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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.

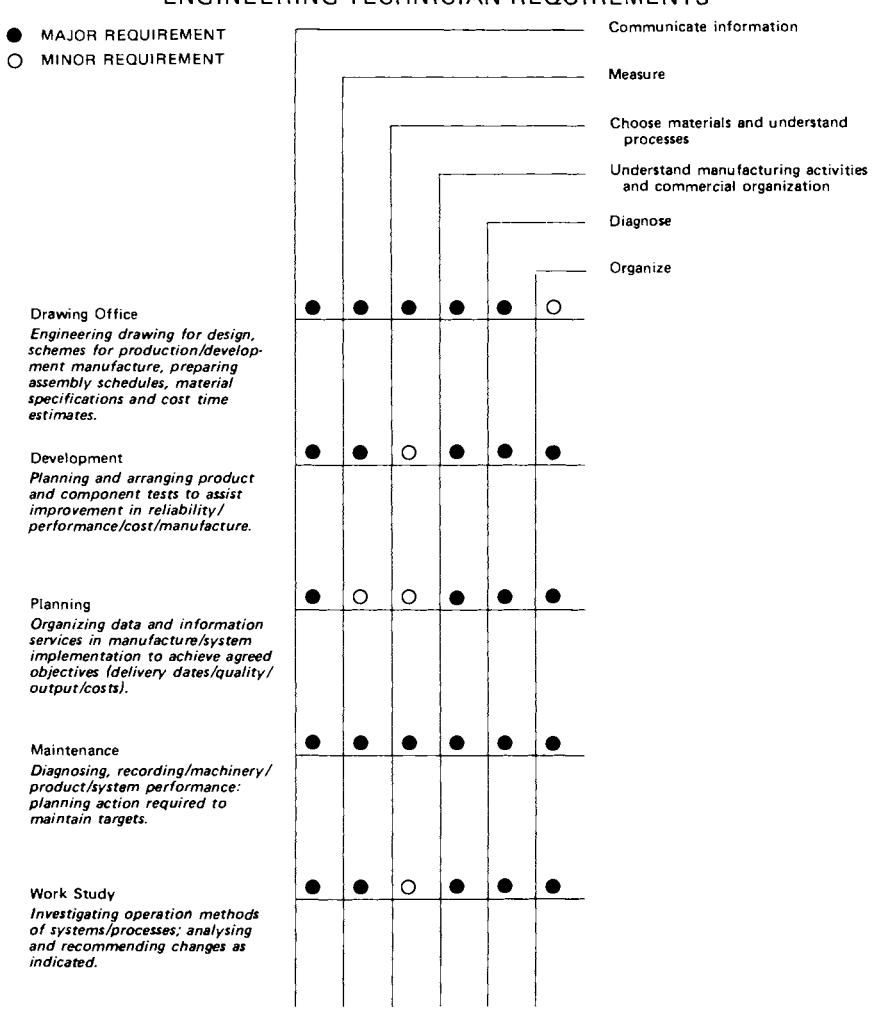

Figure 1

(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.

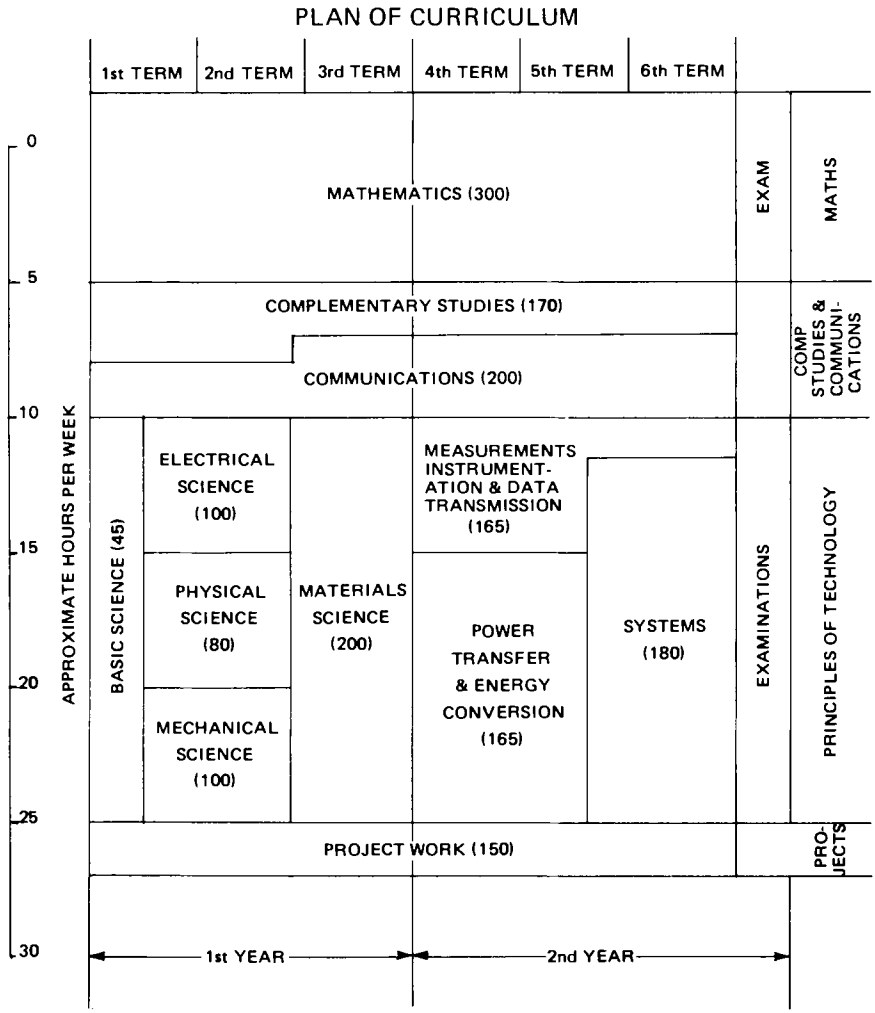

Figure 2

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.

