technique best suited to particular syllabus items. Formal class contact hours, excluding project work and private study, should not exceed 25 hours per week. A plan of the curriculum is shown in Figure 2 opposite.

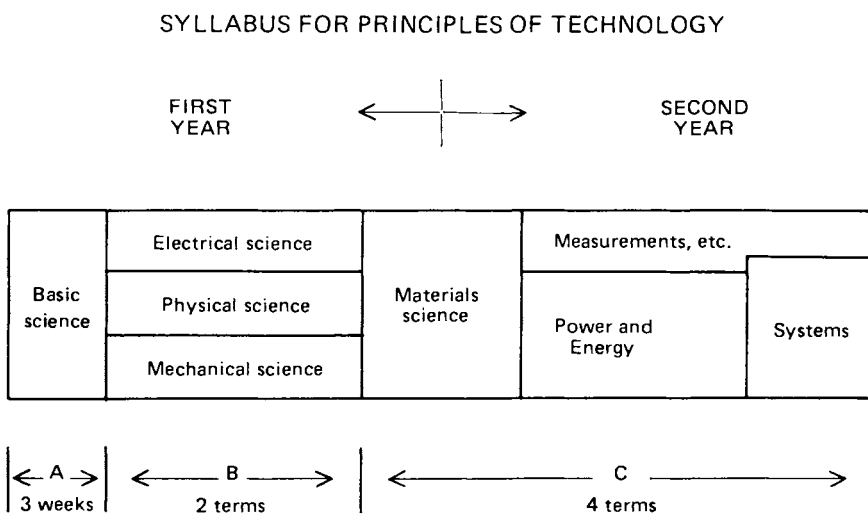

Figure 3

'Principles of Technology', to which 1030 hours are allotted, constitutes approximately 50% of the course. It embraces subjects which are often dealt with separately (e.g. mechanics, electricity, applied heat, physics).

The syllabus is arranged in a number of parts as shown in Figure 3. There are three phases, A, B, and C.

Phase A, the basic science part of the course, is intended to provide an opportunity for refreshing and reinforcing the student's understanding and grasp of basic concepts and for preparing the ground on which the principles of technology stand.

The intentions of Phases B and C are worth setting out in detail:

Phase B: Electrical, mechanical, and physical sciences

The Phase B syllabuses are intended to provide essential foundations in electrical, mechanical and physical science so that the student has the pre-requisite knowledge and understanding of fundamental principles, theory and experimental work to enter *Phase C* and be ready for the more unified approach adopted there. It is considered preferable to retain traditional type sub-divisions in *Phase B* though it is hoped that teachers will not regard these as watertight bulkheads which must not be pierced at any cost, but rather as dividing lines which are retained at this stage only because they may help the student. Phase B extends over the remainder of the first two terms.

Phase C: Materials, energy, measurement and systems

Phase C lasts from the end of the second term to the end of the course. Its substructure represents a deliberate attempt to encourage the development of teaching programmes that emphasize the underlying unity of principles and ideas between the various branches of technology rather than continue sub-divisions that seem to be of diminishing importance as technology develops. It is cast into four parts: materials science; power transfer and energy conversion; measurements, instrumentation and data transmission; systems. Each of these is regarded as representing an area of knowledge that is of importance in all branches of technology and that needs to be looked at in the round in this course, rather than facet by facet in separate subjects. It is appreciated that this new approach will pose organizational difficulties initially and present teachers with new challenges, but it is hoped that the extensive guidance provided with the syllabuses will be of real help to teachers.

The properties of materials and the technology involved in their application are of fundamental importance and are dealt with in materials science in the third term. Materials of many kinds are dealt with, together with a wide range of properties (electrical, mechanical, optical, thermal, etc.) and structural aspects which influence these. Forming processes are also dealt with; their study should involve investigations in laboratory and workshop and also be linked with the engineering drawing of communications. The materials science is purposely placed at the beginning of Phase C, partly because it is considered to be a very suitable initial unifying area of study, partly because a good knowledge of all aspects of materials will be required later in Phase C. If students are to be ready for the workshop investigations of forming processes they will need to have been given previously some time in the workshop for an introduction to basic skills and processes.

Next it is considered that the emphasis needs to shift to power and energy considerations and to measurements, instrumentation and data. The importance of power transmission and energy conversion processes is obvious and needs no emphasis. Similarly the importance of measurement and instrumentation is obvious since, like science, technology depends heavily on the principles of measurement and equipment for making and interpreting measurements. But, as technology becomes more complex it becomes more and more dependent on systems of all kinds for transmitting and processing data and information, for communication generally and for the exercising of control in many different situations.

These have their own basic principles and methods which are already as important to many technologists as are the principles and techniques of the older physical sciences. It is therefore important that students be given some introduction to them in principles of technology if they are to be able to reach informed decisions about the branches of technology they wish to pursue subsequently.

The instrumentation, signal and data transmission aspects of the measurement, instrumentation and data transmission section of principles should be seen as linking with much of the systems section as well as with the earlier work on measurements. The systems section is intended to provide opportunities for introducing students to elementary systems thinking and ways in which systems of many kinds are needed in technology. The syllabus includes the dynamic behaviour of simple physical systems and the intention here is that useful parallels should be emphasized between the behaviours of simple electrical, mechanical and other systems. Simple ideas of analogue computing are also developed as are elementary principles of closed loop control systems.

Detailed syllabuses are given and commended, subject always to the encouragement given to colleges (in the introduction to the notes for guidance) to 'adopt a flexible attitude and, using the data issued in this document, produce a course which is consistent with the latter part of the twentieth century and applicable to their own students . . . Curricula should not be static but should be continually kept under review with the aim of striving for improvement in the light of progress'.

3. Mechanical Engineering Technicians Courses

The Advisory Committee for Mechanical Engineering of the City and Guilds of London Institute has set out the following syllabus and pattern of examinations.*

This scheme for courses of part-time study and related examinations is intended to provide a broad education and an appropriate qualification for those employed in mechanical engineering who follow an apprenticeship, or other suitable form of training in industry, and whose objective will be a position of some responsibility which necessitates a basis of practical training. It is especially suited to the needs of those who aspire to supervisory duties, shop and process control, drawing office practice, plant maintenance and other forms of responsibility, based upon practical experience and detailed knowledge of machines and processes, combined with technical ability to allow the unaided solution of routine problems and difficulties.

The course and examinations have been devised in three parts.

Part I is appropriate to the needs of apprentices and junior technicians who require a general understanding of the basis of their work. It is designed as the first part of an integrated scheme, but it may also be used as complete in itself, with or without supplementary studies.

Part II makes provision for further study, some of which is of a general character, but it also includes specialized studies in certain important techniques.

Part III covers a number of different aspects of control and supervisory duties and provides for the higher grade technician.

**Mechanical Engineering Technicians,* 1973 Onwards. City and Guilds of London Institute 1972. p. 12.

The course of study leading to the Part I examination should comprise at least 550 hours, extending normally over not less than two years of part-time day studies or three years of evening-only studies. In block release or sandwich courses, a minimum of 650 hours of college study including more laboratory practical work is considered appropriate.

At least 25% should be devoted to practical work, in accordance with a set scheme. In the science section of the syllabus, approximately 50% of the subject time should be spent on experimental and demonstration work.

The subjects for Part I of the course are: (a) Workshop Processes and Practice; (b) Engineering Drawing and Materials; (c) Engineering Science; (d) Mathematics; (e) English and General Studies.

Although separate syllabuses are given for the various subjects there should be close co-ordination in the teaching of them throughout the course.

To provide for specialized needs, there are also the following Part I optional supplementary subjects: (a) Non-metallic Materials; (b) Electrical Theory and Practice; (c) Primary Processes A – Raw Materials; (d) Primary Processes B – Melting and Casting; (e) Primary Processes C – Forming and Joining; (f) Power Production; (g) Basic Physics.

Each subject should form the basis of a course of not less than 60 hours' instruction.

The course of study leading to the Part II examination should comprise at least 550 hours (of which 75% will again be for technical studies), extending normally over not less than two years of part-time day studies or three years of evening-only studies. Block release or sandwich courses should extend to a minimum of 650 hours, which should include additional practical work in some branch of applied technology. In Engineering Science and Workshop Technology, not less than one third of the total time should be spent on laboratory/practical work.

The courses are designed to provide for a degree of specialization where students are following certain specified occupations. They continue on broad lines and in all cases have a common basis of science and mathematics.

The subjects for which Part II courses are provided are: Workshop Technology; Press Tool Technology; Plastics Mould Making Technology; Plant Maintenance and Works Services Technology; Testing and Development Technology; Mechanical Engineering Drawing; Control Systems Technology.

For each specialism the course includes: the appropriate technology; laboratory/practical work; construction and materials (if applicable); engineering science; mathematics; general studies.

The courses of study leading to the Part III examinations should comprise not less than 250 hours of study of approved subjects extending normally over two years of part-time study, and in addition the study of a related Applied Technology comprising not less than 70 hours. In the case of Plastic Moulds Design and Utilization, the course should extend to not less than 300 hours of subject study and 100 hours of Applied Technology. In the case of block re-

lease and sandwich courses, the hours should be increased by not less than one third. As much work as possible should be done in tutorial groups in which the experience of each student is used to the fullest advantage.

The subjects for which Part III courses are provided are: Jig and Tool Design; Product Design; Engineering Production; Mechanical Engineering Inspection; Plant Engineering; Press Tool Design and Utilization; Research and Development; Control Engineering; Plastic Moulds Design and Utilization.

English is included in these courses so as to help the potential technicians to develop their ability to absorb, interpret and transmit information, whether by the written or the spoken word. This entails widening the student's vocabulary, improving of his powers of comprehension, and providing practice in analysing and selecting relevant information. In addition the student should be encouraged to read widely and to write frequently.

General Studies is intended to contribute to a student's general education and personal development. It should help him to take an intelligent and enquiring interest in the world around him, perhaps with particular reference to the locality in which he lives and the industry in which he works. The stimulation of leisure activities will become increasingly important as the amount of time available for such activities increases.

The City and Guilds of London Institute does not examine in English and General Studies, but an internal candidate will not be accepted for the Mechanical Engineering Technicians' Part I and Part II examinations unless the principal of the college certifies that he has satisfactorily completed the English and General Studies section of the course.

The Institute sets the following entry requirements:

Entry to the Courses

The selection of the students for the courses is within the discretion of the college, but the Institute recommends that students should satisfy one of the following conditions or have reached the appropriate standard by an alternative route. Depending upon the student's previous qualifications the college may require him to undertake additional studies prior to his entering or during the course.

(a) Part I – Year I
  (i) Completion of a secondary school course which, in the final year, has included Mathematics, a suitable science subject, and technical drawing or a metalwork subject.
  (ii) Satisfactory completion of the first year of a General Course in Engineering.
  (iii) Part I Certificate in a mechanical engineering craft subject where appropriate.

(b) Part I – Year II (Direct Entry)
  (i) Passes in three subjects (including Workshop Processes) in the General Course in Engineering, or satisfactory completion of the Army's General Engineering Certificate.
  (ii) Passes in three subjects, including mathematics and a suitable physical science, and Metalwork or Engineering Drawing, in the General Certificate of Education at Ordinary level (or 'O' grade in the Scottish Certificate of Education) or the equivalent in terms of the Certificate of Secondary Education.
  (iii) Part II certificate in a mechanical engineering craft subject where appropriate.

ORGANIZATION OF COURSES FOR MECHANICAL ENGINEERING TECHNICIANS

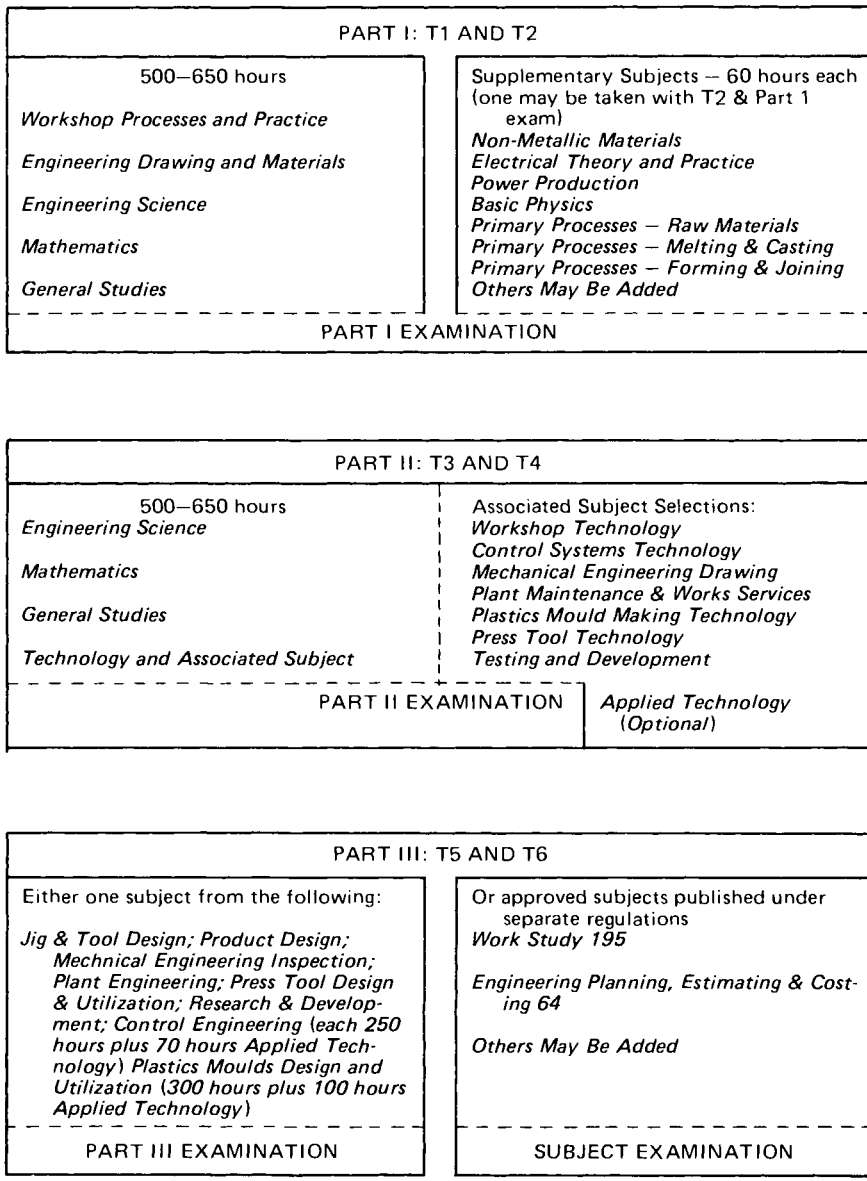

Figure 4

(c) Part I – Supplementaries.
As in (a) or (b) above.

(d) Part II
(i) A pass in the Institute's Part I examination for Mechanical Engineering Technicians or the corresponding examination of a regional examining body.
(ii) Completion of other suitable courses in engineering, e.g. Ordinary National Diploma or Certificate with Workshop Technology as an assessed subject.
(iii) Appropriate academic ability in a mature student.

(e) Part III
(i) A pass in the Institute's Part II examination for Mechanical Engineering Technicians or the corresponding examination of another appropriate engineering technician's scheme.
(ii) Any appropriate Higher National Diploma or Certificate.

Overseas Countries.
This scheme is available outside the United Kingdom at those colleges which have received the Institute's approval. Applications for approval of a course should be made on Form 2045 obtainable from the Overseas Branch of the Institute.

Figure 4 on page 40 shows the organization of these courses for Mechanical Engineering Technicians.

Planning and Constructing a Technician Course

In constructing a technician course, consideration must first be given to the following matters: its purpose; the people for whom it is to be designed; the intended category of technician and his level of responsibility; the form of attendance (e.g. full-time; evening; block release); the selection of students; the number of hours of tuition; the division of time among subjects; the examination requirements; and the terminal qualification.

The syllabus should then be expanded and laid out in terms of a scheme of work which will include the title and year of the course; the subject and standard; the objectives of the syllabus; specific objectives for the session; the class (age range, trades, range of employment, previous education); the time allocation (e.g. to teaching new material, laboratory work, workshop activities, testing, homework discussion, revision, industrial visits and speakers, and examination practice).

The plan can be laid out in ten columns, as in Figure 5 on page 42.

General Education: Liberal Studies

General education or liberal studies in the technician curriculum serve to encourage creative imagination and clear, liberal, challenging thinking. Adolescents cannot be confined to thinking only of vocational matters. They will want to consider and criticize current social, political, national, international and industrial issues and ideas. Liberal studies provide the opportunity to examine such matters rationally, and help students to make informed, discriminating judgements.

Liberal studies discussions and activities will almost inevitably challenge authority. They depend on informed controversy which cannot be kept to

PLAN OF A TECHNICIAN COURSE

1	2	3	4	5	6	7	8	9	10
Period number	Title of activity	Aim of activity	Content of activity	Content of related subjects	Teaching methods	Illustrative material	Aims and types of homework	Industrial application	Further reading

Column 1. Period: a space for each period allocated to the subject.
Column 2. Title of activity: the title of each activity in each teaching period (each activity or topic should be listed in sequence opposite the appropriate period).
Column 3. Aims of activity: a simple, clear, concise statement of the minimum the students will be expected to have learned and be able to apply to relevant industrial tasks at the end of each teaching period.
Column 4. Content of activity: the salient facts to be learned in each period.
Column 5. Content of related subjects: correlation and dove-tailing between the different subjects in the course and between different teachers.
Column 6. Teaching methods to be used: variety and balance of teaching method in relation to the topics to be taught: informal methods as often as possible so that active methods of learning are more frequently used than formal lecturing. The kinds of method have to be anticipated at the programme and scheme of work planning stage to ensure co-ordination between teachers, laboratory and workshop and educational technology technicians, stewards, library and resource centre staff and with outside organizations.
Column 7. Illustrative material: includes precise details of everything which is to be used to give the students a clear mental picture of what is being taught: details of demonstrations and experiments, charts, film strips, tapes, films; the detailed chalk board summaries, material for felt board and magnetic board, the sectioned and exploded components and the working models to be used are best kept to the individual lesson preparation.
Column 8. Aims and type of homework have to be planned and co-ordinated during the analysis and syllabus expansion.
Column 9. Industrial applications: it is important that the learning material in each period is associated with its vocational applications: by completing this column the teacher can assess whether or not his material is too academic in content and presentation. It can help teachers to identify and clarify their own deficiencies of knowledge about industrial processes.
Column 10. Further reading: library references prepared by teacher for each topic.

Figure 5

specific and politically 'safe' topics or be stopped short when discussion reaches a combustible stage. A test of the sincerity and success of educating for democracy in an educational institution is the influence students are permitted to exercise through student organizations or staff-student councils. If students are not allowed to affect the organization, administration, curriculum, quality of teaching and all those aspects of the college that touch on their living and learning, it is pointless to provide courses on the philosophy and principles of methods of government, management and human relations.

Clear thinking should be emphasized as much in the learning of technological subjects as in liberal studies and it is important that the teaching methods used

by liberal studies teachers to foster logical analysis, rational argument, active learning and effective communication are also used by teachers of specialist subjects.

The subjects which follow are those that most frequently appear in college curricula. There is a considerable overlap in their aims and methods, and one of the tasks of the course co-ordinator – whether he is the principal, a head of department, or a senior teacher – is to ensure that the subjects are structured and sequenced in such a way that duplication is avoided, and that the themes selected for study are integrated in a meaningful way.

Aids to Study

This subject, which aims at guiding students to plan and use their study time, should come early in the course. It should be short and well documented, practical and immediately applicable. It should be illustrative of the principles and techniques being advocated; not theoretical, abstract, academic and bookish. It should include the elements of work planning, progressive task organizing, programming and systematizing learning, using library resources, rapid reading, comprehension, abstraction, note making and note taking, precis writing, organizing and presenting material (orally, in writing, and by means of diagrams, designs and working drawings) and deal with techniques of self evaluation. The success of the course will depend on the quality of the scheme of work prepared by the course co-ordinator. This scheme, which should be issued to students on the first day of their course, should set out the sequence of topics and the dates of their treatment, salient points to be dealt with, sources of information, precise references to required reading, and other materials for study (such as files of information, reports of laboratory equipment, pictures, slides, and transparencies).

