Section 3

PRODUCTION AND TRAINING

The third meeting on low-cost science teaching equipment, sponsored by the Commonwealth Secretariat and held in Papua New Guinea, had training as its main theme; 'Training for Production' and 'Training for Use' were the topics of the two lead papers.

In this section an attempt has been made to relate the components of an equipment development and production unit to schemes of training for personnel who would be required to staff the sections of such a unit.

Training for the Development and Production of Low-Cost Teaching Equipment

As can be seen from the previous section, there are already a number of production units in existence around the world which could be used as a model for establishing a unit. But in any country the unit with the greatest chance of success is the one that takes into account such local factors as the educational system (particularly its economics and organisation) national industrial structure, availability of small scale-industries, and available manpower. The danger of taking another unit as a model is that all the factors used in establishing it are relevant only to that particular country (1).

Whatever system of production is established, a range of skilled and unskilled manpower will be needed. The skills required will include engineering, administration, design, production, storekeeping and driving. Suitably qualified staff are of prime importance in a production centre, and a full appreciation of their importance can only be obtained by studying the components and operations involved in producing the end product.

Components of a Production Unit

When considering the production of any item we are concerned with the method of obtaining the end product through the inputs, the production process and the outputs. With inputs we are concerned with such items as buildings, plant, materials, finance, supervision, labour, management, orders, as well as design and ideas, etc. With production we are concerned with the manufacturing and assembly of the end product, whilst with output we are concerned with getting the goods to the classroom.

We can include within this process three basic components. These are the premises where the production takes place, the people who carry out the production process, and the production process itself. It can be seen, therefore, that the operation of producing the end product - in our case the provision of school science teaching equipment - is a complex business.

Let us consider this process. We should first dispel a myth regarding the teacher's role in equipment production. It is a commonly held idea that teachers are the best designers of science teaching apparatus, and consequently the best producers of their own requirements. A number of efforts have been made to get teachers or students to produce science teaching apparatus in bulk, and some simple production units have been set up in teacher establishments, including universities, using existing facilities. In all cases the large-scale production aspect has not been realised. The reasons can be summarised by saying that teachers can produce a piece of simple apparatus for their own needs after having acquired some basic skills in woodworking and metalworking, but to mass produce the same item to an educationally 'student proof' quality requires skills and physical resources which teachers do not possess. A science teacher's training does not normally involve acquisition of skills relating to engineering production.

Nevertheless the teacher's role in the development of a piece of learning apparatus is extremely important since the pupils are the most important beneficiaries. It operates at the beginning when protoypes are being designed and tested, and at the end when the finished product is being used in lessons. The intermediate stages of functional design and production are not the teacher's concern, for they are the problems of design and production engineers.

The production of equipment thus has three fairly clearly defined stages. The first is the 'ideas' or 'input' stage when a prototype linked to the curriculum is produced and tried out in schools. The second stage is the 'production process' during which the final prototype is turned into an 'industrial design' and the item is mass produced. The third stage is the 'output' or 'distribution' stage when the items are collected from the producers and distributed to the user. It is interesting to note that there is a very important appendage to this third stage, namely 'repairs' or 'after sales service', about which more will be said later. Each of the three stages will be looked at in turn.

Stage 1: The Design and Development Process ('Input')

Curriculum Requirements

In Section 1 an attempt has been made to outline the changes taking place in the science curriculum. The changes are mostly leading towards an inquiry-based approach to the learning of science. An important point mentioned is that successful science curriculum development nessitates the collaboration of many educational institutions. Curriculum units or centres, teacher training institutes, and university education facilities must work with teachers in the field to produce material that is relevant both to national educational goals and to teachers working in the classroom.

This is equally true for the development of teaching apparatus, which must be related to the curriculum. Equipment production centres therefore require a section which can liaise with the curriculum development groups and develop their ideas and requirements into practical terms.

From the engineering point of view this constitutes part of the market research activity (the investigations necessary before deciding what article is needed). The questionnaire developed by SEPU to survey the existing equipment position prior to developing material is a good example of part of the market research process. It is shown in Appendix 1, at the end of this Section.

The Design and Development Section

This section should be staffed by qualified, experienced science teachers, qualified technicians in a number of disciplines, and a design engineer. It is most important that the design engineer forms part of the team since, besides being involved in the development of prototypes, he or she will be responsible for converting the prototype approved for production into a series of mass production components.