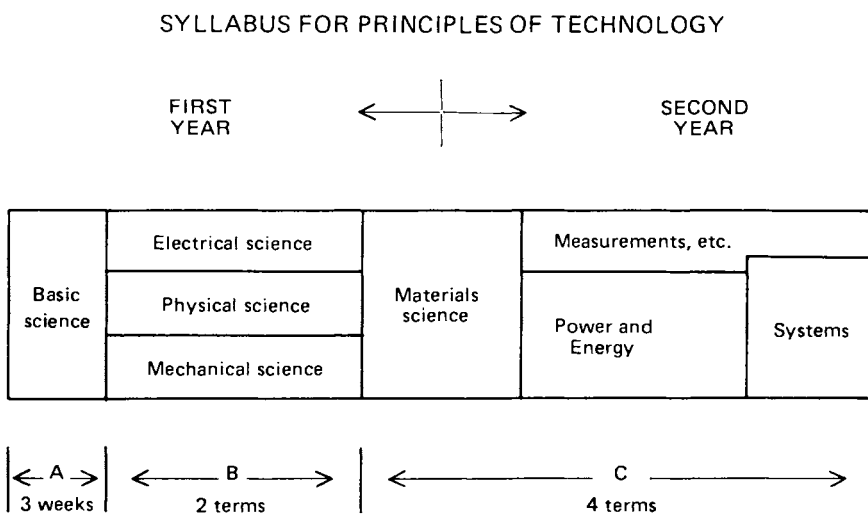

Figure 3

'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

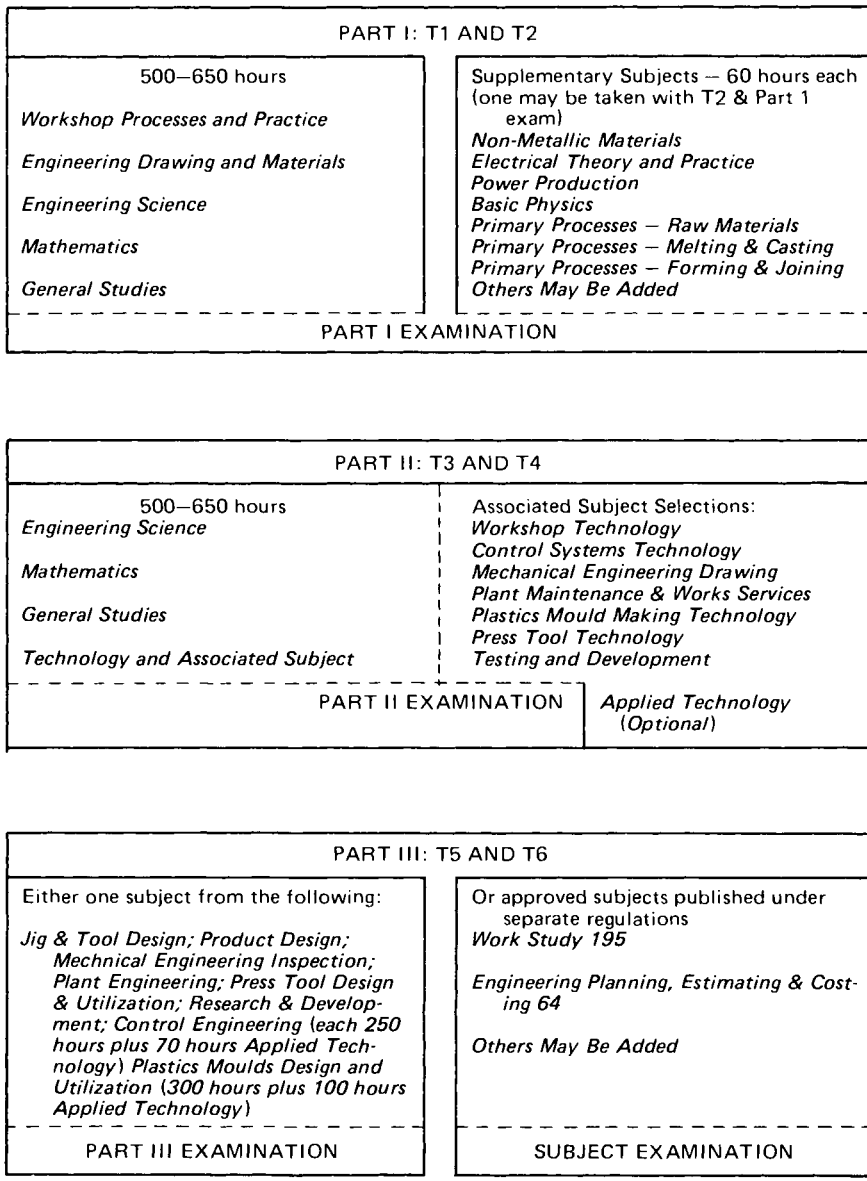

Figure 4

(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.