Language Studies

Language and literature form a considerable part of most courses. The aims are to encourage logical thinking, clarity of expression, grammatical appreciation and the growth of vocabulary. The teaching methods include exercises in logical analysis and clear thinking, comprehension, precis making, discussion groups, seminars, syndicates, lecturettes, debating, committee procedures, reading plays, poetry and prose, stage production, and mock parliaments. Clear speech is encouraged by using tape recordings to reveal errors of pronunciation and delivery, and it is common practice to listen to examples of speech, expression and communication on the radio, on records and on television.

Written projects are concerned mostly with history, economics, human relations and industrial aspects of specific technologies, and with reports of project investigations within an organization. Exercises of this sort are necessary for technician students who aspire to industrial responsibility. They can be supplemented by more creative, non-vocational experiments in self-expression. It may be important that technician students should, as part of their general education, learn to fill in official forms and write letters, but such skills are

limited in content and do little to advance self-expression. One exception is teaching the student how to study advertisements for jobs suited to his qualifications, and how to write to referees first to seek their support and then to thank them and inform them of the result of the application. Interview technique and interview behaviour are part of the same exercise. Elementary form filling, like any other simple skill, can be taught quickly as the need arises.

Specialist technical teachers should be encouraged to undertake non-vocational further study in order to broaden their thinking and to qualify them to participate in the general education programme. At present too few technical teachers participate in liberal studies, and too few 'specialists in language, general and liberal studies' are familiar with the educational, industrial, and sociological background of young workers.

Current Affairs

This subject helps students to read critically, listen carefully, obtain relevant facts, analyse ideas, have flexible points of view and be adaptable to changing conditions. Worth-while discussion cannot be limited to bare facts, to slogans or platitudes, to the 'official view', or to interpretations of the ideas of the Establishment. Students are interested in how people (including their teachers) arrive at their opinions, and in the kinds of argument that they use to support those opinions. They cannot be expected to accept unqualified, authoritarian assertions.

Background to Science and Technology

Time needs to be allocated for learning about the history, philosophy, and responsibility of science and technology. The subject matter has to be related to social change, and to challenging traditional ideas and culture patterns. The technical teacher can correct over-romantic accounts of invention and discovery by stressing the persistence required by research workers. This will help students to see that technical qualifications do not by themselves endow people with the right to a particular job or to promotion: personal qualities, such as reliability and persistence, willingness to learn and readiness to accept advice are also essential.

Social Studies

However the subject is labelled, it aims at helping technician students build the knowledge, attitudes and behaviour which make for good citizenship. The subject matter includes economic, industrial and social history; the philosophy, principles and structure of government; mechanics of elections and parliamentary procedures; the civil service; central, regional and local civic administration; finance and taxes; education and health; planning and building; roads and transport; police, welfare and social services; the philosophy, principles, organization and administration of the law and justice; hospitals, clinics, prisons, public libraries, art galleries, museums, and recreational facilities; water and sewage; voluntary community services and youth clubs; and the press, television, radio,

advertising, and propaganda. Students have to learn in practice the meaning of truth and what makes for enlightened and independent thought. They should grow towards a deeper understanding and belief in the inviolability of the individual, and react strongly against any misuse of power.

Industrial Relations

Loyalty under a variety of labels is a common aim in these courses. It usually means loyalty to the organization. If loyalty is discussed in its broadest aspects, it can be a liberalizing exercise. On the other hand it can be an intellectually stifling activity if it is confined to conditioning thought to an existing regime, and towards traditional interests and practices. Students can learn how different kinds of industry under different systems of control can be organized to function for the national good. Discussions can range freely about what can go wrong in relations between management and managed; and what material about industrial organizations appearing in the press, on television, radio and film is true or untrue, exaggerated or distorted, or serves to cover the motives of one interest or another. The trade union movement can be discussed less emotionally outside a specific industrial or government organization than within it. Discussion can deal with the strengths and weaknesses of unions, and with their evolution, development, and changing functions.

For technician students their own working group is probably the most suitable starting point for the treatment of all parts of the liberal studies course and particularly for human relations. It can help towards a better understanding of the situations which lead to improved productivity and improved working conditions for the benefit of society.

Leisure

Education for leisure is being given serious attention in the industrialized and industrializing countries. With the increased tempo of modern industrial life, nervous and emotional troubles are increasing. Colleges can help students to counteract these pressures by participation in such leisure activities as physical education, individual and team games, reading, drama, music, art, and handicrafts. Technical teachers can contribute their personal non-technical interests to education for leisure: it would be a sad thing if they had no leisure interests outside their work with which to enthuse some young people.

Creative Studies

Technical teachers are continually being urged to foster the creative abilities of their students. As things are organized at present, this is no small task. In order to meet the requirements of examining bodies, all technician students have to carry out much the same exercises, use similar materials and tools, and learn much the same things in the same way at much the same stage of their course in almost every country. There is little opportunity to experiment with creative industrial design and activity. The existing system compels everyone — teachers and students — to conform to one pattern. Under such circumstances

any creative talent aroused in school can soon be stifled. Moreover, few technicians will have scope or be allowed to exercise their creative ability in industry. The liberal studies course should therefore do all it can to offer opportunities for technician students to learn to apply their practical skills to creative craft activities. In this way students can learn the meaning of good standards of workmanship and recognize shoddy work hidden by a synthetic veneer.

Organization of Technician Courses

Different kinds of course organization have to be developed to suit particular needs and conditions. Ten examples are given below:

1. Full-time integrated courses

Several advantages are claimed for full-time integrated courses. These are: theoretical and practical training can be integrated under the control of the educational institution; attention can be concentrated on practical and laboratory work and not subordinated to production; standards of performance and achievement can be readily established; and the courses do not depend either on the conditions or the availability of employment in local industry.

There are also some disadvantages. The industrial atmosphere is not present; colleges tend to follow technological change at some distance and are not up-to-date; colleges may lose contact with the requirements of the industry or occupation for which instruction is given; industrial equipment and resources are lacking; practical work may have to be on a smaller scale than in industry; and simulation of real situations is difficult.

2. Sandwich Courses

Sandwich courses require at least eighteen weeks' continuous full-time attendance at a college. They are particularly effective where industry participates in the spirit of training. There are several patterns, but all of them consist of alternating periods in college and industry, and begin and end in college.

Some countries, although acknowledging the effectiveness of sandwich courses, have been unable to put them into operation, sometimes because firms do not have sufficient technicians to permit release, sometimes because distances are prohibitive.

3. Block Release

Block release from industry is a comparatively new arrangement by which students attend college full-time for periods varying from two weeks to three or four months at a time. The most popular arrangement is for full-time attendance for a term of twelve weeks. One argument for block release rather than day release is that it allows for a larger intake of apprentices – an important factor when technician manpower will be increasingly required in the years ahead. Others are that the continuity and intensity of study are more effective, that the teachers and students get to know one another better, that there is more time for integrating language study and liberal studies with technical studies, and that

there are more opportunities for developing student interests in art, music, drama, handicrafts, sport and corporate activities. Firms which support block release find it possible to make more effective use of training facilities because they can be used every day all the year round.

The educational arguments against block release are not strong in a densely populated, highly industrialized country with a well-developed technical college system and good local transport facilities. But there is some force in the arguments that the lapse of time between blocks of attendance at college can result in much that has been learned being forgotten; that students can lose the benefit of the continuous urge to effort provided by regular attendance; and that theory and practice can get out of gear resulting in loss of skill and retardation of practical training.

4. Day Release

Day release means that a student is released by his employer for one or, preferably, two full days a week to attend college. In addition, attendance is normally required on two evenings per week. Day release is only suitable in relatively large industries in urban centres.

5. Induction Course

This is an arrangement by which industry sends its young employees to the local college for a period of induction to further education lasting for two or three weeks up to as many months. The scheme, as with all educational release by industry, is entirely dependent on the attitude of the employers.

The broad aims of the induction course are to provide opportunities for educational and vocational guidance based on the techniques of diagnostic and prognostic testing; to experiment with methods of remedial and intensive teaching, particularly in mathematics and science; and to help young people to understand the need for further vocational and general studies.

6. General Course

British industry seems to prefer general courses which are planned for school leavers in order to maintain continuity of learning based on vocational interest. At present such courses are full-time pre-employment or part-time day or block release courses for those in employment. They concentrate on mathematics and science because these are the subjects most likely to lead to success in higher technicians' courses, but there are additional subjects including drawing and English studies. As in all technical college studies, the educational aim is to encourage intellectual versatility and the rational understanding of vocationally-relevant fundamental principles, rather than to provide industrial training in precise skills and techniques.

Appraisals are made about the kinds of special vocational education courses which students should follow. Thus, at the end of the first year a student may be transferred to the first year of a technician's course, or he may continue into the second year of the general course if he shows the ability for a National

Certificate course (which is a higher technician qualification). Most students who have completed the general course continue attendance at college for two further years to obtain the Ordinary National Certificate, or for four or five years for a Higher National Certificate.

7. Before or after working hours

This type of course is frequently used to up-date, up-grade and retrain workers in conditions where it is not possible to arrange teaching during the day. However, evening-only arrangements should be avoided if possible as they have a low success and a high wastage rate.

8. During working hours

Where it has been organized this type of course is claimed to have the enthusiastic support of worker and employers. It takes up four hours each working day; two hours out of the employer's time and two out of the worker's time.

9. Accelerated courses

There are many reasons why this arrangement may be necessary: there may be an urgent demand for technicians to meet an unforeseen need; a company may have to re-equip because unanticipated changes have to be made to the product and the manufacturing processes; possibly technicians have to be retrained in new skills and techniques, or upper-level craftsmen be up-graded to technicians. Each course has to be tailor-made to suit particular requirements, and there is no specified number of hours. The course content is designed, structured and planned by the college teaching staff in collaboration with the training staff in the firm. If modern teaching aids prove effective in speeding up the learning process for workers on accelerated training courses (or, for that matter, for any students on any type of course) serious consideration should be given to shortening the course. The suggestion has been made that trainees who have followed and successfully completed an accelerated course should be given a special certificate which could later be up-graded by successful completion of a complementary course.

10. Correspondence courses

Much technician education in Australia and New Zealand is carried on by correspondence courses reinforced by radio. An important feature of the study scheme is block attendance by students at various times during the year in order to meet and exchange ideas with their tutors. There is little evidence of wastage, or drop out, in either country.

Collaboration in Organizing Courses

The specific aims of technician education are not complicated. They are to provide the vocational education which supports industrial training, to contribute to an increase in productivity, to sustain and raise standards of living, to educate men and women to recognize and accept their social obligations and responsibilities, and to understand the purpose of science, industry, and business.

Philosophers and educationists throughout the ages have accepted that people should be educated and trained to earn a living. They have had different ideas about what should be taught and at whose expense, and how the rewards of work should be distributed, but they have never argued that society could survive on education alone. The different political parties, private and public employers and the trade union movement are agreed on the same interpretation of the obligations resting on technical education.

Broadly speaking, it is in the college that the student learns to understand the theory and principles underlying the practices, methods and techniques he learns to apply during his industrial training. The methods of integrating college theory and industrial practice continue to present problems of co-ordination and integration. Even in institutions where theory and practice are taught under one roof to the same students under the same overall control and direction, it is not unusual to hear the teacher of a theory subject describing practical skills and, more incongruously still, to see students in an industrial training workshop sitting round a blackboard between idle machines listening to a lecture when they should be acquiring and applying specialist skills.

Integration of theory and practice is even more difficult and can be less effective when college and training workshops are under separate control in different buildings with independent staffs. Such separateness should be avoided wherever possible as it adversely affects the quality of the technical education and the industrial training and ultimately retards the growth of productivity.

Even more fundamental is the need to create and maintain an effective integrating liaison between colleges and industry. This collaboration serves three purposes. The first is to ensure that vocational theory and industrial training progress at the same rate and in harmony. The second is that theory is shown to be immediately applicable and relevant to industrial training projects and experiences. The third is to help the student to understand the materials, processes, equipment and practical techniques of his job in industry. Without such collaboration students may mistakenly believe on the one hand that college is a world of its own, distinct from the realities of production and the economics of living, or, on the other, that the only industrial training of any importance is that which is gained in industry itself. Some students, resistant to learning, are victims of the outdated philosophy of the virtue of 'coming up the hard way'. Whatever this may have implied in the past it has little place in today's industry, depending as it does on mental rather than physical effort, and on scientific and rational method rather than on rule-of-thumb procedures. Without a close relationship between education and training, students are unlikely to develop the flexibility they will need in their work, or to overcome the outdated notion than an apprenticeship or equivalent training in youth will suffice until retirement.

In the past there was ill-defined responsibility for preparing curricula for vocational education and training. In most countries it was teacher-centred, and it was administered, controlled and managed by Ministries of Education. To a

large extent this is still true but the administrative barriers between education, government and industry are being removed, and divisions between technical education and industrial training are breaking down. Areas of total education on the one hand or total industrial responsibility on the other are blurring, and zones of mutual interest are being developed. Industrial training boards, apprentice training boards, technical examining bodies, and joint councils with wide-ranging educational, industrial and government representation are now operating in many countries. National technical education and industrial training councils, commissions, committees, and curriculum-building working parties and study groups have representatives from all sectors of industry, education and government. College governing bodies are being established with a broadly-based membership of people with influence and power in top-level policy and decision making in education, industry and government. College faculties and departments have advisory committees which include representatives from industry and regional and local government to advise on curriculum, equipment, staffing, and financing, and to ensure that resources are made available and that access to industry and government is made easy.

Despite all that has been written about the value to young people of having specialists from industry as teachers, it is still rare to meet a person who is released by a firm to participate in day-time teaching. The reason for having teachers from industry is that they can improve the quality of technical education by relating scientific principles to industrial situations within their particular areas of specialism. It is the person actually engaged on the job who can best help to make learning relevant, important, worth-while and interesting. Few would expect industry to release specialists to teach at an elementary level, but in any case their help is needed most at the higher technician levels where active up-to-date knowledge and experience is all-important. Specialist part-time teachers from industry can help in other ways. They can arrange for students and technical college teachers to have access to laboratory and workshop facilities in their firms. They can assist the firm's training officer in arranging rotational industrial assignments in different departments for college students, and in mounting in-plant seminars for college teachers and securing places for them on sponsored training courses.

The main emphasis in industrial liaison is probably rightly focused on the need for technical teachers to maintain close and active links with industry. Timing this liaison will differ from one circumstance to another. Sometimes a half-hour visit is all that a teacher needs to clarify his mind about a particular technological application, to see a new process or piece of equipment, or to discuss a particular aspect of his teaching material. At other times longer visits are required, for example in order to make an intensive study of industrial developments, technologies, techniques and processes, and work out the content and methods of technician subjects in relation to the workshop operation.

Discussions with a firm's training staff need to be fairly leisurely if their outcome is to be objective, constructive and penetrative with regard to quality

of integration and rate of teaching development. Teachers can have the opportunity to learn about projected developments and the kinds of change that will be required in the curriculum of different types of course. They can learn to manipulate equipment, carry out operations and reorientate skills which may have been introduced since they were last in industry. They can learn to correlate job titles with different kinds, levels and functions of technicians in a firm and to make an activity analysis of some of the job titles and of the tasks in some of the jobs. They can meet the people with whom they have rarely come into contact, the managers, accountants, economists, planners, sales and servicing chiefs. In such ways teachers can be made to feel that they are part of a combined effort; that they are working with colleagues who are as interested, sensitive, well-informed and concerned as themselves about the aims, purposes, and quality of technical education. In such ways, too, teachers broaden their background knowledge about the factors which influence productivity, thus becoming better informed about the complete dependence of any social service, including technical education, on the sale of industry's products.

The question is often posed as to why many more technical teachers do not spend more time in industry. There does not appear to be any straightforward explanation, but perhaps the fact that their technical knowledge is in many cases less adequate than that of the younger people they are likely to meet in industry leads to a lack of self-confidence. Many of the younger teachers on the engineering side, for example, have had only very little, if any, practical workshop, laboratory or research experience.

The McNair Report* made the following observation on the same subject.

> Witnesses from the chemical industries stated that many teachers of chemistry, in spite of their academic attainments, have insufficient knowledge of industry and thus are not able to adapt their knowledge and methods to the needs of their students. The building trades representatives emphasized that many of the higher teaching posts are held by architects, many of whom have not had much experience of practical building and of the many trades associated with it. In many trades the men and women available as instructors are ill-equipped to take part in the education of adolescents. The textiles representative said that many graduates with degrees in technology were not well advanced in the fundamental sciences associated with their work. The engineers, while agreeing with this view, added that teachers who have lost touch with industry are not up-to-date in their instruction and that others suffer from a lack of any significant experience of industry before they begin teaching. The teaching of some commercial subjects, especially typewriting and, to a less degree, shorthand, is often undertaken on old fashioned methods regardless of valuable research now available in the teaching of these skills.

It is a common criticism of technical teachers that they teach what they learned many years before, that they use bookish, authoritarian methods, and that there are considerable discrepancies between what they teach and what the technician needs in order to do his job.

Technical teaching obsolescence is of equal concern to industry, government and colleges. Industry could help itself more by offering greater opportunities

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**Teachers and Youth Leaders.* Ministry of Education. H.M.S.O. 1944.

to full-time technical teachers for special, industry-based up-dating modules of vocational education and skill training. Industry could also nominate more members of technician manpower for special courses arranged in collaboration with college staff. Greater encouragement could be given to technicians to attend special short courses in fields not immediately associated with their work. Colleges could be involved to a greater extent in technician staff development programmes. Government education authorities could make their essential contribution to the modernization of technical education by offering more incentives to teachers to improve their technical knowledge and skill within industry during their vacation periods so that they can make themselves professionally proficient in terms of modern industrial practice and the new courses and syllabuses that are required for technician education. Tutorial staff development involves three activities: namely, special subject matter extension, up-dating, and reorientation; skill and knowledge of industrial processes and techniques; and training in methods of teaching new specialist technical subjects in the new technician courses being developed. All involve the closest possible liaison and collaboration between technician education and industry.

The co-ordination of industry, government and the education system for the modernization and extension of technical education must be undertaken far ahead of economic development to ensure an adequate supply of qualified technician manpower. It takes five years to train a technician and double that time to establish, equip, and staff a technical college.

It is a matter for regret that some technical teachers have no real interest, appreciation or understanding of their responsibilities to students and the industries in which they wish to make careers. Such teachers are particularly out of place in the education of adolescents who are preparing to become technicians. It may be that in the recruitment of technical teachers there should be a greater emphasis than at present on quality, variety, level and responsibility of industrial experience, on recency of personal technical and general education, on motives for choosing teaching, and on attitudes to learning, to young people, and to social situations.

More regular and more frequent liaison at the national and local level could provide opportunities for open discussion about the aims and purposes of technician education in relation to life and living. Conflicting views exist about ways of achieving national economic objectives, about the effects of rapid industrialization and modernization, about the control of multi-national complexes and about many other matters of social policy which are of direct concern to the technician. These need to be debated by everyone involved, not only by employers and educationists. Increasing numbers of people are unwilling to accept that only those in industry and technical education have the wisdom and right to decide the pattern and the economic and social uses of industry and education.

Another purpose of fostering close collaboration between technician training colleges and local and regional industrial organizations is to turn out men and

women trained not merely in the somewhat rarefied atmosphere of college laboratories and workshops but also in the brisk, hurried world of commercial competition. The balance between these two elements is difficult to assess, and even when a ratio has been chosen it is difficult to put it into practice.

College authorities can ensure that local and regional industrial organizations are represented on the top policy-making councils, on the governing body and on decision-making committees about college development, planning, finance, organization, management, courses, staffing and resourcing. Industrial representatives on college academic and faculty boards can advise on the kinds of courses that are required to produce the right kind of technician manpower in the right numbers. They can advise on curriculum content, and on the balance between theory and practice. Industrial specialists on college department advisory committees can contribute their expertise to the selection of students for courses, to structuring syllabuses and schemes of work, and to devising and supervising student projects and assignments which co-ordinate theory and practice with on-the-job work experience. They can advise on laboratory and workshop equipment and the specialist section of the college library and the education technology centre.