The role of evaluation and experiment cannot be over-emphasized. One can still find some 'ivory tower' people who claim that trial testing is not needed since they know the requirements. It often happens, however, that the more remote they get from day-to-day teaching the more vague become the memories of classroom practicalities. For this reason the rotation of the teacher component of the development section is desirable. In some places this scheme already operates with teachers being seconded from the classroom to the centre for a period of two or three years and then returning to the classroom. By operating a staggered system of recruitment, the development section is always staffed both by 'experienced developers' and by 'new boys' who can bring in the up-to-date classroom problems. RECSAM, for example, attempts to include in all of its training courses personnel from previous courses, and this appears to provide the necessary continuity.

Evaluation also needs to be a continuing activity. Curriculum projects are often evaluated as they progress, and some projects employ a person to do the formative evaluation as the development of the material progresses. Unfortunately very little attention appears to be given to evaluating the development of science teaching equipment produced by low-cost production units. More often the 'good idea' is turned into a piece of apparatus, or kit, which is distributed without first testing its effectiveness.

Evaluation, however, needs to be more than formative, for items of equipment will need further evaluation once they have been in use for a period. This applies not only to apparatus and equipment but also to curriculum and printed materials, especially where commercial interests are involved in their marketing and distribution. Science equipment manufacturers, either international or national, may decide to manufacture and market items developed locally. The inexperienced teacher who has to order equipment from a catalogue without seeing the item beforehand is liable to be influenced by the publicity.

Whatever method is adopted for marketing and distribution, a further evaluation will be needed. This should best be carried out by an impartial observer, since anyone involved in the actual development process can easily be biased towards 'proving' the product. In the United Kingdom there are examples of two groups which evaluate science equipment. One is the Scottish Schools Science Equipment Research Centre (SSSERC), based in Edinburgh and financed by the Scottish Education Authority. The other, in England, is the Consortium of Local Education Authorities for the Provision of Science Equipment (CLEAPSE), based on the campus of Brunel University in Uxbridge but wholly financed by member education authorities. Though both primarily examine and assess existing apparatus, they also seek to modify or develop new apparatus or equipment. Close liaison exists between them and equipment manufacturers, and relevant information is disseminated to teachers via regular bulletins and through exhibitions and other activities on 'open days' when teachers visit the centres to discuss professional problems. On a smaller scale it is possible that an evaluation group established within a Science Teachers Association, or at a national university, would be equally effective.

When budgeting considerations are being made for the production centre, special attention needs to be given to the design and development section. Since the section is concerned with making and trial testing apparatus, flexible budgeting arrangements are needed for travelling and expenses, as well as for procuring materials. Ease of local purchase is essential for a development operation. A delay of a few weeks in obtaining a box of screws or a packet of solder brought about because the centre has to purchase everything through a government ministry is sometimes a great stifler of enthusiasm. A centre which has its own accounts section can overcome this stumbling block.

Industrial Design and Manufacture

Whereas the educators are the link to the consumer, the industrial designer is the link from development to production. It is at this stage that the teacher plays a passive role. He or she will be asked to trial test the production model before it is mass produced, but if the designer has been working properly during the prototype stage, very little difference should exist between the finished prototype and the end product. It is likely that the difference will be 'cosmetic' rather than functional, differences in the choice of suitable materials, colour, scale, etc.

The design team will probably consist of the team leader who is the design engineer and draughtsmen who are capable of preparing the detailed working drawings. Once the team have decided upon materials and operations, the item will be 'costed', that is, an estimate of the production cost will be made. This estimate will include such details as cost of new materials, any special tooling needed, any sub-contract work to local industry, labour charges and so on. Once this has been carried out, final approval for the go-ahead to manufacturers may be sought from the policy-making committee. This approval will generally be a rubber stamping operation since the original approval to develop the article was given before the development stage (i.e. during the initial market research). At this stage the most important factor is the provision of adequate finance to manufacture the article.

Another individual who is involved with the design team is the production engineer. As head of the production process his or her experience in programming work through the various workshop facilities is utilised in order to fit the new item into existing production schedules. Besides programming he or she will also assist with the advance procurement of the necessary materials needed to make the components, and will also indicate which items have to be sub-contracted out for manufacture by local industry. In a small-scale operation the design and production engineers are likely to be the same person.

The Education and Training of Curriculum Developers

The normal pattern is via diploma and degree courses in education, usually leading to a Masters' Degree. Project work related to such courses may often involve some aspect of apparatus/visual material development. The courses are of one or two years' duration, and are organised by most universities worldwide (refer to directory of courses at university of choice). For science education, universities with science education centres can be an advantage. Two main centres in the UK are Chelsea College Centre for Science Education, University of London, and University of Leeds School of Education Centre for Studies in Science Education. The Science Education Centre at the University of the Philippines, the Science Curriculum Centre, Njala University College, Sierre Leone, and the Institute of Education, University of Ibadan, Nigeria (particularly for evaluation techniques) are of particular interest.