As external assessors and examiners, senior industrial staff can contribute to the maintenance of appropriate standards of achievement by college graduates in different levels of technician occupation. They can ensure parity of standards between departments in a college and between colleges in a region, and consequently parity of esteem for the qualifications and the occupational status of the technician.

One of the most productive contributions which an industrial organization can make to the work of its local or regional college – and at the same time to its own manpower recruitment – is to provide part-time teachers for the specialist sections of the technician curriculum. College governing bodies need to ensure that college staff development programmes include regular practical, and intensive up-dating experiences in the appropriate job in the right department of an industrial organization. Incentives should be provided to encourage teachers of technicians to spend much of their vacation time in industry acquiring knowledge directly relevant to the immediate employment needs of the technician students they teach.

3

The Selection and Assessment of Technicians

In selecting students for technician courses, the main aims are to guide each individual into the type of job in which his abilities, aptitudes and interests, academic performance, intellectual and practical strengths, personal qualities and potential are most suited, and to place him in the course in which he is most likely to succeed.

For several reasons it is not possible to obtain clear information on how technicians are recruited for industry. One is that many employers do not identify a technician category in their manpower classification. Another is that job classification in industry is fast becoming obsolete. And a third is that there is considerable mobility of people into, through, and out of the technician category. The mobile groups include large numbers of technicians who are promoted from craftsmen, and who usually had no formal qualifications on leaving school. They also include significant numbers of relatively highly qualified graduate engineers who are passing through the technician category to higher-status employment and are not getting recognized technician-type training to fit them for technician jobs.

However, the number of technicians who have not received formal training is declining, and older people who have qualified by experience are giving way to younger people with formal technical qualifications. Better educational opportunities have made it possible for more young people to obtain formal school leaving qualifications. Today technician apprentices or trainees are mainly recruited from people who have had sufficient secondary schooling to have acquired G.C.E. or equivalent-level qualifications. The technician category has grown partly in response to a demand arising from technological change and industrial innovation, and partly because the development of secondary and technical education systems has produced a greater supply of people with the necessary general education and technical knowledge.

In most countries and industries a technician employment pattern is becom-

ing apparent with its own level of general education, technical education, and vocational training. There is understanding and acceptance of academic study as a complement to practical training, and of post-secondary education qualifications as being reliable criteria on which to assess the level of an individual worker within the overall technician category.

Secondary schools in many countries offer pre-vocational foundation programmes containing practical and theory elements of lower technician courses. The educational aim is to encourage intellectual versatility and the rational understanding of vocationally relevant technological principles rather than to provide industrial training in precise skills and techniques. The programmes are planned to avoid wastage of human ability by allowing reasonable time for students to discover which technician course suits them best, or alternatively to switch to a craft or skilled worker course. Special arrangements are made for students to transfer to higher technician courses of three to four years' duration if they obtain good passes in mathematics, an appropriate science subject, and a subject requiring facility in the use of spoken and written language.

Technician and similar vocational course entrance requirements are having an effect on secondary school curricula. In a four-year secondary course the normal pattern is becoming two years of studies which all students take, followed by a further two years planned to allow for vocational interests to become the focus of teaching and learning. There is an increasing emphasis on science, mathematics, drawing, and practical and vocational subjects.

Pre-technician courses specifically designed for those who are potentially capable of satisfactorily completing a technician course but who lack the necessary entry qualifications, are another developing feature of secondary education. One of the purposes is to provide educational guidance by studying students over a fairly long period. The courses concentrate on mathematics and science because there is evidence that success in these subjects is likely to lead to success on a higher or middle-level technician course. Those students who successfully complete a pre-technician course frequently do better on technician courses than those who enter directly from school by virtue of examination success. A pre-technician course within the system of technical education could therefore be an appropriate channel to technician training. However, entrants would need to be carefully screened: attempts to use the course itself as an instrument of selection by admitting every applicant would lead only to a very low pass rate in the examination at the end of the course or to a lowering of standards.

Problems of selection for technician training arise for several reasons:

1. A shortage of suitable candidates with basic qualifications in mathematics, science and language subjects due to a national lack of adequate secondary education opportunities and resources.
2. An excess of applicants possessing minimum admission qualifications to technician training.

3. The transfer of craftsmen lacking secondary education to the technician grade.

One reason for the existence of the second of these problems is that the academic standards of recruitment for some blue-collar technician and skilled worker jobs are set far above the required ability levels. The technician training programme, particularly at the middle and lower levels, does not require the academically well-qualified student from the top third of his class. A job-motivated person of average ability and the capacity to stick to a task until it is completed is likely to have the profile required for an effective technician. The selection and recruitment requirements must be directly related to the content and objectives of the technician training course – not so low that wastage is high, or so high that good candidates are excluded. The technician teacher has to ensure that the student of average ability and persistence is encouraged to learn and succeed.

The selection process is concerned with the initial qualifications required before an individual can be trained to do a particular kind of technician job. Although it is not possible to produce a detailed analysis of the type and range of work from which to structure a valid and reliable selection process for technicians, it is possible to identify two kinds of technician: those in whose work practical knowledge and ability is foremost and for which the training should have a substantial craft emphasis, and those in whose work there is greater emphasis on theoretical knowledge and for which the training should approximate to professional standards. Both are concerned with implementation rather than innovation, and both have little involvement in management, planning, evaluation or control. But the higher technician requires a more extensive knowledge and discretionary ability which he can apply over a much broader area of activities than the other technician whose job tends to be much more routine and narrowly defined. This is reflected in the higher technician's vocational education requirements to do the job and in the higher general educational requirements to be selected for higher technician training. In its publication *The Training of Technician Engineers,* the Engineering Industry Training Board (London) lists six main abilities which appear to be demonstrated to a greater or lesser degree by all technician engineers in whatever branch of the engineering industry they may be working. These are:

(a) The ability to use and communicate information.

(b) The ability to measure or make use of measurements which involve a variety of tools and/or instruments.

(c) The ability to choose materials and components and understand the processing of materials.

(d) The ability to understand manufacturing activities and the general commercial organization and practice of their companies.

(e) Diagnostic ability.

(f) The ability to organize (but not necessarily supervise) and give direction to the work of others.

In considering these, it should be noted that there is very little difference in the types of communication carried out by technicians at different levels. Except for draughtsmen, written and verbal communication with customers, suppliers and colleagues is the most time-consuming activity. Draughtsmen, however, spend more than half their working time on the preparation of drawings and sketches. This form of occupation also accounts for between a third and a quarter of the time of those technician engineers who are employed on design. Technician participation in design is limited. Among non-draughtsmen technicians, drawing alone accounts for little more than five per cent of time worked. Draughtsmen working in production appear to have the narrowest range of duties.

The entrance requirements to technician training and the selection mechanisms must be related to the appropriate kind and level of technician training and employment. The mechanisms must measure applicants against the tasks they will have to perform and not against the criteria of the education system that produces them. The kind and range of selection mechanisms must be realistic in terms of the particular country's stage of industrialization, applicable to existing conditions in industry, and directly relevant to technician jobs which are already available or will be available in four or five years' time. The characteristics of both the job and the individual to fill it are interdependent and have to be examined together. Co-operation in selection between industry, school and technical college produces the best results. Vocational guidance counsellors and employment selection staffs are presented with a dilemma if industrial organizations do not specify their educational and other requirements at technician level. Those responsible for selection and guidance need to have from industry a job description and a specification of the make-up of the kind of individual required. They need to know the level of authority of the job in the particular industrial organization, the functions of the job within the firm, the kind of work carried out, and the qualifications required to carry it out. Technician job profiles are standard under a number of headings, such as job title; age; school leaving qualifications; training (apprenticeship); type of work; range of activities; and breadth of knowledge. The profile is based on analysed real-life industrial situations and experiences and is likely to be the most objective and valid evidence available on which to structure such selection devices as tests of general and special abilities, personality inventories, attitude and interest schedules, rating scales, sociograms, and interviewing techniques.

Tests

Tests have been devised to assess an individual's general and special abilities, educational achievement, interests, temperament, and potential. They are used for educational and vocational guidance and selection, and for assessing achievement and progress in scholastic and employment situations. The aim of all

tests is to contribute to a pool of objective information about individuals. In course programme subjects, tests – including scientifically constructed questionnaires, inventories, and schedules – are used to supplement, confirm or adjust teachers' assessments of students' achievements. In vocational selection they are used to eliminate as far as possible candidates unlikely to succeed on the job after training.

The usual reason given for having a testing programme at the stage of initial selection for training is that it facilitates the sorting out and job allocation processes, and reduces the possibility of expensive mistakes. It is based on the theory that there is a framework or profile of abilities and traits relevant to particular occupations and jobs. However, test designers have not constructed valid tests of the basic knowledge, skills, experience and personal make-up necessary for success in particular occupations, and care should be taken not to rely on them too heavily.

The information from tests can be built into the student's record. From the record a profile of abilities can be constructed. This profile is a diagrammatic way of charting and communicating information about an individual. It gives standardized information about his general intelligence, special aptitudes and capacities, and his performance in academic subjects and practical skills. It provides a basis on which a youth's abilities, interests, and personality can be matched with the requirements of a vocational training programme or with a job specification; it offers clues about personality, social maturity and adjustment; and it enables individuals to be compared with one another. But no matter how many tests are used and how well the information is interpreted, the profile can never be complete. All it can do is help us to avoid some of the erratic judgements and decisions which can result from selection based on one test or on a collection of tests which themselves may not be reliable. It cannot by itself be a framework for valid prediction about occupational selection or job placement.

General Intelligence Tests

General intelligence tests are the most widely used instruments in selection techniques. General intelligence is an essential characteristic for students who are tackling the theory associated with vocational training, and who must therefore understand the application of scientific principles to the tools, machines, equipment, materials, processes and techniques of manufacture, construction, and production. A good level of intelligence is an essential characteristic for higher-grade technicians.

However, the value of measuring general intelligence depends on having data from industry about the minimum and maximum intelligence required for success in a particular kind of employment. Such information is very difficult to obtain. As a general rule, tables have been compiled by research workers equating broad intelligence bands with broad occupational bands. In one of them the 100-115 intelligence band (average and somewhat above average) is

equated with skilled work which in modern terms probably includes most technicians. The 115-130 band (superior to very superior) is equated with technologists. Other tables differ considerably from this, and selection and placement staff should exercise caution before using what might appear to be authoritative information.

The intelligence demands of many jobs are overrated by employers. Special abilities or aptitudes are as important as general intelligence when selecting technicians, or any other category of worker. It would be a tremendous move forward if principals of technical colleges were able to provide objective information about the intelligence ranges, special abilities, interests, attitudes, personality traits, social factors, and emotional and motivational make-up likely to contribute to success in technician courses.

Aptitude Tests

Aptitudes for specific activities are difficult to identify and assess. Less is known about them than about general intelligence. They begin to be revealed at the age of thirteen or fourteen and, together with vocational interests, to become stabilized at about fifteen. This, therefore, is the age range when the school curriculum should have a broad vocational bias to give students opportunities to explore their occupational aptitudes and interests.

In some countries the last year of secondary education is used as an occupational diagnostic year by their teachers who build up records of their students' abilities, interests, and achievements. In some cases students are allocated to a particular school offering special pre-vocational courses (e.g. in agriculture, commercial and business subjects, engineering, construction, or applied science). The allocation is based on parents' wishes and pupils' interests, and on headmasters' reports which normally include evidence from standardized tests of general intelligence, aptitudes, subject achievements, personality traits and character qualities. An alternative is to allow students in their last year at secondary school to attend a technical college. There are several reasons for this. For one thing, teachers in technical colleges are accustomed to working with students in their middle teens taking vocational courses and with adults from different levels of many occupations. They can therefore help adolescents to make reasonable choices about the kinds of work and further education from which they are likely to get and to give satisfaction. For another, the technical colleges with their laboratories, workshops, and specialist staff can provide a wider spectrum of vocationally-based studies than all but the largest and most modern secondary schools.

Psychologists do not agree about the nature, measurement and grouping of aptitudes, but they do agree that an individual's pattern of abilities has significance in vocational guidance and selection for training and employment. A rating of general intelligence is probably the most significant component in the aptitude profile of an individual's abilities, but it is not infallible and it does not supply all the information required for vocational guidance or job selection.

As a result, other tests have been devised which seek to distinguish and evaluate an individual's special abilities or aptitudes. The Minnesota Occupational Scale covers 400 occupations in terms of six abilities: academic, artistic, clerical, mechanical, musical, and social. The U.S. Employment Service General Aptitude Test Battery comprises 22 occupational ability patterns for over 500 jobs, and tests general intelligence, verbal ability, numerical ability, spatial ability, form perception, clerical perception, motor co-ordination, finger dexterity and manual dexterity. It takes some two and a half hours to administer. Test batteries usually include individual tests for general intelligence (G), verbal ability (V), and motor ability (K). They are supplemented as necessary for form perception (P), manual dexterity (M), and spatial ability (S). Depending on the purposes for which the scores are to be used, they can be supplemented by evidence from standardized tests of language, science, mathematics, mechanical drawing and other subjects considered to have predictive value in a particular situation as well as by data from tests of personality traits and character qualities.

There are paper and pencil tests and manipulatory tests constructed to measure many capabilities. These include aptitude for mechanical comprehension, mechanical reasoning, the abstract reasoning required to isolate underlying principles in a complicated situation, mechanical judgement, mechanical assembly, manual dexterity, precision of movement, finger dexterity, motor co-ordination, methodical ability, attention to detail, clerical ability, dealing with spatial relationships in two or three dimensions, and speed of co-ordinating reactions. There are also tests for particular occupations, such as specialist engineering or construction craftsmen. Whilst it may be true that low scores in a particular section of an aptitude test do not necessarily mean unsuitability for an occupation, it is seldom wise to ignore them when selecting a student for vocational training. Thus, to take an example, there are many highly intelligent, professionally well qualified and capable people who are unsuited to administrative, management, supervisory, personnel, or teaching jobs because they lack the personal qualities required for effective human relations. They may be able to enunciate the principles of good administration and management, to give lectures on group and inter-personal relationships, to write authoritatively and informatively about management skills, attitudes and techniques, but they lack the aptitude to apply the theories in real situations. As in most walks of life it is easier to 'tell people what to do and to talk about how to do it than to show them how to do it, or in fact to do it.'

Selectors have to decide what are the best tests to use to find out what they need to know about each candidate. Some aptitude tests have such a large intellectual content that people of high general intelligence can score well on them without having much ability in the special test area. This applies, for example, to some tests in mechanical reasoning which are supposed to predict ability to analyse technical data. On the other hand, even with training some people of high intelligence are incapable of using the simplest tools for oper-

ations requiring the most elementary skills. To some extent, also, past experience can influence an aptitude test score. Thus a person's score on a manual dexterity test or on an assembly test such as fitting together the parts of an electric bell, a clothes peg, or an electric switch, may reflect the extent of his experience in using simple tools. In many countries and in many social groups there are still few children who are accustomed to using tools or playing with construction kits or who go to a school that has a well developed technical subjects department staffed by capable teachers of practical craft subjects. For these reasons it is unwise to draw hasty conclusions or make final judgements about an individual as the result of a 'once for all' aptitude testing programme. In any case, no selection testing programme in education or industry should be allowed to be mounted without a clear, convincing statement of its purposes, objectives, techniques and intended consequences. It should have precisely defined limits of content and time requirement. It should not be perpetuated unless there is valid evidence that it correlates with success on the training course and on the job.

Achievement Tests

Educational achievement tests are an important feature of the selection process for technician training. They are often the basis for allocating new students to particular kinds of course in technical colleges and for assigning trainees to courses in works training schools. Some national examination programmes provide the required achievement information. For example, passes in mathematics and science at the ordinary level of the General Certificate of Education after four years' secondary schooling in Britain is a nationally-recognized measure of scholastic achievement. It is also an indication of probable success in most technician courses. Four passes – mathematics, science, English and one other subject (or the equivalent) – are required for admission to courses for the Ordinary National Certificate, a middle-level technician qualification which in turn admits to courses for the Higher National Certificate, a higher technician qualification.

Achievement tests are also used to assess the proficiency of individuals before being granted the status, employment conditions, and pay of a technician. These tests are often under the control of a joint panel of the relevant trade union and employers' association which is responsible for admission qualifications, for the training curriculum, and for ensuring the standards of the vocational education associated with the training.

Though achievement tests are a reasonable measure of *past* performance in other educational or occupational spheres, the evidence regarding their *predictive* value is scanty and not convincing. Success in an occupation cannot be predicted with assurance from achievement tests at the selection stage. One reason for this is that although there appears to be a framework of abilities and traits relevant to a particular occupational group, circumstances can change the nature of the work and the levels of responsibility in the years after initial selection.

Thus some graduates and higher technicians who are reasonably successful for the first few years when they are learning the job and working under direct supervision may later become a liability when transferred to work requiring foresight and creative imagination in perceiving a problem and mounting a sensible plan to solve it. Other aspects of personality, and other factors – such as the nature and quality of teaching, supervision and guidance – influence the way in which a person faces challenges, uses initiative, and learns from mistakes.

Assessing Personality

The techniques available for assessing personality are based on the assumption that each individual has his own pattern of characteristics which can be assessed as separate traits. These traits are the qualities that give a person individuality: for example, creativity, responsibility, integrity, honesty, leadership, co-operativeness, initiative, and drive. Although it is possible to produce standardized tests for some traits such as general intelligence, it is harder to measure those just mentioned or others, such as determination, vitality, independence, consistency, and sensitivity. As a result, personality tests are not highly reliable, and their value in predicting success or failure in any kind of training or employment is limited. However, they can contribute to the production of a personality profile provided their results are combined with the information obtained from other tests, questionnaires, inventories and interviews, and the teachers' records of the student's behaviour in group activities, role-playing situations, discussions, etc. The social aspects of personality are probably the most important in making selections for technician training. Good general intelligence and vocational aptitude can be nullified by inability to adjust to other people, to training, or to the work situation.

It is an individual's attitudes that give meaning and motive to his life and indicate how he will react to an occupation and to the problems that arise in it. They play a large part in determining whether or not a youth completes a full secondary course, goes on to university, or seeks a technician occupation. Professional-class parents understand this and deliberately set out to influence their children's attitudes in favour of university education and white-collar professional jobs which have high social status. Such attitudes may permeate society as a whole, and adolescents beginning work in industry may feel themselves disadvantaged. Attitudes, however, are not permanently fixed. They can change considerably after a youth has begun a technician job which can provide him with status, security, pay and prospects of promotion. Once he perceives a target as being worth-while he will usually modify his attitudes to achieve it.

An individual's occupational interests are of importance in selection and guidance, and opportunities to help him to discover and develop them should be provided in school. Teachers should have as complete a record as possible of their students' interests. However they may need facilities to broaden their own practical and technical interests and widen their own educational horizons if they are to be able to offer the specialist help that students need. Another

requirement, which applies in all countries, is to develop operational research programmes to discover which factors, in school and at home, are concerned in arousing, developing, and sustaining vocational interest among adolescents. However, it should be remembered that success is less dependent on interest than on the possession of the right profile of abilities and temperament. To have great interest in a job is not the same as having adequate ability to do it.

Various techniques can be used to obtain a profile of an individual's pattern of interests. The student can be invited to talk about his interests, and estimates can be made of the extent of them, ranging from total rejection at one extreme to complete involvement at the other. Interests can be listed, classified and appraised by trained observation of the things a student chooses and does, the way in which he works, the time he devotes to different kinds of activity, the way he uses his spare time, the optional curriculum subjects he chooses, and the persistence he displays in different subjects and activities. A person's hobbies are a poor predictor. Though they may indicate a leaning towards some careers, they are not good indicators of the success he is likely to achieve in them.

Interviews

An interview provides an opportunity to explore the nature, content and quality of a candidate's previous education and training, his level of personal development, his maturity and adjustment, and the degree to which he possesses the special qualities he needs to undertake a particular kind of training or enter a particular occupation. It can also be used to elicit information not provided on application forms, and to inform candidates about working conditions, education and training programmes, wages and payment systems, career prospects and other matters. The people on the interviewing panel should be skilled interviewers with up-to-date and reliable knowledge of the present and future employment market, and with clear ideas about what needs to be learned from and communicated to each candidate. They should study copies of relevant documents – such as application forms, confidential references, specimens of work, and observations by teachers and instructors – in advance of the interview, and be given precise instructions, a schedule of questions, and the rating scales and check lists to be used in making their assessment. Each interviewer must conduct his part of the interview according to his brief.

Interviewers for technician training courses should have reliable knowledge of the existing technician job situation and the technician employment changes likely to take place over the next five to ten years. They must have access to detailed job descriptions and to specifications of the kinds of person most likely to match various occupations. They should have first-hand experience of the occupations and industries for which they are selecting technicians for training.

Many selection interviews are conducted within the framework of *The Seven Point Plan* designed by Professor Alec Rodger of Birkbeck College and the National Institute of Industrial Psychology, London. The seven points are structured to explore and report on a person's physical characteristics, attainments,

general intelligence, special aptitudes, interests, temperament, and personal circumstances. The plan allows for flexibility, development and interpretation according to the skill and experience of the interviewers and the precise purpose of the interview. It also ensures that no aspect of the individual is neglected and prevents irrelevancies from being introduced.

The Seven Point Plan

1. PHYSICAL MAKE-UP
Has he any defects of health or physique that may be of occupational importance? How agreeable are his appearance, his bearing and his speech?

2. ATTAINMENTS
What type of education has he had? How well has he done educationally? What occupational training and experience has he had already? How well has he done occupationally?

3. GENERAL INTELLIGENCE
How much general intelligence can he display? How much general intelligence does he ordinarily display?

4. SPECIAL APTITUDES
Has he any marked mechanical aptitude? Manual dexterity? Facility in the use of words? Or figures? Talent for drawing? Or music?

5. INTERESTS
To what extent are his interests intellectual? Practical-constructional? Physically-active? Social? Artistic?

6. DISPOSITION
How acceptable does he make himself to other people? Does he influence others? Is he steady and dependable? Is he self-reliant?

7. CIRCUMSTANCES
What are his domestic circumstances? What do the other members of the family do for a living? Are there any special openings available for him?*

Professor Rodger required that the matters covered by his *Seven Point Plan* should conform to four criteria:

'They should be relevant, in that they should pin-point influences that are commonly and demonstrably connected with occupational success and failure.

'They should be independent in that they should be sufficiently separable from one another to enable us to avoid overlapping assessments that would be wasteful.

'They should be assessable in the circumstances in which the assessments have usually to be made.

'They should be few enough to keep the risk of hasty, superficial judgement to a minimum, but numerous enough to cover the ground adequately. There can be no objection to the addition of items to the standard list where this seems desirable for a special purpose. . . What should be avoided is the changing or omission of existing items, and provided this need is observed others can be put

*Alec Rodger, *The Seven Point Plan,* NIIP Paper No 2, National Institute of Industrial Psychology. 1952. (Third edition 1970.).

in. Even if the new ones make an attempt to break an existing item into component parts, they can reasonably be added, provided that the parent item remains'.

The Plan includes three cautions. The first is that '. . . the order in which the headings appear is not meant to carry any implications whatever about the order of their importance. The weight to be attached to a particular heading. . . will depend. . . on the nature of the employment or training for which an applicant is being considered'. The second is that '. . . it is not intended that any attempt should be made to deal with the seven sections of the plan in the order in which they appear on the paper'. And the third is that '. . . the questions under the seven headings are not meant to be put directly to the applicant by his assessor. They are questions for the assessor to ask himself about the applicant'.

Student Records and Reports

If properly maintained an individual's cumulative school record is of much more value in selection and guidance than the subjective judgements, general impressions and guesses of individual teachers. Teachers should therefore work together as a team to provide a useful, scientifically structured, and well-organized record through which each student can have access to further education and train for a career offering worth-while life opportunities.

The framework of an institution's cumulative record system should be based on a clear statement of the aims of the institution. The plan should require the minimum of paper-work by teachers commensurate with building up an adequate annual profile of the characteristics and achievement of each individual student. Agreed decisions about what has to be written in the record by each teacher should result in a streamlined, uniform, simple method of recording which can easily be kept up to date. Wherever possible, record forms should be tabulated so that they can be completed by clerks.

School or college report material should not include subjective information likely to reflect adversely on the student making a new start in technician education and training. The need is for objective information which will help to guide and advance the student in his technician studies, in his vocation and as a person. The report should evaluate academic achievements, and give assistance with regard to the kind of training course for which the student is best suited.

The cumulative record is the basis of the report prepared by the head of a student's secondary school for use by a selection board, a technical college, a training institution or a potential employer. Woolly thinking about educational measurement and the content of the cumulative record can produce a half-baked report that can be a handicap rather than a help to the student seeking selection for admission to a technical course.

To be effective the record should be started as early as possible in school and be continued through technical college and technician training. The information it provides should be presented in a form in which it can readily be interpreted by other educational institutions and industrial organizations and used as a basis for producing reports, leaving certificates, references, and testimonials for

employers. It should be based on tests and inventories, check lists, sociograms, case studies, vocational interest blanks, and interviews, and enable the individual's personal needs, abilities, behavioural patterns, traits, character qualities, occupational interests and ambitions to be assessed.

It should contain:

1. An account of the individual's progress through school, technical college, and vocational training.
2. A case history of his personality development including information about social factors which could influence his educational and vocational choice, opportunity, and progress.
3. Relevant, usable, meaningful information whether it is complimentary or uncomplimentary to the individual, his teachers, or his school.
4. Relevant documentary evidence to support the validity of judgements.
5. Information on a five-point scale. (See pages 93–94.)

The circumstances in which ratings are made must be stated. A student record containing only a statement of terminal and sessional examination marks is practically useless as a selection tool. The problem is to decide what to include without making the individual's folder unwieldy and without rejecting anything which could be useful. In addition to educational information, the list can include such items as the capacity to make effective use of assigned and unassigned study time; orderliness in work habits; conforming to task plans and directions; neatness, speed, and accuracy of performance; attitudes to the care of buildings, tools, material, equipment, library books, etc; self-reliance and initiative; keeness and interest to learn; willingness to accept advice; industriousness and dependability; energy and persistence in completing a task; attitudes to work regulations and authority; ability to get on with others; readiness to assume responsibility; adaptability; self control; tolerance; flexibility; companionability; general interests and leisure activities; interest in other peoples and community activities; likes and dislikes.

Information about health is necessary to inform selection and guidance staff about the existence, nature, and extent of any known disabilities that are likely to limit an individual's educational progress, personal development, vocational choice, and career opportunities. Standardized check lists are available for recording this information. It is important to know if a candidate for employment suffers from health problems such as headache, allergies, a vision or hearing deficiency, or inability to stand for long periods or to work for long periods in particular conditions.

There is much published information available on the many ways of arranging the items in a record folder, and various views about the design of printed record cards and the main categories of information required to produce an individual student's longitudinal record. General information is best contained in a specially-designed record cover with a contents index refering to specific numbered items arranged in sequence in catalogued sections.

There should be no possibility of matters of personal privacy being at risk. Confidential records, if and where they exist, should be kept under lock and key. Only records which are not confidential should be readily available to teachers. A student should have access through a member of the teaching staff to his own record but not to anyone else's record.

All senior members of staff who are concerned with the progressive guidance, work efficiency, selection and career development of other persons need training in the fundamental principles and practices of using record building and assessment devices.

Examinations and Technician Course Evaluation

External examinations serve a number of purposes in technician education. They test the quality, standard and level of work in the technical college or training institution. They provide an independent check on the validity of teachers' assessments and an objective measure of a person's educational attainment or his proficiency in a job before being granted the qualification, status, employment conditions and pay of a technician. They act as a convenient, accepted, and relatively economical way of testing knowledge and skills and, thereby, of grading and classifying people completing a technician course. They allow technical colleges to compare their results on technician courses with those of other colleges. They can be a selector or predictor of suitability to proceed to further courses. They provide a goal for the student and thereby an important motive for learning. They provide the student with a measure of his performance. They help to ensure that the technician diploma has a wider recognition and status outside the college.

Control of the vocational curriculum by technical colleges may be traditional and appropriate but this does not mean that technical teachers should claim to know everything about the vocational needs of the technician on the job or to have exclusive control of the national examinations taken by technical students. Employers have a direct concern with the content of the technician syllabus, with planning the technician teaching curriculum, with technical examinations, with the evaluation of technician courses, and with the maintenance of technician standards of training, qualifications and performance. Without the involvement of employers, standards can become academic, occupationally remote, and even irrelevant as far as the needs of industry are concerned.

For this reason the final qualifying examination in some countries is under the control of a joint panel of trade union and employers' organizations. The same panel is responsible for the content of the training curriculum and for ensuring the standard of the vocational education course associated with the practical training. It is an arrangement which promotes a close collaboration between employers and technical colleges. It creates opportunities for appraising the knowledge, skills and personal qualities relevant to technician task performance in on-the-job situations. It motivates technical teachers to be less academic in their teaching and attitudes, to be more conscious of production and pro-

ductivity in industry, more technician job-oriented, and more aware of the technician's role. It encourages teachers to develop a closer collaboration with industry to ensure that their technician students are acquiring the appropriate knowledge of subjects relevant to their future job needs, and are gaining sufficient knowledge of processes in workshops and laboratories to operate, supervise and control the situations prevailing in industry.

External examinations may have bad as well as good effects on the work of a college. They tend to confine teaching to the strict content of the syllabus. They may enable questions of a particular type to be spotted so that standard, essay-type answers can be prepared in advance, with the result that the student's intelligence is not given full play. They may lend support to teaching methods in which students regurgitate dictated notes. They may go on too long: in some cases examinations of one sort or another consume more than a third of each term! They may test a poor sample of the total course content. These drawbacks can be reduced if examinations are regarded as the servant rather than the master of the curriculum. To accomplish this it is essential to establish at the outset the critical objectives of each significant item of the training course, to determine the depth to which it is to be taught, and only then to decide how the achievement of the relevant objectives should be measured. This means there must be close and continuous collaboration between those building the technician curriculum, those who test the results and those who employ the graduates – that is between the educationists, the examining bodies and the employers. At the end of his course a technician should be able to tackle any reasonable job put in front of him. The examination should therefore seek to test that ability, and not reflect some abstract concept of the occupational needs of a technician or notion of all-round excellence.

The task of examining in the technician field grows increasingly difficult for many reasons. These include the breaking down of traditional subject boundaries, the need for frequent revision of syllabuses, the widening range of subject matter in specialist areas, improved educational measurement techniques, rising numbers of entries, the greater involvement of teachers in the assessment and examination process, and a growing tendency to replace the completely external examination by college-based examinations or by combinations of both. Among the alternatives are: a written paper externally set and marked; a written paper internally set and marked; a written paper internally set and marked with external assessment; an objective test externally set and marked; a practical or oral internal or external examination or combination of both; course work assessment by the student's teacher; and project work, internally or externally assessed.

Continuous Assessment

The purpose of continuous assessment of the performance of technician students is to encourage them to work steadily and continuously throughout the course. Personal responsibility and enthusiasm for learning are fostered when students are informed of their progress. Students want to know if they are doing better or

worse than last week – if they are achieving appropriate targets, if they are likely to obtain a good pass in the end of course examination, and if they need to take action to prevent a possible failure.

Continuous assessment allows the teachers to have feed-back on individual student performance so that remedial training can have maximum effect. With an end-of-course test there is no such opportunity. Nor can instruction be tailored to cater for individual student differences as they become apparent during the course. Continuous assessment is also more reliable and more valid than a once-for-all end of course examination.

One useful form of assessment is to set students a continuous series of laboratory exercises or a project involving exercises from the design to the production stage. Another is a series of short tests set at appropriate stages to appraise the student's understanding of the principles, processes, systems and techniques covered up to that point. Cumulative records based on progressive tests and giving a systematic assessment of performance must be kept to ensure that adequate control of assessments and standards is maintained. Students need to maintain logbooks, work diaries and notebooks that can give an external assessor a reasonable account of the level and standard of the activities completed during the course. The external assessor or moderator must have access to all the information in the students' folios and record files.

The scope and maintenance of national standards become more important to students and employers as more people seek vocational qualifications. Although the techniques for the validation of standards is a retrospective process, it is important that standards match the immediate needs of industry. The needs should be checked as frequently as possible. The data and information made available by the employer to the institution regarding the performance and changing duties of technicians is important. Equally important is the employers' methods of evaluating the technician for the purposes of job evaluation, promotion and additional responsibilities.

Technician Qualifications

Full technician certification and status should imply satisfactory performance in a technical college technician training course and in approved (on- or off-the-job) industrial conditions. A full technician qualification involves a number of stages. An intermediate examination may assess scientific and technical knowledge, a final examination can give a technical qualification of some merit, and a further examination can add a specialist qualification in a subject as applied to particular industries or processes. The currency of the qualifications must be readily understood by employers and students. The usual practice in industrialized countries is for the college to assess the academic parts of the course, for industry to test ability to apply knowledge and skills effectively on the job, and for a national body to manage final examinations and award certificates and diplomas. It implies close collaboration between government, industry, education, and examining and awarding bodies.

Historically, technician qualifications have not been regarded as important in their own right, but as evidence of failure to proceed to professional engineer or technologist status. This is an ill-considered attitude. The work of the technician is of national economic and industrial importance and his qualification should reflect his worth and his claims to employment and status.

Technician Education Council (TEC)

The Technician Education Council for England, Wales and Northern Ireland, established as an independent organization in 1973, provides one kind of national model for technician education. The Council has published a Preliminary Statement (October 1973), a Consultative Document (November 1973), and a Policy Statement (June 1974). These are obtainable from the Chief Officer, TEC, 76 Portland Place, London W1N 4AA; and the following information is derived from them.

The Council's terms of reference are summarized as follows:

> The Council will be concerned in the development of policies for schemes of technical education for persons at all levels of technician occupations in industry and elsewhere. To this end it will, as proposed in the Haslegrave Report*, plan, administer and keep under review the development of a unified national system of courses for such people and will devise or approve suitable courses, establish and assess standards of performance, and award certificates and diplomas as appropriate.

In addition to rationalizing the existing provision, thereby saving valuable resources, the Council will keep the system it introduces under review. It will innovate, and it will also make use of the innovations it hopes will come from colleges and other establishments. Its aim is to provide a system of technician education responsive both to industrial requirements and to students' needs, while remaining economical and efficient in operation.

The Council will be concerned with promoting advances in technician education, thus enhancing the status of technicians. It intends that the qualifications it awards should be well understood and recognized by professional bodies and the community at large and gain a truly national and international currency. Schemes of study will be built on units, defined as 'self contained and significant components of a programme which may be separately assessed and, if successfully completed, count for a credit towards a student's award'.

The Council's committee structure enables it to perform the functions of validating schemes, designing programmes and acting as an examining body. There are three sector committees, A, B and C, associated with Engineering, Construction, and Science-based subjects respectively. Numerous programme committees function within each sector.

The Council will award Certificates, Higher Certificates, Diplomas, and Higher Diplomas. This range of awards will recognize different levels of performance and different experiences but will not be associated with particular modes of attendance, which may include full-time, sandwich, block release, day release

**Technician Courses and Examinations*, HMSO, 1964.

and evening study or combinations of these. Students who cannot study regularly in a college will also have opportunities to obtain awards.

The Certificate will be the Council's basic award. It will be broadly comparable with the Ordinary National Certificate and approximately half way between Parts I and II of the City and Guilds of London Institute Technicians Certificate (T3). The standard of the TEC Higher Certificate will be broadly comparable with that of the Higher National Certificate and of the CGLI Technicians Certificate Parts II and III combined. Diploma programmes will often have no less depth of technical content but will be broader than those leading to Certificates.

In seeking to establish acceptable standards the Council will take many factors into account, including the following:

(a) The objectives of TEC programmes, which include transmitting a body of knowledge and a command of certain skills and techniques, and increasing the student's capacity to learn, to adapt, to communicate, and to take responsibility.

(b) Acceptability to the student in terms of his personal and vocational needs; to employers of technicians; to professional and other qualifying bodies and industrial training boards; to validating bodies for purposes of admission to courses of higher education; and to authorities within the EEC for purposes of mutual recognition.

(c) Value for purposes of establishing technician education in its own right and improving the status of technicians.

(d) Comparability with existing technician awards in the U.K. and with technician awards overseas.

The Council attaches importance to the achievement of high and generally acceptable standards, and includes among the factors related to this the teaching and supporting staff available and the teaching and learning situation. It does not wish the requirements for obtaining an award to be unnecessarily demanding, believing that a student who meets admission requirements and studies conscientiously should be entitled to a reasonable expectation of success. The Council will be concerned if this does not happen in practice.

The Council expects colleges to be flexible about admitting students to TEC programmes at different ages and different levels of attainment, and to give appropriate credit for previous relevant study.

The Council has also, in its publications, set out guide-lines showing, for each kind of award, the minimum number of units the programme should comprise, approximately how many hours' study in college this involves for the average student, and how many years it will take for students having the minimum entry qualifications.

Programme	*Units*	*Hours*	*Years*
Certificate	12	900	3 (day release)
Higher Certificate	8	600	2 (day release)
Diploma	25	1800–2200	2 (full-time)
Higher Diploma	16	1200–1500	2 (full-time)

Students following sandwich programmes may also be able to gain Diplomas in two years and Higher Diplomas in two years provided they obtain adequate experience in industry. A Certificate holder may qualify for a Diploma by completing the required additional units. Conversely, a Diploma student who fails to qualify for his Diploma may be awarded a Certificate if he has successfully completed the units required for it.

The Council has approved principles for assessment. The main principles are that assessment should be related both to the aims of the programme as a whole and to the learning objectives of the individual unit; that the students' work during the programme should be adequately recognized and there should be no undue emphasis on formal examinations; and that units in the early stages of a programme should normally be internally assessed, with external moderators being concerned with the assessment only of those units that contribute significantly to the award.

4

The Supply and Preparation of Teachers

Technical education is an integral part of a country's general education system and it is therefore right that in most circumstances the initial training of technical teachers should not be isolated from that of other teachers. Segregation can reinforce belief in lines of division whereas, in fact, the training of specialist technician teachers has much in common with the training for teachers of the 15 to 19 age-group in secondary schools, particularly with those who will teach mathematics, science, technology and practical subjects. Some of the instruction in the basic initial training course could be shared. Examples are: aids to study; the philosophy, history, structure, and administration of the national system of education; fundamental ideas in educational psychology and sociology; curriculum studies and syllabus construction; educational technology; finding and presenting information; communication skills; techniques of writing educational objectives; basic principles and techniques of educational measurement and evaluation; the purposes, content, structure, maintenance and use of the individual student record; and the administrative management and organization procedures within which teachers work.

Most of the instruction common to senior secondary and technical college teachers can be organized in learning units, and much of it can be undertaken by junior training staff who are not necessarily or exclusively technical or science specialists. The full-time subject-oriented specialist in a training establishment can be prone to giving academic, theoretical, bookish, tutor-centred instruction not directly applied to the day-to-day tasks of the teacher. What the technical teacher most needs – and most seeks – during his training are the essential fundamental ideas, principles, methods and skills that he can use in his job. He does not want to be baffled with abstract pedagogical theory. Rather he wants to be equipped with the practical knowledge which will enable him to carry out his tasks, to solve his on-the-job problems, and to ensure that the students he teaches achieve occupationally-useful learning objectives.

The training of individual specialist technician teachers cannot, however, be limited to an understanding of the general needs of all teachers of adolescent and younger adult students. The relationship which technician education and training bears to a country's industrial growth, economic and social development, standards of living, and quality of life also needs to be studied. The ideas, principles, methods and resources peculiar to the teaching of the technician teacher's own specialism must be understood and practised. Specialist trainers must therefore be well qualified in their specialist technical knowledge and skills. They must have a range of good, relevant, recent industrial experience at technician level, and, if possible, have been members of industrial project teams working with specialists in management, action research, operational development, planning, organization, and training. They must understand and be in intellectual harmony with national economic and social development objectives, with the purposes and objectives of industrial development, and with the aims and objectives of technician education and training. Length of teaching experience is probably of less importance than the ability to understand and accept change, and the willingness to adapt to innovation.