The Education and Training of Designers

The design process normally starts with the designer discussing what is required. The designer then sketches design proposals, sometimes making models to check that the design works. Once the design proposals are agreed the designer works with others on the production prototypes and drawings which act as instructions to those who will make the product. Design can be divided into two broad headings, industrial and engineering. The sub-categories of industrial design are broadly graphic, textile and fashion, and three-dimensional design. This latter grouping is further divided into environmental and industrial design (engineering). The sub-categories of engineering design are mainly mechanical, electrical/electronics, aeronautical, chemical, civil, marine, municipal and production engineering.

Industrial Design (Engineering)

A few degree courses are offered by universities but the widest range are in the polytechnics and colleges of art. The normal pattern is a three-year course leading to a first degree (or a four-year sandwich degree course).

Engineering Design

An engineering designer needs technical knowledge which takes some years to acquire before he or she can design products, first becoming an engineer and then specialising as a designer. The route would normally be through an engineering course at a university or a polytechnic. Since this area is more relevant to the production aspect, details are given later. Following on from a first degree (or other acceptable qualification) a number of postgraduate courses are available ranging from one to three years' duration. These courses generally lead to a MA in design.

To complete the picture there are a number of pre-degree courses available. For example, some colleges offer foundation courses of one or two years' duration which are designed to lead on to a degree programme. It is also possible to study for GCE A level awards in design and craft. Vocational courses of from one to four years are also available, often geared to the specific requirements of industry. They may be either regionally examined or nationally certified such as those of the City and Guilds of London Institute. Reorganisation towards TEC courses is taking place in this area.

When selecting individuals from a production unit for further training in the field of industrial design (engineering) it is likely that the most suitable candidates are going to be science graduates or technical teachers.

For design courses in the UK, a minimum period of three years should be considered. Suitable centres for study are Central School of Art and Design (London), and the polytechnics of Birmingham, Leeds, Leicester, Manchester, Newcastle-upon-Tyne, Sheffield and Teeside. For further details refer to 'Design Courses in Britain' available from: The Design Council, 28 Haymarket, London SW1Y 4SU, UK.

At present few opportunities for training in this field in the Third World are available. Certain universities in Canada have industrial arts courses. In India there is a National Institute of Design established by the Government. A professional course of education leads to a diploma in design after some five and a half years of study. Reference should be made to the Commonwealth Universities Year Book for specific courses.

The Education and Training of Draughtsmen

The drawing office is the section within the design, development and production unit which is under the direction of the designer. It is from this point that the rough sketches or simple drawings of the prototypes are turned into the detailed working drawings from which the workshops will make the finished article.

Courses of training for draughtsmen will usually be available at a government trade centre or technical training institute and it is unlikely that overseas training programmes would be required for this category of staff.

Before leaving the curriculum and equipment design and development unit it is necessary to consider the workshop of the designer for developing the prototypes. This small workshop needs to be staffed with technicians who have a range of skills to meet the needs of the design staff. The role of the well-trained science laboratory technician can be of value in this capacity, as well as in the area of repairs and maintenance of school science equipment.

Training Courses for the Training of Science Laboratory Technicians

The provision and training of school and university science laboratory technicians is long established in the United Kingdom as well as in some of the Commonwealth countries. With the increasing emphasis on learning science through practical activities, many countries are paying attention to the local development and production of apparatus and the maintenance and repair of equipment. Both of these activities require trained science laboratory technicians (2).

The internationally recognised course for the education and training of science laboratory technicians is the City and Guilds of London Institute Course 735 - Science Laboratory Technician's Certificate. This course was designed by the Institute, in conjunction with the Institute of Science Technology. Its purpose is to meet the needs of technicians employed in educational institutions, and may also suit those in research and industrial laboratories. It aims to provide a thorough grounding in basic laboratory practices and a sound knowledge of the underlying scientific principles. The course is divided into three parts: Part I, general science and techniques; Part II, biology or chemistry or physics techniques; Part III, science laboratory administration plus an elective subject such as scientific instrumentation. This latter part is usually taken after some years of experience in science laboratory technology and can lead to the award of a Full Technological Certificate of the City and Guilds.

Within the United Kingdom changes are taking place with regard to all technician-type courses. These technician courses of the City and Guilds, as well as the ONC/HNC courses of the various professional institutes have been rationalised into new courses which are administered and examined by the Technician Education Council (TEC) and the Scottish Technician Education Council (SCOTEC).