It is often difficult to convince the technician teacher of the specifically vocational industrial orientation of his teaching functions. For this reason much of the specialist teacher trainer's work with in-service technician teachers may have to be concerned with subject and job attitude re-orientation, stressing the need to change antiquated attitudes to teaching methods, to being subject kings, to operating strictly within traditional departmental boundaries, and to legendary ways of planning special vocational syllabuses and schemes of work. These must be replaced by a broader professional approach, and emphasis should be laid on the need to modernize the ways in which technician teachers function so that the total resources of technical colleges are directed to the preparation of students for immediate technician employment, social responsibility and effective citizenship in their community. The principle should also be established that technician teachers will require in-service professional development so as to up-date and extend their knowledge of specialist subject matter and their first-hand experience of modern processes, techniques, equipment, work organization, management and supervision in industry. They will also need to learn new ways of planning and organizing the teaching of specialist technician material through formal and informal methods including individual and group industry-based asignments and projects, team teaching, learning packages, case studies, role playing, programmed learning, and the techniques of educational technology that individualize learning and take account of differences which influence the rate, rhythm, level, extent and quality of learning between students. This is not always easy. The belief and attitude that attendance at an in-service course *must* lead to a promotion-earning paper qualification dies hard. A teacher trainer is often faced with the difficult job of modifying the attitudes of people who have a great capacity for looking backwards and who, despite exhortations to change, continue teaching what they want to teach, and what they can most easily teach.

The kinds of person required as technical teacher trainers are expensive to hire and difficult to retain. They are sought not only by training colleges but by the civil, social and armed services, by industry, and by international agencies for their technical, industrial, and training qualifications, and their proven on-the-job abilities. Their time and effort should not be dissipated on routine administrative or clerical tasks that seal them off in offices and isolate them from full-time commitment to teaching, tutoring and counselling technical teachers. Their contribution is needed to instruct teachers on the most productive methods of teaching the specialist subjects in technician courses. They should also help to organize special method teaching packages, including correspondence courses, for in-service technician teachers who are unable to attend a full-time training course and who need help to do their jobs more effectively. In addition, they should be actively encouraged to attend courses designed specifically to train the technician teacher trainers.

The most suitable programme for technical teacher training courses is still under discussion. This discussion pivots on how best to prevent technical teachers from being isolated on the one hand from other teachers in training, and, on the other, from the vocational, educational and training institutions in which they will be employed. There is general consensus that the initial basic training course common to all teachers could be provided in general colleges of education for senior secondary teachers, in university departments of education or in senior technical colleges that offer behavioural science for other purposes. Much of the special method training could be undertaken by teachers in technical colleges who could be given special training for the technical teacher training job. A recent and widely accepted view is that all teacher education and training courses, general and specialist, from nursery to postgraduate level, are likely to be less educationally divisive and to be more socially relevant and more educationally effective if located in tertiary vocational education and training establishments. These are becoming more comprehensive in their range of work; they are providing inter-disciplinary technical, vocational and non-vocational courses which cross subject barriers; and they are bridging departmental fences and breaking down faculty barriers. In addition, they are building up considerable resources of specialist tutorial and supporting manpower in a wide range of technologies at technologist and technician level, in the behavioural sciences, and in organization, planning and management; and they possess a full range of laboratories, practical rooms, workshops, and large well-equipped libraries.

Technician Teacher Training Course Planning

No matter how well conceived are the plans for the development of a country's natural and financial resources, their implementation depends on skilled manpower, that is on the quality and quantity of technicians in the country. This in turn depends on the supply of technician teachers, particularly those with good practical experience. Unfortunately, trained technician teachers are not easy to obtain. Too often their salaries are more closely related to the lower levels of

school teaching than to posts in universities, higher technological institutions or in industry where they can obtain good career prospects, more attractive working conditions, better standards of living, and higher social status than they can in teaching. In their place graduate professional engineers or technologists may be employed who lack the industrial training and the practical, shop-floor experience required to train technicians properly. These people are often academic, theoretical, and bookish, and have little concept of what technicians need to know. As a result, their students are not industrially orientated and may not always be willing to train for production-line jobs.

Industry, having identified the tasks to be undertaken by specialist technicians, defines the knowledge, skills and attitudes they need to do their jobs. The objectives and content of technician courses decide the kind of teachers required, and the qualifications and industrial experience they must have. Existing teachers may have to take subject courses and undergo further industrial training to familiarize themselves with modern equipment, processes, techniques and systems of work organization, and newly recruited teachers may need to attend a technician teacher training course. All training courses should be kept under systematic review by training institutions, whose reviews should also involve representatives of industry, technical colleges, and examining and qualifying bodies, so as to meet the changing needs of technicians, teachers and industry.

The staffs of training institutions should be in regular contact with the staffs in the technical colleges for which they train the teachers. Otherwise they can become intellectually isolated and professionally remote from the objectives and tasks of a specialist technician teacher.

In industralized countries it is possible to require a person to have technician qualifications, industrial training and industrial experience before he is employed as a technician teacher or admitted to a teacher training course. In industrializing countries, however, this is not always feasible. His technical education rarely begins before he leaves secondary school, and it normally takes the form of full-time study in a technical college which has workshop facilities for off-the-job practical training. His professional training may follow immediately or after some years of teaching. Less commonly teachers' colleges provide technician education, practical training and professional training in one synthesized course, in which case the final qualification may be a degree in technician education which equates the technician teacher's status with that of colleagues in academic sectors of education. There may be access to courses for higher degrees in technician education.

In some countries there are full-time one-year pre-service courses for people wishing to become technician teachers straight from industry. These may be extended by one term to revise and extend knowledge of basic subject matter and ensure familiarity with modern industrial practices. There are four-term sandwich courses for in-service teachers with two or more years' experience, the first and fourth terms being spent in the teacher training establishment and the middle two terms in the parent technical college. There are also day and block

release courses at easily accessible centres. Teachers attend a centre for one day a week for two years, and a teacher training institution for one month in each year. The aim is to make technical teacher training courses available to the maximum number of in-service teachers without requiring the individual teacher to leave his home and his job in a technical college for weeks at a time. The advantages are that the staffing problem of the parent college can be reduced, a greater number of teachers can have the opportunity to train, and the specialist staff of the training institution can be better utilized.

Such programmes are expanding in several countries, particularly where teacher training institutions are closely associated with senior technical colleges so that all stages and aspects of in-service technical teacher development can be planned, co-ordinated, conducted, monitored, assessed and evaluated from within one fully-resourced, comprehensive organization.

Experience has shown that course planning is best undertaken by a small group of senior staff in consultation with colleagues who are responsible for activating and supervising the course programmes. Training staff and in-service teacher study groups are a necessary forum for ideas, opinions, and suggestions about the organization of a programme and the day-to-day work of tutors, particularly those with the main face-to-face training commitment. In-service teacher involvement in their own programme planning is essential, as is the involvement of technical college principals, heads of department, government administrators and technical education advisers at the policy-making stages.

Course planning must take account of what tasks are performed by newly appointed and in-service teachers at different grades, how much time and what proportion of it they spend on each task, and what significance the tasks have in relation to the allocation of hours. The clusters of knowledge and skill required to do the tasks become the basis of training programmes.

It is in the allocation of tutorial manpower – which tutor does what with whom, where, when and how – that programme planning requires the most detailed appraisal and objective statement. Maximizing the effective, economic use of all the training resources and supporting manpower to meet the requirements of the course is the most important task. Not much less important is the full economic and productive use of the training accommodation – hall, lecture theatres, classrooms, tutorial rooms, laboratories, workshops, library. The co-ordinated utilization of laboratory and workshop technicians is fundamental. Senior tutorial training staff should be engaged on the more formal, more high-level specialist lectures and tutorials for about two-thirds of their teaching time; on more general-level group work for the remaining third. Their trainee contact hours should normally be not less than ten or more than 15 hours a week. Contact commitment for middle-level and junior tutors could be of the order of 15 to 20 hours a week, mainly with groups and individuals following up the work initiated, planned, and co-ordinated by senior tutorial staff.

Four broad areas of work need careful planning in technical teacher training courses. These are, first, education studies including general principles and

methods of teaching; second, special methods of teaching particular subjects or co-ordinated integrated groups of subjects; third, communication subjects; and fourth, guidance of practical teaching experiences.

Within this broad pattern, decisions have to be made about the content of courses for different categories of technician teacher; about schemes of work for the tutorial staff and for the teachers on the training courses; about the allocation of hours to each subject area and topic within it; about the sequence and co-ordination of topics; and about the time to be allocated to formal lectures, syndicates, individual studies, and tutorial guidance. Programme flexibility should allow for professionally-acceptable choices by students. Compulsory topics should be repeated throughout the session to allow tutors and students a choice of time and topic sequence. There should also be flexibility in tutorial counselling and guidance. The student groupings can be of two kinds – specialist, for the special method activities, and inter-disciplinary for the non-special method elements (e.g. general principles, general methods, teaching aids, and communication).

Practical teaching helps student teachers to assess, diagnose and improve their work while they are still in a training institution. There is therefore good reason for beginning practical teaching as early in the course as possible. This can be done if the teachers are sent out in groups to technical colleges on practice-teaching sessions, which seem to be successful in units of three or six weeks. Having mixed groups of teachers on practical teaching at the same time enables the best use to be made of training accommodation, tutors, and supporting staff. In addition, carrying out the training in colleges close to the training institution allows tutors to pay more frequent visits.

It is frequently asserted that teachers need to carry out some lesson planning and preparation *before* sampling practical teaching. This, however, often gives rise to nothing more than narrow skill training and conditioning to the tricks of the teacher's trade. What is more essential is that teachers should know how adolescents learn technical subjects and appreciate liberal subjects, what factors aid or hinder vocational learning, how to make use of diagrams and charts, how to use audio-visual aids, case studies and other techniques in presenting technical material, and how sociological, psychological and interpersonal factors come into play in the teacher-class situation. Much can be learnt about these things during practical teaching, where guidance is provided by a specialist tutor from the training institution or by a nominated member of the parent college staff. Now that technical colleges are being given increasing responsibility for guidance and assessing pre-service and in-service practical teaching, they are appointing professional tutors to advise teachers about general and special teaching methods. Each methods tutor in a training institution should have responsibility for a specific area of work. For example, a building subjects tutor should be concerned mainly, if not entirely, with relating general teaching principles and methods to those groups of subjects which are identified as being building technician subjects in syllabuses, time-tables and work diaries. The specialist tutor needs con-

siderable time to develop projects and assignments and to tailor individual studies to suit the needs of particular groups of teachers employed to teach the vocational subjects on technician courses. His efforts should therefore be conserved for the functions in which he has specialized knowledge, not spread so thinly across the whole training curriculum that he has no scope to concentrate on the tasks that he alone can do.

The Teacher Training Staff

The training tutor needs to be well informed about the political, economic, educational and social aims, ideas and opinions which shape the pattern, structure and organization of technical education and training. In particular, he should be sensitive to changes in attitudes, values, standards, patterns of living and social behaviour resulting from scientific discovery and technological development. He needs to have up-do-date knowledge of proven principles and methods of teaching, and to be in harmony with forward-looking philosophies and practices in education. Not only must his contribution be based on reading, investigation and discussion, and on recent, successful experience in the field of technician education, but it must be directed to helping teachers to become better at their jobs. Teachers must feel that the training course is professionally worth while, and that they are thinking deeply, penetratively and productively, not that their time is being misused. They must feel convinced that the training is specific to their job needs, not out-of-date, over-generalized, or isolated from the day-to-day problems of a teacher of technician subjects. There is a tendency in teacher training institutions to treat Education, General Principles, Educational Technology, and General and Special Methods of Teaching as if they were remote from the realities of technician education and employment, and of national and personal development. Training tutors need to make maximum use of technical college-based projects, investigations and case studies which are directly relevant to the interests and job needs of technician teachers. Many opportunities arise in such fields as motivation, organizing interest, class activity, class organization and management, physical, intellectual and emotional development in adolescence, and techniques of evaluating learning achievement.

Where necessary, a technical college geographically accessible to other colleges can be used to provide modules of teacher training, and its classrooms, laboratories, workshops, practical rooms and library can become a teacher training workshop in which specially-tailored courses can be mounted during long vacations, and on afternoons, evenings, and week-ends in term time. These courses are convenient because they do little to disturb technical college organization, and relevant because they are based on the realities of the technical college environment. In addition they carry conviction because they are not abstract; neither do they use sophisticated equipment and educational gimmickry that will not be available in the colleges themselves in the foreseeable future.

The trainer's task is to help the technical teacher improve the job he is doing within the constraints of the system and the resources available to him. There is

no dividend from a training programme in which tutors talk *in vacuo* about a non-existent world where there is no need for profitable productive industry, and where there are no constraints of accommodation, administration, finance, time-tables, syllabuses, and examinations. To prevent this from happening, specialist teacher trainers must keep in close touch with industry and with the increased complexity of the products and manufacturing methods with which technicians have to be familiar.

Tutors need to understand how the present pattern and structure of technical education has developed in their country and how particular categories and gradings of technician fit into it. They should remember that important details of the pattern change when primary education for all comes nearer to realization and secondary education becomes more widely available; and where improved guidance services and an increasing vocationalization of the secondary curriculum provide a better preparation for tertiary, technical, vocational, and employment-oriented courses. Opportunities should be given to them to fill any gaps in their knowledge so that they can become more effective in their technician teacher training tasks; otherwise they can easily get their training priorities out of focus and become increasingly inward-looking.

The main aim of technician teacher training is quite clear. It is to equip the technician teacher with knowledge, skills and attitudes to help technician students to do the best work they are capable of. To achieve this aim the right teachers must be found – people with the right mix of knowledge, skills, experience, and attitudes. To attract such people, the rewards, conditions of service and career development opportunities must be comparable to those in other fields where their services are in demand. To train them, there is a need in most countries for more facilities in the form of teacher training departments and centres, which should preferably form parts of more comprehensive technical institutions. To meet the inadequacy of existing facilities the various Bursary and Fellowship schemes may be useful as an interim measure. 'Third Country' education and training schemes in particular need to be more actively encouraged and more generously financed.

Course Content

The initial training of technician teachers should concentrate on those studies which are strictly relevant to the teacher's job, leaving practical experiences to the technical college in which he is employed, or to be employed, and delaying broader studies of education to in-service courses or to higher diploma or degree work. In determining the content, structure and organization of the courses, the experience and advice of teacher trainers, advisers and administrators from other sectors of the education system should be sought. Training and staff development experts from industry can also contribute to programme planning, and can provide reliable data based on job and task analysis about the knowledge and skills which technicians use on the job. Experts from the examining and qualifying bodies can give reliable information about technician course content

and identify – from an analysis of examination scripts – which topics are well taught, badly taught or not taught at all. Principals and heads of departments are able to give advice from their day-to-day jobs of organizing and supervising the work of technician teachers and of allocating resources. Technician teachers can provide very important information about the way they plan, organize and sequence their work, the topics they find difficult to teach, their problems in the laboratory and workshop, and the learning difficulties which adversely affect the performance of their students.

Training Units

It is common practice to divide the content of training courses into units or modules. This is a particularly convenient practice when the training institution offers alternative arrangements, as for example one academic year of eight months, or the same course for an equivalent length of time in a sandwich or in a day and block release arrangement. The time allocated to each unit, and the selection and arrangement of the material, are decided by the course and curriculum planners. Combinations of units and their sequencing are kept flexible to make good use of specialist tutorial and supporting manpower, of equipment, and of teaching and residential accommodation. Carefully planned, properly managed, and closely co-ordinated tutorial team work is essential to ensure that each unit fits into an integrated course. Newly appointed teachers should be encouraged to undertake initial training units (e.g. general principles and general methods of teaching together with two additional appropriate units) before or shortly after taking up a first appointment. They could take additional units, as convenient, to build up credits towards a recognized qualification. They could also take those special units required by the nature of their jobs. The training institution should anticipate and prepare to meet needs for additional units.

On pages 77–78, course planning for technical teacher training courses was divided into four broad areas. These can be further broken down into eight units, as follows, constituting a total course of 1,000 hours:

1.	Course orientation		10 hours
2.	General principles of teaching		60 hours
3.	General methods of teaching		30 hours
4.	Development in middle and late adolescence		60 hours
5.	Education	(a) Nursery, infants, primary	30 hours
		(b) Secondary	30 hours
		(c) Technical	60 hours
6.	Special methods of teaching		210 hours
7.	Practical teaching		360 hours
8.	Additional units	(a) Language and communication	150 hours
		(b) Educational technology	
		(c) Programmed learning	
		(d) Liberal studies	
		(e) Special method tutorials.	

Orientation Unit (10 hours)

The main purpose of the orientation unit should be the development of a rapport between the individual teacher and his tutor, leading to the former's participation and involvement in his own programme planning for the full course. To make the first contacts purposeful, each teacher needs to be given a statement setting out the overall aims of the training course, the objectives in each area of study, and the subjects, options, and combinations. With this information, and the knowledge he has of his own technical qualifications and industrial experience, the teacher can begin to assess himself in relation to the kind of post he is likely to obtain or, if he is taking an in-service course, to his job. This also gives the tutor a starting point for discussing the teacher's programme and offering guidance about choosing elements in the course. Thus by the end of the first or second interview the trainee teacher ought to have arrived at a fair analysis of his abilities, qualifications, experience, interests, and potential within the course structure governing his time-table, and have an understanding of the philosophy and principles on which his particular training programme has been constructed. By the end of his orientation he should also have discussed the nature of his progressive guidance throughout the training course, the data and processes by which his progressive assessment profile will be constructed, the information he will be given about his course assessment profile, and the reasons lying behind each activity he will undertake throughout his training.

General Principles Unit (60 hours) and General Method Unit (30 hours)

The aims of this lecture course are to give teachers a foundation on which to base their practical technician teaching, to start them building up information about the learning behaviour and learning problems of technician students, to convince them of the value of applying proven principles which encourage and sustain persistent learning effort, to enable them to experiment with different methods of making their teaching more effective and of identifying and correcting their teaching errors, and to help them to prepare teaching topics and appraise varieties of formal and informal presentation. Though the course should question and challenge the in-service teacher's attitudes and opinions, and reveal any prejudices underlying his teaching techniques, it should do so without undermining his confidence. The technician teacher, like most mature adults, recognizes and accepts his limitations. He works within them to give and to get satisfaction in his job. Nevertheless he does need the knowledge on which to base reasoned, objective judgements about such matters as different methods of teaching, class discipline, teacher-student relationships, general studies, and autocracy in the classroom.

The lectures in general principles and methods are not complete in themselves. They are starting points for syndicate work, discussion groups, individual tutorial and study assignments, and written work based on prescribed reading.

The two sets of lectures should be integrated and, if possible, delivered by a tutor who is not only a technical specialist (e.g. in engineering, mathematics, or

building), but a trained teacher with a further qualification in Education and with experience in industry and in teaching technician subjects.

The general principles of the teaching programme should include the following:

1. The meaning of learning in relation to the employment needs of students attending technician courses in technical colleges. Principles involved in the preparation and presentation of technical material for formal and informal presentation.
2. Evaluating quality of learning in terms of the technician student's ability to utilize the knowledge and information in industrial situations.
3. Incentives and motivation influencing the quality of individual student learning effort (e.g. interest, attention, persistence, and attitudes to learning, to subject, to occupation, and to career and working environment).
4. The kinds of learning conducive to character building and personality development; also those involved in practical technical skills, technical theory, general subjects, etc.
5. The literature and research relating to learning technical and vocational subjects; the evaluation of learning.
6. Factors in learning: general intelligence and its correlation with kinds of learning; kinds of student and levels of technician course; aptitudes, their nature and measurement; relevance of aptitude profiles to selection and placement and to techniques of teaching technician subjects; heredity, environment, social class background; motivation; home background support; industrial support; health; personal qualities; quality of teaching.
7. Individual differences in technician classes; grouping and streaming; individualizing teaching.
8. Learning difficulties in technician subjects; diagnostic and remedial techniques and devices. Remembering in relation to the technician student's occupational needs.
9. Technician teacher and technician student learning relationships: authoritarianism and democracy in the classroom; staff student councils; students' unions.
10. Resources of educational technology. (The precise use and application of these devices and techniques is a main element in special method courses.)

The teaching programme for the General Methods course should include:

1. Topic analysis, collection, selection, preparation, arrangement and layout of material for presentation to students in technical colleges; lectures, lessons, discussion groups, assignments, case studies, role playing; immediate, intermediate and long-term aims and objectives; structure of the lesson period.
2. Class and classroom organization and management. Organizing class activity, individual participation and activity; co-operation. Homework.
3. Evaluating quality of learning and quality of teaching: testing and exam-

ining techniques; lesson assessment techniques and devices; self-assessment techniques.

4. Students' note-making, file-keeping and self-development record-making.

5. Analysis of particular teaching methods observed in technical colleges.

6. The factors to be considered in preparing a scheme of work for a session from a published syllabus.

7. Organization of the technical college and the teachers' responsibilities; personal records; student records; progress charts; reports; administrative arrangements for examinations; technical college discipline; tone, status, public relations and responsibility of teachers.

8. Collaboration with industry at teacher and student levels; arranging educational visits to industrial organizations.

9. Inter-staff relationships.

10. Storage, care and maintenance of equipment.

Development in Middle and Late Adolescence Unit (60 hours)

The purpose of this unit is to equip teachers to understand the behaviour of adolescents attending technician courses; to understand the need for sensitivity to the influences affecting the behaviour of young technicians; and to help teachers to appreciate the inter-personal relations affecting the learning environment. Teachers should carry out a number of case studies in their parent or host technical colleges, in industry and in youth clubs. The studies are supported by a general introduction to interviewing, questionnaires, attitude surveys, schedules, sociograms, and rating scales, and to the general literature of adolescent personality development. Guided reading from the relevant specialist literature as well as studies of novels, plays and films about young people in industry are an important part of the unit. Youth workers, careers officers, industrial personnel and training staff give talks and lead discussions.

In some cases the adolescent programme incorporates the following studies:

1. Intellectual, physical, emotional, and social development in middle and late adolescence; the learning process in relation to personal development and adjustment; influences on personal development; group and individual differences among technician students.

2. Heredity and environment in the personal and social adjustment of adolescents going into industry; importance of home, school, college, and working environment, and of parents, teachers, managers, supervisors and other adults in their lives.

3. Social and occupational structure of society and industry and their influence on the development of adolescent intelligence, aptitudes, temperament, culture, interests, and attitudes, and on adolescents' opportunities.

4. Development of attitudes in adolescents: growth and pattern of vocational, social and personal interests, ideals, standards, values and ambitions; personality growth.

5. Constructing, interpreting, and using sociograms, inventories, and ques-

tionnaires; group techniques in studying adolescents in industry.

6. The maintenance and interpretation of cumulative records.

7. Final years at secondary school; transferring from school and adjustment to work and technical education; agencies concerned with young people; problems of adolescent social adjustment at work and at technical college.

8. The literature of physical and social maturation, and of family living.

Education Unit (120 hours)

This unit should be a vehicle for the interpretation and application of educational ideas to the situations that confront a technician teacher on his job. It should not over-emphasize general educational theories. Teams of tutors need to integrate their collective knowledge and expertise to tackle such problems as how to teach a junior technician to read and use a blue-print; how to deal with variety in ability and attainment in mathematics, science, and the use of language; how to work with technician students with very different interests in learning; and how to make the teaching of technology liberal and at the same time applicable to the processes of industry. Technician teachers must be helped to think critically about how educational ideas, historical, economic, and sociological factors have converged at particular times to produce evolutionary changes in education, and technical education in particular; and about the sequence of development in an industrializing nation's development plans. A short general introduction to the school system of a country could lead to tutorial discussions, reading assignments, and projects dealing with the aims, objectives, content, and structure of the school curriculum, methods of teaching, organization and techniques of educational and vocational guidance, the growing technological and vocational element in secondary education and its impact on the technical college curriculum, and the transfer of students from school to specific technical courses.

The units on technical education are of greatest importance. They should help teachers to understand that the purpose of technical education is to support national industry and the national economy, to perceive the relationship between technical education and education as a whole, and see that educational opportunity and vocational choice in an industrialized society are closely related to its occupational, social, and educational structure. Teachers should also learn how official technician education reports are produced, how technician education committees and examining bodies function, how industrial innovation comes about, how courses are reviewed and how changes are made to syllabuses, examinations and qualifications.

Education Programme

1. Making and arranging personal notes and files; aids to study; clear thinking; using the library.

2. The school system – aims, history, development, organization, administration, management, curricula, teaching methods – and transfer from one level to the next. New approaches to curriculum building in secondary schools and their impact on technical colleges.

3. The purposes of technical education, and its recent development, organization, administration and management. (Much of this might be dealt with by visiting speakers actively engaged at policy and management levels, supplemented by visits to technical colleges and by projects based on official reports.)

4. The purposes and employment structure of industry. Levels of liaison and collaboration between technical colleges and industrial organizations.

5. The history of the growth of selected technical colleges. The organization of different kinds of technical colleges doing different kinds of courses. The development and purposes of technical education advisory councils.

6. Examinations in technical colleges; regulations and administration; the changing systems and patterns of examinations and final assessments for qualifications; the consequent need for the further education and training of technical college teachers in the principles and methods of examining students and of compiling, maintaining, and interpreting student records.

7. The technical education purposes of the relevant professional institutions, of manufacturers' and employers' institutions and federations, and of trade unions.

8. Methods of education and training in industry.

9. The organization, courses, curricula, methods of teaching, and qualifications in government training centres (now called 'skill centres' in Britain).

10. Vocational and educational guidance in school and technical college; the careers teacher; the industrial training officer.

11. The technical training and re-training of adult workers at all levels of industry.

12. The philosophers and philosophies influencing general education and particularly technician education in the country.

Special Method Unit (210 hours)

The special method unit is concerned with the interpretation and application of educational ideas to the circumstances in which technician teachers work. Its purpose is to equip the teacher to become a good practitioner in a technical college. In this sector, the relative lack of information, training experience, literature and research is most felt, and tutorial staff are most difficult to recruit. Short in-service special method courses are in demand and are generally oversubscribed. In several countries technician teachers attend supporting technical studies courses before starting special method courses. These supporting studies revise, extend, and up-date the students' knowledge of basic subjects and help them to become more familiar with modern equipment, techniques and processes in industry. They also include instruction in new subjects being introduced to specialist technician courses. They are tailored to the individual technician teacher's needs which depend on the level and recency of his technical qualifications, on his teaching subjects, and on his industrial experience. The duration of supporting studies courses varies from a few weeks to a year. There are four main problems. The first is devising ways of identifying and assessing the gaps in

the individual teacher's knowledge and skills. The second is planning the content, structure, organization and tutorial staffing of the extension course. The third is identifying the specific kinds of industrial experience the teacher needs in order to integrate theory and industrial practice when he is teaching technician students on a specialist course. The fourth is finding the best place to locate the extension course. An eminently sound approach being adopted in some countries is to locate it in a comprehensive polytechnic organization along with all the other components of technician teacher education, training and industrial orientation.

On completion of the supporting studies course, the teachers work in special method groups with specialist tutors. These tutors should possess the necessary technical qualifications and have had responsible industrial experience and successful teaching experience. They must therefore be put to optimum use. First-class organization and supervision are required to prevent fragmentation of tuition which can arise from having so many tutors involved that the teachers think in terms of isolated pieces of knowledge rather than of an integrated course. In general the fewer the teachers involved in any learner's specialist education, the more integrated and effective his learning is likely to be.

Experience indicates that the energizing influence in technician teacher training comes from the tutor who knows how adolescent and young adult students can be motivated to make the personal effort to learn, who engages in relevant research, who keeps his specialist knowledge of industrial practice up to date; and who is able to communicate with practising teachers. Such a tutor can apply general principles of technician teaching to precise statements of lesson aims and objectives, and give reliable guidance on the selection and analysis of learning material. He can also pin-point where technical education impinges on productivity and the economic life of the country and where it develops character and personality by equipping students with the occupational knowledge to give and to get statisfaction in their daily work. In dealing with tools, instruments, machines, and components, a tutor with these qualities and attainments can also help teachers to think through their purposes and design, their principles of operation, their construction and assembly, their functioning and use, and their care and maintenance. He will also be knowledgeable about audio-visual aids, methods of demonstrating the application of relevant scientific principles, and ways of anticipating and dealing with difficulties.

In training special method teachers, laboratory, workshop and library projects and assignments are valuable. These emphasize the application of principles to the equipment, materials and processes of industry, and integrate theory and practice in ways which support the new technician syllabuses being formulated in many countries. Teachers in technical colleges are likely to be in most need of science and mathematics knowledge, laboratory and demonstration skills, and up-to-date industrial background. Some shortcomings in these areas can be tackled by in-service courses of the kind with which industry is becoming familiar.

Recruitment of technician teachers is a serious problem in some Commonwealth countries. Already the Commonwealth Education Fellowship Scheme

and 'third country' education and training schemes make provision for Bursars and Fellows to revise, extend and bring up to date their technical and professional qualifications and obtain industrial training experience. It might be worth exploring the provision of regional staff training centres to develop concentrated short courses for more senior and experienced technical education staff who could become trainers of technical educators and trainers in their home countries. The same centres could arrange courses for people to train industrial trainers and vocational guidance staff. They could act as information centres. And they could conduct seminars for middle-level technical education executives, administrators, decision makers, advisers, technical teacher trainers, principals, heads of departments and key teachers.

Modern special method courses are designed to promote change and innovation in technician teaching methods; for example by replacing traditional lectures, dictated note-giving and fact memorization with methods based on individual learning, by developing flexible intellectual and manual skills, and by emphasizing those principles that must be understood by students in whatever sphere of technician activity they are about to operate.

Special Method Programme

This programme, which applies teaching methods to the changing content and organization of technician courses, should be planned by specialist tutors along with the individual teachers on the training course so as to match each teacher's studies with the special subjects he will teach. It should consist of not more than two main special method courses and two additional shorter special method courses. A teacher should take only those courses for which he already has the necessary technical qualifications. Laboratory-based studies should include:

1. Laboratory design; layout; organization; management; safety precautions; teachers' and students' records; projects and assignments for individual and group work; examining, testing, and progressively assessing laboratory work; the duties and supervision of laboratory technicians; and sources of information on laboratory studies, equipment, and technical college laboratories.
2. Organization of laboratory work to integrate with related topics and technology courses for different years of a technician course.
3. Published reports on the teaching of laboratory work; the analysis of common mistakes made in the laboratory at different stages of a technician course, and possible causes and remedies.
4. Small-scale equipment in laboratories of various kinds.
5. Devising and observing laboratory programmes for closed circuit television; the place of film and film strip in teaching laboratory procedures; and programming laboratory work for teaching machines.
6. Demonstrations on the teaching of 'difficult' laboratory subjects.
7. Laboratory projects by each technician on the teacher training course.

Topics

Topics within any special method programme should include:

1. The aims of a special technician course and syllabus; the educational, industrial and social background of the students; the nature and content of any induction and core curriculum courses that are required to revise and extend subject knowledge prior to the commencement of the course itself; the value and limitations of existing devices for selection, placement, and guidance.

2. Group projects in which technician syllabuses are converted into schemes of work; the allocation of time to different activities; the aims and content of each lesson and their relationship to the scheme of work as a whole, to other subjects, and to industrial training and experience; the methods to be used in teaching and evaluating the success of each lesson; the homework, library, and other assignments to be undertaken.

3. Principles and methods of technician lesson preparation, with demonstration lessons by tutors, teachers, and experienced specialists from technical colleges involving experiments, chalk-board and other summaries, charts and diagrams, models and components.

4. Techniques for dealing with individual differences among students in the same class; common learning difficulties; remedial techniques.

5. A study of relevant reports (including examiners' reports) concerning the teaching of the subject; researches in teaching the subject.

6. Marking theoretical, laboratory and workshop material; compiling, maintaining, interpreting, and using technical college records; reports for different purposes.

7. Specialist laboratory, workshop and practical room organization, management and supervision, and related safety education; ordering, storing, maintaining equipment and consumable materials; responsibilities of teacher, technician, steward, store-keeper, caretaker and cleaner.

8. Appraisal of reference material, textbooks, source books, journals, magazines and handbooks from professional and industrial organizations.

9. Examination and discussion of possible causes of wastage in the particular course and classes concerned; research reports; researches in progress.

10. Arranging and conducting special method educational visits.

11. Actual involvement in industrial, school and other forms of liaison to establish the need, value and methods of close collaboration.

12. Technician students' personal note-books, files and other methods of building-up records of course work and other relevant information.

13. Discussion and involvement in team teaching experiments in technical colleges.

14. Skill learning; rote learning; habit formation; boredom and fatigue; analysis of skills; job analysis; demonstration techniques; modern techniques with audio-visual aids, simulators, off-the-job exercises and preliminary training and preparation; researches being conducted; teachers' and learners' problems of communication and their solution.

15. The contribution of technician subject teachers to the general studies programme; involvement by giving talks, leading discussions, and participating in art, pottery, music, drama, poetry reading.

16. Specialist technician teachers' attitudes to their subjects; to teaching, to students and their corporate life; to college, industry, local schools, and the local community; the teacher's function and responsibilities as a personal tutor to a group of technician students.

17. The history and probable future pattern of teaching the specialist subject.

18. Safety education.

Language and Communication Unit (30 hours)

The purpose of this unit is to help teachers to communicate their knowledge and skills effectively to the technician students they teach. It should be based on the principle that tutorial example has more influence than precept.

The programme of activities should include:

1. Learning to use language to communicate ideas, opinions, instructions and directions, and to report specific situations with clarity of meaning and expression; building a work vocabulary; note making; routine work in langauge (writing letters, using the telephone, phrasing telegrams, completing forms, etc); writing a statement of requirements for a job to be done by a technician in a technical college.

2. The mechanics and techniques of good speech and delivery; speech therapy where necessary.

3. Reading; verbal and written summaries of reading; short composition exercises; rapid reading; learning to use an organized library; appraisal of articles in journals.

4. Discussions on current affairs; expressing views, and making judgements about what is said.

5. Chairing a meeting; being a committee member; building self-confidence by giving short talks, by role playing (e.g. for a job interview), and by acting and the use of mime and gesture.

6. Exercises in logical analysis; principles of clear thinking and expression based on the analysis and appraisal of teaching experiences; improving the quality of thinking; comprehension and précis making; debating.

Educational Technology Unit (30 hours)

The aims of this unit are to help technician teachers to acquire the skills of(a) defining and analysing educational objectives, (b) planning and organizing resources for student learning situations, and (c) evaluating, selecting, manipulating, using and co-ordinating the media available to them in their parent technical colleges.

The Educational Technology programme should include:

1. Design and production of technician course material such as hand-outs, graphs, charts, diagrams, transparencies, and overlay assemblies of transparencies

for an overhead projector.

2. Making models and mock-ups, dioramas and displays.

3. Using 8 and 16 mm film and cassette loops, filmstrips, slides, prints, sound recordings, teaching machines and programmes, duplicators, photocopying machines, and various forms of TV including video-tape recording.

Liberal Studies Unit (30 hours)

The main objective of this unit is to assess each teacher's educational background with a view to helping him to overcome any weaknesses that exist in it, and to extend his special interests and share them with others. The presence of a cross-section of students from many walks of social and industrial life enhances these opportunities. However, while it is easy to discover background weaknesses it is not so easy to be constructive about their treatment. Though there is a general agreement that a liberal studies course in a technician teacher training programme should encourage the questioning and challenging of ideas, not all tutors are willing to expose themselves in debates and discussions with students.

A second objective of this unit is to enable some of the students to become general subject teachers in technician schemes of work. These students could be invited to work closely with the specialist technical groups to think out the kinds of course that could be useful and interesting to technician students. This is an area of teacher education and training that requires much more research and experiment.

Practical Teaching Unit (360 hours)

The purpose of the practical teaching unit is to give the teacher experience of putting into practice what he has learned in the special method unit. He should be expected to make fairly detailed studies of laboratories and workshops in his own specialist area and less detailed observations in other areas. He should be asked to learn about the reasons for different designs for practical rooms; the types of specialist equipment and the use made of it; the selection and ordering of equipment and stock, and the methods used for receiving, checking, storing, allocating and servicing them; the organization and management of laboratories and practical rooms (including the safety precautions built into practical courses); and the records maintained by technician teachers and students.

There are many advantages and few disadvantages if the in-service teacher fulfils the practical teaching requirements of the training course in his parent technical college. He has ready access to the range of resources he needs for the preparation and teaching of his material. He knows the students and the staff, and can more easily participate in the professional, corporate, and social life of the college than he can in an unfamiliar establishment. In addition, he has more opportunity to carry out and evaluate new teaching methods, to make self-assessments of achievement, and to reappraise (and where necessary modify) personal attitudes and patterns of behaviour.

The training institution tutor can collaborate with the trainee teacher to produce a range of exercises, assignments and projects which are directly

and immediately related to real life situations. He can make modifications to lessons, to practical demonstrations and to laboratory schemes or drawing office exercises in the light of first-hand experience. If this tutor is made responsible for the whole of the teacher's practical teacher training and development programme, he can discuss the teacher's progress convincingly, and he can advise and demonstrate how to develop more creative, varied and self-critical methods.

Assessment of Practical Teaching

The reasons for having visits by tutors or assessors during teaching sessions need to be defined if the learning experience is to be worth while to the teachers concerned. Tutors must be in a position to decide whether they are giving assessment an exaggerated importance to the detriment of constructive guidance. The assessment mark can certainly become too important in the teacher's mind, and tutors should therefore endeavour to prevent this from causing a poor tutor-teacher relationship. One thing the tutor can do is to inform a teacher well in advance about the time of a forthcoming assessment. This allows the teacher to present himself at his professional best. Another is to make sure that the teacher is fully aware of the purpose of the visit and the criteria on which the assessment will be based. If the assessor has personal points of view that will affect the assessment, the teacher should be informed of them so that he can adjust his performance accordingly. In any case there should be scope for an exchange of ideas, opinions and points of view between the assessor and the teacher. When an assessment is being undertaken, observation should last from beginning to end without interference. Afterwards the tutor should help the teacher to make his own evaluation of what he has just done. The teacher needs to possess this skill if he is to improve his work after completing his training course. Any written comments that are made should be based on the evaluation made by the tutor and the teacher together. A copy should be given to the teacher for his file.

Characteristics which tutors may find useful starting points for discussion before, during, and after observing a teacher at work are:

1. Teacher Personality and Characteristics
Is punctual and businesslike
Knows his subject matter
Quickly establishes responsive relationships
Is relaxed and at ease: shares in humorous situations
Is readily approachable
Is able to maintain a productive emotional climate
Generates confidence: is supporting, encouraging, stimulating

2. Planning Skills
Makes a sound pre-assessment of the students
Anticipates learning difficulties
Chooses clear, definite, specific objectives which are neither too easy nor too difficult for the students
Selects material, activities and learning aids appropriate to objectives
Carefully plans each step of the lesson

Plans learning tasks achievable in the time available
Plans tasks so that all may experience some success

3. Instructional Skills
Is able to motivate students
Is effective in gaining and holding attention
Adequately prepares the class for new learning
Uses a variety of techniques and teaching methods
Chooses challenging learning situations
Encourages students to seek explanations, solve problems, and discover relationships
Speaks in a clear, precise, and interesting way
Asks questions that stimulate divergent as well as convergent thinking
Makes use of responses, including wrong ones
Shares ideas with students
Balances teacher and student participation
Elicits discussions and directs them well
Elicits questions from the students and makes good use of them
Makes good use of the chalk-board and a variety of teaching aids
Acts as a resource person
Relates the subject with others in the curriculum and to long-term educational objectives

4. Organization and Management
Effectively arranges the room and the equipment
Effectively initiates, organizes, and sustains group activity
Gives well-timed, relevant, adequate and clear instructions
Handles routines efficiently
Makes good use of the time available
Handles unexpected situations skilfully
Anticipates and solves disciplinary problems skilfully

5. Awareness
Displays an understanding of individual students and their needs
Is quick to identify opportunities and learning difficulties
Attemps to involve silent, hesitant, and diffident students
Is aware of restlessness and lack of interest
Is skilled in handling the unexpected

6. Evaluation
Assesses effectiveness of instruction
Uses student participation in evaluation
Keeps a continuous record of each student's progress
Uses well constructed tests, observation, check-lists
Is concerned with skills and attitudes as well as with content
Effectively uses the results of evaluation in future planning

No one, of course, can be expected to display all these characteristics in a single lesson. But over a period of time the check-list can help the tutor and teacher together to analyse strengths and weaknesses and enable the teacher to continue to improve his work in the years to come.

When grades are required, assessment can usefully be made on a five-point scale:

A. Exceptional. These are outstanding people who will make their mark in any technical college and under any circumstances.
B. Very Good. These are people who will do an efficient job irrespective of

the quality of the teaching environment.

C. Average. In most circumstances these people will do a reliable, steady, unexciting job without much originality.

D. Below Average. These are people with marked weaknesses who need sympathetic guidance from principals and supervisors in their first years of teaching.

E. Fail. These are people who are completely ineffective.

Course Work: Progressive (or Cumulative) Assessment

In some countries a formal examination system is not considered to be necessary in a training institution dealing with mature students who already have good technical qualifications, who may have given up good posts in industry, or for whom a technical teacher training course is not a compulsory professional requirement. The place of formal examinations is taken by a process of progressive assessment. This is a good thing. Examinations can create an intellectually inhibiting circle of cramming, memorizing, rehearsing, spotting questions, and regurgitating tutor's notes. They affect tutors, too. The syllabus comes to be interpreted in terms of answers to past examination papers, and the challenge to educational experiment and innovation is stifled. In such circumstances there is no incentive for tutors to keep themselves abreast of industrial change and technological innovation, or to prepare young technicians for modernizing and developing industry.

Progressive (or cumulative) assessment, consisting of tests given at the conclusion of each assignment, project, or unit of work, enables teachers to pace their own learning. It also enables tutors to be more venturesome, and experiment with less formal kinds of class and work organization and management. However, it can become a source of tension for students if they are not fully informed of the criteria on which the assessments are made and if they feel that the assessments are not sufficiently objective, valid, and reliable. Good organization is required to overcome these problems. Tutors can be given commitments with several groups of students so that they can keep in close touch with a cross-section of the whole student body. Their assessments can be correlated in a number of ways and validated by internal and external examiners. The external examiners would normally see examples of written and practical work, observe practical teaching, see records of all cumulative data used in arriving at an assessment, interview individual students with complete folders of work and notebooks, have discussions with groups of students, and follow the progress of a sample group of students right through the training institution.

A training institution proposing to use a system of progressive assessment should set up a study group to consider such questions as:

1. What are the advantages of assessment over a final examination?
2. What are the aims of progressive assessment?
3. What is likely to be progressively assessed?

4. What will the final assessment tell the student about himself?

5. What professional knowledge, skills, attitudes and achievements are to be assessed?

6. What criteria should be used throughout the progressive assessment and at the end of it?

7. What part will the individual student play in collecting and evaluating his own data, and in rating himself?

8. What part will a group of students play in making assessments?

9. What devices should be used to obtain data for progressive assessment?

10. What will be the minimum requirements in each area of study?

11. Can use be made of a credit/hour/mark system for assessments?

12. What administrative system is needed to ensure comparability of standards?

13. What internal examining system should be used as an integral part of the assessment?

14. How can individual student differences be identified and catered for in the assessment?

Post-Initial Technical Teacher Training Courses

Many countries have, or are planning to have, pre-experience and post-experience diploma courses, and first degree and higher degree courses in further or technical education, or industrial training, or a combination of these.

Training Industrial Training Officers

In Britain courses for training officers employed in industry have been an important, expanding activity since the passing of the Industrial Training Act in 1964 and the establishment of Industrial Training Boards. The introductory study courses are normally located in an institution for further or higher education.

Courses of this kind can be organized on a sandwich basis with two three-week periods in college separated by a period of six weeks during which course members are required to undertake a project relevant to their own and their company's training needs. About six months afterwards it is useful to have a short follow-up programme to review a topic at a more advanced level.

The aim of such a course is to help new or recently-appointed training officers to realize their own capabilities, to develop sound attitudes to industrial training based on objective appraisal of existing needs and training methods, and to start undertaking worth-while training work in the organization in which they work. Essentially, the course caters for full-time training officers, with sufficient practical experience of industry or commerce to allow them to participate actively.

Course Content and Objectives

The basic subjects and supporting studies in the course are listed below, together with the main skills and abilities they are intended to develop in the training officer.

BASIC SUBJECTS IN THE COURSE	RESULTING SKILLS AND ABILITIES
1. Identification of Training Needs and Resources	To state the main factors which must be considered in identifying training needs and to be able to investigate training needs within his company. To help management establish priorities to maximize effectiveness of training resources. To identify the personnel in any training situation whose support is important, and be able to involve them in preparing plans for systematic training.
2. Job Analysis	To analyse non-supervisory jobs using interview and observation techniques to determine job content in sufficient depth to allow the construction of an effective training programme. To examine the jobs of individual managers and supervisors using documentary and planned interview procedures so that training programmes can be planned in outline on an objective basis.
3. Specifying Training Objectives	To specify training objectives (based on the training specification) appropriate to a specific situation. Objectives will, as far as possible, be established with respect to (a) the desired terminal performance of the trainee; (b) the important conditions under which this performance will be attained; and (c) the criteria of acceptable performance.
4. Design of Training Programmes	To design effective training programmes with respect to (a) training specification; (b) sequence and timing of learning experiences; (c) training methods, aids and instructors; (d) validation methods; and (e) presentation matters.
5. Training Methods	To state the main characteristics and uses of the following training methods and be able to select an appropriate method for a given situation: (a) training talk lecture; (b) demonstration; (c) group discussion; (d) case study; (e) role playing; (f) projects and practical work; (g) programmed learning.
6. Training Costs	To define those accounting terms and procedures which are applied in the costing of training. To describe how training budgets are established and how training costs are identified.
7. Training Technology	To state the materials, equipment and procedures available for use in producing and presenting material. To operate basic equipment and implement instructor- or machine-presented material in a training situation. To prepare material for presentation and use available techniques to help trainees to learn a specific part of a training programme.

8. Validation and Evaluation of Training	To effect internal validation using tests and other measures of performance. To effect external validation by identifying and analysing job performance subsequent to training. To state the main factors by which the value of training can be assessed.

SUPPORTING STUDIES

1. Trainees and how they learn	To state the characteristics of the main types of learning and illustrate their application to training methods and training technology. To list the most common areas of difficulty encountered by trainees and to state how these difficulties can be tackled.
2. Administration of Training	To analyse the training system within a company and identify those areas where information needs to be made available on a regular basis. To establish a record-keeping system so that feedback is provided effectively and information made readily available. To examine critically existing paperwork (forms and registers, etc.) and make suggestions (where possible) designed to improve its effectiveness.
3. Principles and Methods of Personnel Specification	To list the methods available and describe their uses and limitations. To prepare a personnel specification and an interview note-sheet using the appropriate job analysis so that selection becomes as structured and objective as possible.
4. Individual Differences of Trainees	To describe the way in which individual differences of trainees affect their ability to learn, with reference to (a) young people, and (b) older workers.
5. Objective Testing	To describe the principles underlying the construction of objective tests to validate the knowledge element of training programmes, and be able to assess their usefulness in industrial training.

Workshops in particular activities may be mounted for more experienced industrial training officers. Here are two examples, together with their aims:

1. Workshop on Management Development

This course does not concentrate on any one approach to management development. Instead it helps course members to consider and evaluate alternative approaches. Course members are viewed as Management Development Advisers whose main aim is to help management accept responsibility for management development. By the end of the course each member should have prepared a set of proposals for discussion with his own management.

The course is best arranged as a sandwich, with a major project being carried

out by each member during the in-company part of the sandwich. Members are visited by a tutor before and during the course. By the end of the course, members should be able to:

1. State the main factors which could be included in a Company Development Plan.
2. Generate information which will help management clarify their own thinking and facilitate the setting of priorities.
3. Propose a 'shape' for the Management Development Programme, indicate the main alternative strategies, and help managers evaluate these alternatives.
4. Prepare a detailed programme for the development of individual managers, work teams and the whole management process, and an evaluation system to enable the effectiveness of the programme to be monitored and improved from time to time.
5. Select learning situations for individuals and groups on and off the job, and provide tutorial advice as required.

2. Workshop on Industrial Relations Training

This short (one-week) residential course can assist personnel and training specialists (and managers who are responsible for developing and implementing industrial relations policies) to identify training needs and design programmes to meet these needs. The course should include: (a) a background to current industrial relations practice; (b) factors affecting attitudes and behaviour at work; (c) identification of training needs; (d) the design and evaluation of training in relevant skills and techniques; and (e) the selection of training methods with particular reference to the development of interpersonal skills. Its structure should allow for the examination and discussion of problems and situations in the members' own companies.

By the end of the course each member should be able to:

1. Relate the legal framework governing employer/employee relationships to the policies operating within his organization.
2. Identify the essential features of good employment practices.
3. Define the role of the employee representative and describe the trade union structure within which he operates.
4. Identify situations which may create poor industrial relations within an organization.
5. Identify the basic industrial/human relations training needs of manager, employees and employee representatives.
6. Select appropriate training methods, and design training programmes.
7. Develop criteria for evaluating industrial relations training.
8. Identify external resources which may be used within an industrial relations training programme.

5

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.

6

Administration, Finance, Control and Inspection

The aims and objectives of a country's educational system determine such matters as priorities and emphases in technician education as a whole and in the curriculum in particular, the education, conditions of service, qualifications and status of teachers, and the examinations taken by students. Different political interpretations of authority, democracy, discipline, and freedom affect the roles of the governing bodies of technical colleges and of academic boards, staff associations, students' unions, principals, heads of departments, and teachers.

College government is a subtle and complex matter. The modern trend is to appoint an independent, broadly-based governing body containing some elected representatives of the local government authority, the principal and some members of the staff and student body, some nominated officials, and strong representation of the various organs of industry and commerce, including professional and employers' associations and trade unions. This body is made legally responsible for the general running of the college, and is given considerable autonomy and decision-making powers over the design, planning, organization, and resourcing of courses, over internal administration and management, and over the spending of the budget within the limitations imposed by central and local government and the salaried executive.

The legal instrument of government for a college establishes the governing body, lays down its composition, duties and powers, and describes how it should be run. It also sets out the roles of the principal and the academic and administrative staff and the conditions for their appointment and dismissal.

A governing body of about 20, including co-opted members who can make a particular contribution at a particular time, is normally considered to be about the right representative size without being too large to impede action. One of its main functions will be to increase public confidence in the college and in the appropriateness and the quality of the technical education given to the students. Another will be to approve estimates and formulate long-term proposals for

growth and development, introducing new objectives where necessary to match change and innovation in industry and business. The governing body should not be involved with the details of decision making for the day-to-day control or direction of the institution, or with too much committee work.

It will normally set up a committee to appoint the principal and senior teaching and administrative staff, and will delegate to the principal responsibility for appointing other teaching and non-teaching staff.

Academic Board

In smaller colleges offering a limited range of work, it may be possible for the principal to have complete responsibility under the governing body for all actions and decisions taken within the college. In larger colleges offering a wide range of work, it is not possible for the principal to be the sole decision maker or to be personally concerned in all aspects of college activity. Direct involvement presents too great a demand, and the principal has to rely on the knowledge, experience and wisdom of an academic board composed of some of the members of his staff.

The academic board is a formal structure for deciding college academic policy and general development. It is an independent body having executive powers in certain well-defined areas of college activity and advisory powers in others. It plans the pattern and balance of teaching between different areas of study in the college, as for example between theory subjects and practical subjects in particular kinds and levels of technician courses. It is responsible for the procedure for the admission of students, and – within the framework of the appropriate regulations – for the overall structure of the patterns of assessing and examining them, and for monitoring and evaluating their progress. It reviews departmental estimates of expenditure, advises the governing body on matters where academic policy involves financial commitment, and allocates expenditure to departments when it is provided as a consolidated sum. Appropriate members of the academic board participate in making teaching staff appointments.

An academic board must be of a size commensurate with its tasks. Fifteen is probably about the right number. Membership should include all heads of academic departments and representatives of the teaching staff and students. The senior administrative officer is normally the secretary both to the academic board and to the governing body. A college should also have a staff council consisting of all academic members of staff which can make staff views available, submit items for the agenda of the academic board, and be kept fully informed about academic policy and its implementation.

The Role of the Principal

The principal is responsible to the governing body, of which he is normally a member, for the effective use and management of resources and for the discipline of the college. He is the pivot of the college organization. However, it is not his function to diminish or constrain the responsibility or accountability of other members of the academic or administration staff. The principal cannot know or

do everything, and by retaining too much control of administrative detail he can, in effect, have too *little* control of policy. Usually he is given authority by the governing body to make appointments below that of head of department, and is chairman of the college disciplinary committee which has representatives of the governing body, the academic board, the teaching staff and the student body and which makes decisions on matters of discipline. In consultation with the academic board he does the long-range thinking, he prepares, reviews and presents plans to the governing body for the academic development of the college, and he implements plans when the governing body's decisions have been made. Within the college he has a well-recognized leadership role. This is not based so much on formal power as on an ability to deal effectively with people and enable them to get and give satisfaction in their jobs. His success will depend on the status which he personally establishes with his peers as a creative educational thinker who is able to encourage and integrate the ideas and energies of the college into a constructive, coherent policy.

The Role of the Head of Department

The head of a department in a college is concerned with three broad groups of activities: the administration of the department, the organization of teaching in the department, and the teaching which goes on within the department. Many of the administrative decisions made by a college affect his work. For example, decisions have to be made about whether open access for teaching staff, students and visitors to the head of department is necessary or desirable; what kinds of interviewing should be undertaken by the head or by teaching staff qualified to be counsellors; how much routine statistical and clerical work needs to be done by the head, and how much can be delegated to a trained secretary.

Among the responsibilities of the head of department are the maintenance of student records within the record system decided upon by the academic board, and the preparation of confidential references and open testimonials to prospective employers. Also within a framework of policy decided upon by the academic board, and under the general direction of the principal, he must undertake selection and induction of full-time and part-time teaching staff, and arrange for their further education, training and professional development. He must help the academic board to decide where research of any kind should be undertaken or encouraged, what areas of technician education and training activity ought to be studied by which teachers, and who should be responsible for guidance and supervision. He needs to know the extent of his responsibility for education and training policy-making at college level and to communicate the policy effectively to the staff in his department. He must make his contribution to reports such as the principal's annual report, open-day speeches, and reports to academic advisory committees, boards of studies, employers, and parents.

The head of department must also create and establish an organization for maintaining close and regular liaison with industry at technician teacher level. He has to develop techniques for teachers to report their industrial experiences to

one another so that teaching is always industrially applicable. He has to organize special *ad hoc* courses requested by local industry, and decide the level and technical content of courses that are within his province, taking into account the resources of his department and the specialist staff that must be hired from outside the college.

Service on examining and professional bodies is another part of a head of department's professional functions, and he needs to be allowed adequate time to do justice to the task. The number of meetings should be rationalized and organized to suit periods when college departmental pressures are not too intense. The number of committee and sub-committee meetings should be kept to a minimum if busy heads of departments are to be available.

A head of department should rightly be involved in any new building programme, but unless his involvement can be kept within reasonable bounds it can consume too much time to the detriment of education and training.

Policy guidance can help him to determine how much time to spend on these matters, on co-ordinating an examination time-table with other departments, on compiling examination returns, on public relations work, on correspondence, on liaison with secondary schools in the area, and on making the general public technical education conscious.

Organization of teaching

This area of responsibility covers such activities as student enrolment, time-tables, deployment of staff, co-ordination of teaching, organization of teachers' work, staff meetings, and the organization of library, laboratory, and practical room work.

The problems of enrolment are well known to heads of departments. They include the mechanics of enrolling large numbers of students in a few days and of providing adequate vocational educational guidance in the course of a short interview. A number of questions arise on these occasions. Can the guidance be allocated to other teachers? How far does inadequate guidance at enrolment correlate with wastage, examination failures and lack of enthusiasm for technical education? How useful and applicable are secondary school records and headmaster's reports for allocating students to courses? How can the teachers in a specialist department study the techniques used for compiling school records and interpret the information satisfactorily? What correlations are there between school and college entrance examinations and achievement on the course? What are interviews intended to elicit, and how far are they successful? How far should parents of students be involved at the enrolment stage? How far is integration possible among all the agencies concerned with a student starting on vocational education as a preparation for his working life (school teachers, headmaster, youth service officer, youth employment officer, head of department and his staff, industrial training officer, and parents)? How is all the information collected, made available in one place, interpreted, and acted upon in an objective way?

For the head of department, compiling time-tables is an important, complex and time-consuming task. It involves making decisions about the number of classes that he himself should take, bearing in mind his other duties including those of supervision, and the levels at which senior and junior staff should operate to deploy their skills and experience most effectively.

Co-ordination of teaching is a topic which stimulates much discussion among heads of departments. Points of view vary tremendously. Some heads believe that once a teacher is given a syllabus he should be allowed complete freedom of action without supervision of any kind. Others think fairly close supervision is necessary – indeed, that all other duties are subsidiary to it. In addition, the responsibility for co-ordinating the subject teaching within a department, and achieving co-ordination between one department and another, are matters of great importance. How, for example, do heads decide what topics in mathematics will be taught, and in what sequence? How should science topics be related to laboratory and workshop projects? What practical exercises need to be synchronized with theory classes? What methods have proved effective in correlating theory, laboratory and workshop teaching? How can the head ensure that the teaching in his department is properly co-ordinated with particular stages of on or off the job industrial training? Should the head of department decide on a course of study regardless of industrial training, or should industry set the pace for college education? Unless definite and objective points of view exist on these issues it is difficult to co-ordinate college education and industrial training, no matter whether it is on or off the job.

Heads of departments often express a desire to be more involved in the educational process than in the routines of administration. For example, they would like to spend more time with teachers in the preparation of detailed schemes of work, in improving methods of assessment and the maintenance of student records, in diagnosing and overcoming learning problems, and in appraising the effectiveness of different teaching methods. With the expansion of technical education, these and similar matters are likely to increase in importance as the number of new and less experienced teachers grows.

Selecting and arranging industrial visits consume much of the head's time. The work involves deciding which visits are most appropriate at different stages and levels of a particular course, what purposes the visits are to serve, how they are planned and followed up, and how they are co-ordinated with class teaching.

Teaching

The head of department's job description should spell out his professional responsibilities with regard to the teachers and the organization and supervision of teaching in his department. He in turn must inform teachers of their responsibilities. For example, the individual teacher must know to whom he is directly responsible for his work, where to seek advice, information, and assistance, what administrative regulations prevail for staff within the college and within the department, and, generally, what is 'done' and what is 'not done'.

Though few teachers may wish to take part in policy making, all want to understand the processes for effectively transmitting and communicating the policy decisions which affect them. For example, technical teachers like having regular meetings with employers and industrial training officers to discuss mutual interests. Many like to go into industry on an informal regular basis. Others seek opportunities for particular kinds of practical experience and familiarization activities during vacation periods, or paid leave of absence for specific projects within industry. They need to know the head's views on close liaison between the department and industry, and how he intends to obtain it. Does he consider it appropriate only to senior staff, and is he prepared to modify teachers' time-tables to allow for it? Teachers also want to know the part they are expected to play in administration and organization. Many have no interest in either: they are concerned only with teaching and consider it an unreasonable encroachment on their professional commitments when a head of department unloads on them part of his administrative chores. Much of the work, they claim, is trivial and could be undertaken equally effectively by clerks. Senior staff in particular resent having comparatively routine administrative tasks given to them. They feel that they gained their seniority on the basis of high academic qualifications and successful teaching experience, and that they should therefore be fully occupied with teaching.

Other matters on which teachers wish to be informed are the financial arrangements in the department, the ordering of equipment, shared equipment and the procedure for exchange, and the arrangements for obtaining books and other materials for the library. They expect to be consulted about time-table planning, and resent being fitted into a predetermined pattern regardless of their preferences. They want a fairly stable time-table which makes the most effective use of their training and experience. They need time for preparation and marking, and reasonable study and workroom facilities, storage space, classroom furniture and equipment, apparatus, materials and teaching aids. Less experienced teachers should have smaller classes which are easier to teach, co-operative and keen to learn. Even at the risk of having to cancel classes or turn away a request from industry, no teacher should be expected to teach a subject in which he is neither qualified nor interested (e.g. an electrical engineer to teach welding).

The policy for the tutorial staff development programme (i.e. on- and off-the-job further education in special technical subject knowledge, industrial experience and professional training) is the responsibility of the academic board and the principal with the approval of the governing body. The head of department is responsible for its planning, organization, monitoring, and evaluation. The academic board, the principal and the heads of departments need to ensure that the educational and social environment of the college and its departments provide an environment encouraging to individual self-development and professional development. This involves a continuous review of staff to assess their performance, achievements, capabilities and potential in relation to their opportunities for development. Promotion to a particular job should be based on merit alone.

It should be open to all who have the technical qualifications and knowledge, the industrial and professional experience and expertise, the emotional strength, and the psychological make-up to do the particular job concerned. The individual teacher should be kept informed about his promotion prospects and the factors influencing them. He should know whose advice to seek regarding action to prepare for promotion. He should be told frankly when it becomes clear to the head of department that there is little prospect of promotion within the department. More often than not, teachers prefer even adverse criticism to no expression of opinion at all: silence, or an ambivalent attitude by a head of department or the principal, tends to create stress, rumour, anxiety about job security, and a feeling that positive leadership is lacking.

College Management

Direct application of management methods may be suitable for industry but it is not necessarily appropriate for the management of the network of human relations, the financial resources, the equipment and the accommodation of a college. Colleges are not homogeneous, and no single system of administration and management techniques can be applied to them all. This does not mean that the principles of management should be rejected. The governing body as the board of directors (the top authority in the management hierarchy of the college organization) decides what technician education and training work the college is to do, what size the college will be, and what resources of finance, teaching and non-teaching manpower, accommodation, equipment and materials it will need to do the job. The principal is chief executive officer, with responsibility for the central direction of the college. He and the heads of departments and the senior administrative officer constitute the management team which integrates the activities of the separate departments and makes full use of the various kinds of administrative expertise existing in the college. The management team must be sensitive to pressures from outside (e.g. from government, schools, industry, and examining and professional bodies), and from within the college. The team must also determine the specific educational and training objectives for the college and the strategies and tactics required to achieve them, and be flexible enough to cope with growth, innovation, changes in the organization and content of courses and in the composition of the student body.

Finance and Budgeting

It is difficult to measure the effectiveness of a technical college on a cost/value basis. The financial data are often not available in a form to fit them easily into a framework for policy purposes. For this reason many countries and international agencies have set up special units to measure and evaluate the cost of education, and of each different sector of education, in relation to national economic and social objectives. Where technician education is concerned, these units can consider such matters as the effect that the financial structure of the national education service has on the activities and actions of an individual technical college; methods of evaluating the final output from technician education

and training courses; methods of planning, organizing, resourcing, financing, administering, managing and monitoring courses to ensure that the trained manpower outputs and the financial inputs are right; ways of assessing whether teaching and non-teaching staff time, student time, accommodation and equipment can be more effectively and more fully utilized; the comparative cost benefit to society of a student in full-time or equivalent part-time technician education; and devising means for ensuring close control over capital and recurrent expenditure to ensure that technician and other education programmes conform to government priorities.

As most capital investment decisions involve a time lead of several years, most colleges prepare their development plans in the form of a five-year rolling programme. Estimates and data cover at least the actual expenditure for the previous year, the revised estimates for the current year, and estimates for the forthcoming year. The five-year programme is built up from projections of courses to be mounted and the numbers and types of students to be catered for. It is the framework within which the detailed annual budget for the college is prepared.

Budgeting

The estimates for the development plan are drawn up by the principal of the college together with the heads of the departments and some of the teaching and non-teaching staff. Each expenditure head must be built up from the basic requirements of particular items. After discussion with the individuals and committees concerned, and making any necessary modifications, the principal consolidates the information under such headings as maintenance of classes (which includes teachers' salaries, superannuation, equipment, accommodation, consumable stores, transport for students and other relevant items); and administration (which includes salaries and other expenses for the registrar and other administrative officers, clerks, and secretaries), as well as office equipment, maintenance, and other expenses. These headings are not mutually exclusive. For example, it is not possible to allocate the cost of the principal, the heads of departments and key teachers entirely to the maintenance of courses and classes on the one hand or to administrative duties on the other.

When complete, the estimates of anticipated income and expenditure, together with relevant information about staff and students, are submitted by the principal to the governing body about a year in advance of the new financial year. Individual items are approved, rejected, or deferred.

Budgeting in this way can be considered as an instrument of planning. It consists of three interacting functions. The first of these is concerned with obtaining as much information as possible about the costs of a particular project and building, and comparing it with the probable effect of obtaining the same end by other means. The second involves compiling estimates for the principal, the academic board and the governing body of the college. The third consists of making decisions about the acceptance, rejection, or deferment of the items in the estimates, of formulating the rolling plan for the development of the college, and of identifying where responsibility lies.

Costing

When the framework of courses has been established, the governing body has to consider the estimates and decide on the inputs to be allocated to particular programmes. This involves policy choices about how available resources are to be used, about reviews of programmes, and about assessing the contribution that each programme makes to achieving the college's objectives for providing technicians for industry. An increase in one programme can quite legitimately mean a decrease in another.

Estimates should therefore be prepared in such a way that they facilitate comparison between departments and even between different colleges doing the same kind of work. They should enable cost differences between courses, classes, class hours, teacher contact hours, and individual student hours to be analysed. For this reason, in preparing the budget the principal should involve all those who are responsible for any aspect of budgetary control, and ensure that they are fully aware of the financial regulations and procedures of the college and the financial limits within which they are to work.

Because salaries, wages, insurance, and superannuation represent about two-thirds of the gross expenditure of most technical colleges, these costs must be considered with special care. Practical management, based on modern, scientific management techniques – such as surveys, operational research, work study, organization and method – can be applied to appraising and obtaining economic efficiency whilst at the same time enhancing the quality of the courses and the employment prospects of those who take them. The total cost of the staff required is based on the actual cost per class hour. The costing unit in common use is the student hour. It is calculated from the number of full-time students (and full-time equivalent students) enrolled, and the actual student hours for each department for each session. Class contact and teaching hours, separated into different levels of work and numbers of teaching staff and ancillary staff on each grade, can be shown for each department.

If economies are needed, one way of achieving them is to increase the proportion of the working week that is spent by the average teacher in class contact. (This may involve reducing the research time granted to staff – particularly to staff who are paid the highest salaries.) Another way is to increase the size of classes, and a third is to increase the number of teaching weeks in the year. All suffer the drawback that they can easily lead to lowering the quality of teaching, and in this respect administrative economies (such as the maximum utilization of space described on page 107, and improved stores control and buying procedures) are to be preferred.

Routines

Every college has to carry out certain routine tasks which, nevertheless, require organization and management. They include:

1. Enrolment, which constitutes a significant part of the administrative work at the beginning of the session. This task, which provides a source of

essential information about the students, can be undertaken by clerks and may even be mechanized, either by punch cards or by computer techniques.

2. Progressive and detailed records of individual students.

3. Statistical returns for the college authorities and other appropriate bodies.

4. The collection of fees and disbursement of funds in accordance with any regulations that may exist.

5. Registers of attendance. Most government authorities will direct how these should be maintained in order that the appropriate financial grants may be paid to the college.

6. Secretarial and other services for the governing body, academic board, boards of studies, advisory and other committees.

7. Time-tabling, which is essentially a management task. A time-tabling system should show the arrangement and distribution of courses and classes; the loading and location of teaching staff; and the loading of rooms in terms of time, subject, and student numbers.

Inspection

Technical education is concerned as much with the development of character as with education and training for earning a living so that the individual can make a responsible contribution to the economic, social, and cultural development of the society in which he lives. The problems of technical education are therefore complex. They vary from country to country and from one district to another depending on the pace of social and industrial development, the availability and expansion of primary and secondary education, and the attitudes of parents, teachers, employers and adolescents to the value and status of technical education and training for technician jobs in the various fields of employment.

It is within this complex framework that the inspector has to operate. He has to assist colleges in achieving their objectives. He has to work with teachers and help them to develop improved methods of teaching technical subjects so that their students will acquire the knowledge, skills and attitudes they will need to obtain employment and be productive in industry. It is not his job to usurp the functions of the teaching staff or to issue instructions or directions to principals. Though he does make assessments, it is not his main task to evaluate the manpower output of a technician course against predetermined standards. Instead, he should concentrate on offering advice and suggestions on action that could improve the quality of the work in the college.

Full-scale formal inspections followed by a formal written report are now conducted only in exceptional circumstances, as, for example, when they are required by a government ministry or requested by a teachers' association. Their purpose is to enquire into every aspect of the work of the college, and to examine its buildings and equipment.

To do this, a panel of inspectors is appointed. They hold a wide range of discussions and consultations, and see the work being done in the lecture

theatres, classrooms, laboratories, workshops, library, and resources for learning centre. They consider the quality of human relationships that exist within the college and between the college and those organizations with which it is associated. They look at the curriculum of the various courses and programmes, and study such matters as the effectiveness of deployment of teaching and ancillary staff, development programmes for teaching and non-teaching staff, the utilization of space and equipment, teachers' records of work, student records, student counselling, examinations and standards, liaison and involvement with industry, and the management of accommodation.

Before any report is written, the inspection team should have full discussions with the governing body, partly to ensure that nothing in the report comes as a surprise to them and partly to secure their active support in implementing the recommendations. The report itself should in no way detract from the status of the college, the principal, or any members of the staff and student bodies.

Full inspections are unsatisfactory because they construct a profile of a college at a single point in time, because they do not last long enough to do the job properly and because they take place too infrequently to keep abreast of changing circumstances. More creative, constructive and effective work is achieved by means of visits of inspectors and advisers. These provide similar opportunities for discussion, support, advice (and sometimes criticism) but because no report is involved they build up more productive colleague-to-colleague relationships and closer liaison between the staffs of colleges and the inspectors.

The functions of an inspector of technical education are wide and far reaching in their coverage and responsibilities. He is the link in the partnership between the central government administration, the local government administration, the governing body, and the college staff. He interprets the views and wishes of the ministry of education, he provides specialist professional advice and information, and contributes ideas about new approaches and techniques for technician courses and the resourcing, administration and management of technical colleges.

In some countries inspectors have administrative duties and advisory functions; in others they are recruited or seconded on a short-term basis as full-time advisers or consultants; and in others inspection and administration are considered to be two different things, and inspectors are employed for the maintenance and development of educational standards and do not have administrative duties. The full-time inspectorate is the simpler arrangement, but its success depends on having clear job descriptions and a clear delineation of functions, duties and procedures. In either case specialist inspectors have a wider perspective than any college principal and teaching staff in advising on such matters as technician curriculum development, staff development programmes, forward thinking and planning for new kinds of technician course, and ideas about the internal organization, resourcing, and management of technical colleges.

The role of the inspector has changed. Nowadays he spends much more time

than in the past working with others in technical education, industry, professional and examining bodies, and research organizations, so as to acquire and exchange information on new needs, on curriculum reform and on standards in technical education.

A list of the duties of specialist inspectors employed by local authorities in Britain appears in a report *The Advisory Service in the Local Authority* (National Association of Inspectors of Schools and Education Advisers: Britain). It includes: (a) organizing the appointment of new entrants to the teaching profession; (b) the appointment, deployment, and promotion of teachers; (c) advising governing bodies on the appointment of senior staff; (d) inspecting and reporting on the work of teachers who are candidates for promotion; (e) maintaining an education staff development and training plan; (f) the establishment, development and running of teachers' centres; (g) teachers' courses; (h) curriculum development, research findings, new books and materials; (i) advice on internal organization; (j) briefing architects for new buildings; and (k) community relations.

The inspector has to communicate ideas, proposals and suggestions to educational authorities, governing bodies and teachers in such a way that he convinces them that he is a professional who knows what he is talking about. His reasoning has to be good. His appraisals must be more than generalizations, and his judgements must be more than assertions of personal conviction. The inspector should understand the values of the people with whom he has to deal, and appreciate what the work of teaching technician students involves. He should know exactly what the teachers and students are trying to accomplish, how best to tackle the job, and why one teaching method is more efficient than another. He must be able to stimulate development in ways of improving the quality and effectiveness of technician teaching and learning.

As a disseminator of new knowledge, the inspector should be allowed adequate time to keep abreast of current thinking and developments in the theory and practice of education and the associated field of psychology, behavioural sciences, organization and management, economics, and educational technology. He should be encouraged to develop and deepen any special interest he has in particular areas of the technical college curriculum. He should have opportunities for personal research and group research projects. Writing papers on particular educational themes, addressing specialist conferences, and participating in teachers' courses are important functions for which time and resources should be made available to the inspector

Technical Education Research and Development

In the past, research into technical education was generally neglected. It had little status or prestige, and it gained little support from principals and heads of departments. There are signs that this position is tending to change. No one can deny that there are many fields in which research is needed. The suggestions that follow indicate the range of studies from which selections can be made, in some cases by trained research workers, and in others by the staffs of the colleges themselves.

1. Selection for Courses

ADMISSION QUALIFICATIONS

(a) How far does success in a school subject (e.g. mathematics, science, drawing, practical subjects, native language) correlate with success in a technician subject at first-year level?

(b) What is a measure of a good standard of general education and how does it correlate with success in technical subjects and courses and in industrial training?

(c) What aptitudes are required, and how do they correlate with success in technical subjects and courses and in industrial training?

(d) How far does general intelligence correlate with subject and course success? For which technician courses does a student need to have more than average intelligence? In what technician courses and to what level is success possible with intelligence levels below average?

(e) What personal qualities correlate with success at different levels in different courses?

VALUE OF RECORDS FROM PREVIOUS SECONDARY SCHOOLS

(a) What kinds of record are provided from schools, how are they compiled, how is the information validated, and how reliable and objective are the reports? What are their limitations and how could they be modified to be of more value in giving educational guidance at the technical college enrolment stage?

(b) How can inspectors and advisers become more expert in the techniques of educational and vocational guidance in relation to technical courses?

2. Variety Within Classes

VARIETY IN ATTAINMENT

(a) What previous mathematical knowledge is needed before a student starts a technical college course in mathematics?

(b) What techniques can be used to fill in any gaps existing in a student's knowledge before he embarks on a technical course proper?

VARIETY IN ABILITY

(a) What tests exist, and what tests are needed to ascertain individual levels of ability and attainment in different subjects at different levels?

(b) What techniques are most successful in ensuring that the brightest students work as intensively and as quickly as possible to reach the required levels in their technical studies?

(c) What techniques are most successful in ensuring that the least bright have a reasonable chance of reaching the minimum pass level?

VARIETY IN TRAINING

(a) Should students who are taking the same course but who are destined to take up different forms of employment (e.g. one in the drawing office, another on operating machines, another on routine maintenance) be given the same exercises and take the same examinations? If not, what should be done to ensure

that they cover the course successfully?

(b) How can the effect of industrial training on technical college progress in individual subjects be measured? Are compensations desirable? If so, how are they to be evolved and applied?

(c) If it is necessary to practice industrial skills in the technical college, should all students be practising them in the same way at the same time, and if not, what modifications are necessary and how can they be introduced?

3. *Co-ordination with Industry*

(a) How can a technical teacher best learn about the day-to-day programme of students who are engaged or will be engaged on technician tasks in local industry? How can college education be co-ordinated with industrial training so that theory is related directly to practice?

(b) What are the functions of advisory committees and how can the committees be made more effective?

(c) What are the particular values to be attached to different types of industrial experience for technical teachers for the purposes of teaching at different levels on various courses? After how many years does industrial experience cease to be relevant and valuable without refreshment?

4. *Teaching Methods*

EFFECTIVENESS

How can effectiveness of a teaching method be best evaluated: (i) by various types of examinations and other forms of assessment? (ii) in the application of learning to industrial operations (e.g. the relative merits of lectures, lessons, projects, discussions, assignments, case studies, role playing, programmed learning, CCTV, and team teaching techniques)? and (iii) in terms of active learning?

TIME AND JOB ANALYSIS

How can technical syllabuses be converted into schemes of work so that teachers can plan their work on a sensible basis?

TEACHING AIDS

How should the use of demonstration experiments, teaching models, film strips, film, diagrams, and other devices be mixed or put in sequence to raise the quality of technical class teaching?

LESSON PREPARATION

What lesson notes would help technical teachers to improve the quality of their teaching?

5. *Libraries*

What are the relative merits of reference books and textbooks for various subjects at different levels of technician education?

6. *Technical Education as a Subject*

How did any particular technical college start, and what personalities, factors, sequence of events have affected its development?

There can be no doubt that the need for technical education research exists, and that there are enough young technical teachers in any college to make a start. What is often lacking is professional leadership, official encouragement, and an organization to co-ordinate effort. A research committee of persons of established reputation and calibre can advise principals, heads of departments and industry about the best way to proceed. They should also give whatever help they can towards the publication of the results whenever they make a contribution to the thinking and practice of technical education. As things are at present, problems are too often either ignored altogether or approached by rule-of-thumb methods, solved by the mystique of age or divine inspiration, or dealt with in an authoritarian way which industry would not tolerate.

Included among the research activities requiring greater resources than exist in the average technical college are: (a) devising new patterns of technician education and training courses tailored for particular occupations in new and modernizing industries; (b) an analysis of specialist technician occupations and of specialist technican jobs; (c) time taken and time necessary to educate and train different kinds of technician; techniques of accelerated technician education and training; adult technician training and retraining; the development of self-pacing learning programmes; (d) technician education for women; (e) the general pattern of industrial employment in the country, and the immediate and future needs for technician manpower; (f) identification and definition of emerging technologies; (g) the best use of its technicians in industry; (h) the status of technicians in the industrial organizations and in society; (i) design of technical college buildings, and laboratory and workshop equipment for technician courses; (j) the design, furnishing and stocking of technical college libraries; (k) the teaching and non-teaching staffing establishment of a technician education and training institution; (l) the decision-making process for capital investment programmes; (m) planning and managing the economic and effective use of resources of technician teaching and non-teaching manpower, accommodation and equipment in colleges; (n) the content and organization of schemes of practical training for technicians where industrial development is not at a stage to train technician manpower by the traditional methods of industrialized countries; (o) the development of mobile instruction units; (p) the development of correspondence courses for technician education and training; (q) educational measurement; (r) technical subjects in the secondary curriculum; and (s) courses for principals, heads of departments, and other members of the academic and administrative staff.

Though the selection of the priorities for investigation and research will differ from country to country, the principle that research is essential is universally true. In short, unless proper research-based evidence is available, much of the vast investment in technical college buildings, equipment and staff salaries may be wasted and opportunities to improve the quality of technical education will be lost.

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This book, by a recognized authority on the subject, will be of value to all who are concerned with the education and training of technicians. It is uncompromising in its view that the shortage of trained technicians in developing countries has retarded their pace of industrialization, and that their future economic and social progress will depend on the quality and quantity of technicians they produce. For, in the words of L. S. Chandrakant:

'It is imperative for all developing countries to train and develop their own indigenous personnel as competent technicians. In the final analysis the pace and direction of the economic progress of developing countries will largely depend upon how far they solve their technician problem.'

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