Comparability between existing awards and the new awards are difficult to make. A TEC Certificate is intended to be of a standard comparable with that of an ONC (midway between Part I and Part II of the CGLI 735 Course), that of the Higher Certificate being comparable to a Higher National Certificate. Similarly for the Diploma awards it is envisaged that the Higher Diploma will enable students to proceed to degree and comparable courses of higher education.

The TEC Certificate programme which is replacing the CGLI course 735 is the Certificate in Science - Science Laboratory Subjects. A Certificate programme involves the study of 15 units, each unit requiring a minimum of 60 hours study. The TEC modular system places less emphasis on an end of course final examination but requires continuous assessment of students progress by course work and periodic assessments tests within each unit.

In addition to the Certificate in Science - Science Laboratory Subjects, other closely related Certificates in Science are, Medical Laboratory Subjects, Animal Technology, Medical Physics and Physiological Measurements, and Applied Biology.

Although the CGLI course 735 is likely to continue in the UK till the mid 1980s it would be advisable to consider placement for the Higher Certificate or Diploma after 1981. It is envisaged that the CGLI 735 will continue to be operated for overseas centres for some time to come.

When selecting individuals for training as science laboratory technicians, aptitude for the work is as important as the basic qualifications for entry to the course of training. This is the case for all technician training.

Some 60 UK centres offer training in science laboratory technology at various levels, courses lasting from two to four years depending upon point of entry. Three such centres which cover the widest range of options and with expertise for overseas students are Paddington College, London; Mid-Herts College, Welwyn Garden City; and Handsworth and Erdington College Birmingham.

The following list indicates overseas centres where the CGLI 735 course is available: For Part I: University of Addis Ababa, Addis Ababa, Ethiopia; Accra Polytechnic, PO Box 561, Accra, Ghana; Hong Kong Technical College, Hunghom, Kowloon, Hong Kong; Ahmadu Bello University, Zarin, Nigeria; Technical College, PO Box 2958, Dar es Salaam, Tanzania. For Parts I and II: University of New England, Armidale, New South Wales, Australia; Kenya Polytechnic, PO Box 30214, Nairobi, Kenya; The University, Ibadan, Nigeria; Yaba College of Technology, Yaba, Lagos, Nigeria. Science Laboratory Technician training courses are also held at: University of Jordan, Amman, Jordan; and Swaziland College of Technology, Mbabane, Swaziland. Further information can be obtained from: The Institute of Science Technology, 335, High Holborn, London WC1Y 7PX, or the City and Guilds of London Institute.

Stage 2: The Production Process

The Production Facilities

Having completed the process of turning the original design sketches into working drawings for use by the production workshop, a number of steps have to be taken before any components can be manufactured. One such step is 'tooling', the process of making any necessary dies, moulds or jigs for plastic injection moulding, casting, press tools, automatic lathes, and so on. The degree to which this will be needed will depend upon the object to be made, the number required, and whether the production process is to be labour intensive or capital intensive.

The following example of the components of a production workshop at the NCERT is taken from a paper presented by Mr Bhattacharyya at the regional seminar held in the Bahamas in 1976. 'Once the design has been worked out, the design office makes the drawing of the approved model with complete technical specifications. The drawings are then passed on to the production section for the batch/mass production through the production-planning and control section. The various functions of the centre producing low-cost science equipment are as suggested in the diagram on page 59.'

In the case of sub-contracting, quality must be maintained, and it is essential to have within the centre a quality-control group who carry out a regular sampling of products from within the centre as well as items (either parts or whole units) purchased from outside. This group will most likely be part of the production process functioning under the supervision of the head of production.

Looking at the staffing structure of a production unit, we note that a variety of skills are needed. The training of skilled personnel is less of a problem in countries which have an industrial base to build upon. They have technical colleges and trade schools to provide individuals with some of the necessary training. Further specialised training will of course be needed in some fields as, for example, plastics work where the manufacture of the dies is a skilled process. There is a strong argument for regional co-operation when it comes to the use of plastics and the dies required. One consideration is the compatibility of machinery which would facilitate the interchange of dies between countries. Another consideration is the material from which the die is made. A die made for a production run of 100,000 units would need to be made of tougher material than one required for a 1,000 units. This pre-supposes that one country produces similar items to another. Although this has not yet been qualitatively surveyed, a look at a number of countries indicates that there are similarities, and basic items such as test-tube, racks, stands, and clamps, etc, could probably be standardized to one design, requiring regional co-operation. In using plastics one requires some new skills, whereas in using indigenous raw materials it is likely that local craftsmen are already skilled in their use. The employment of such people would naturally require considerably less investment in training.

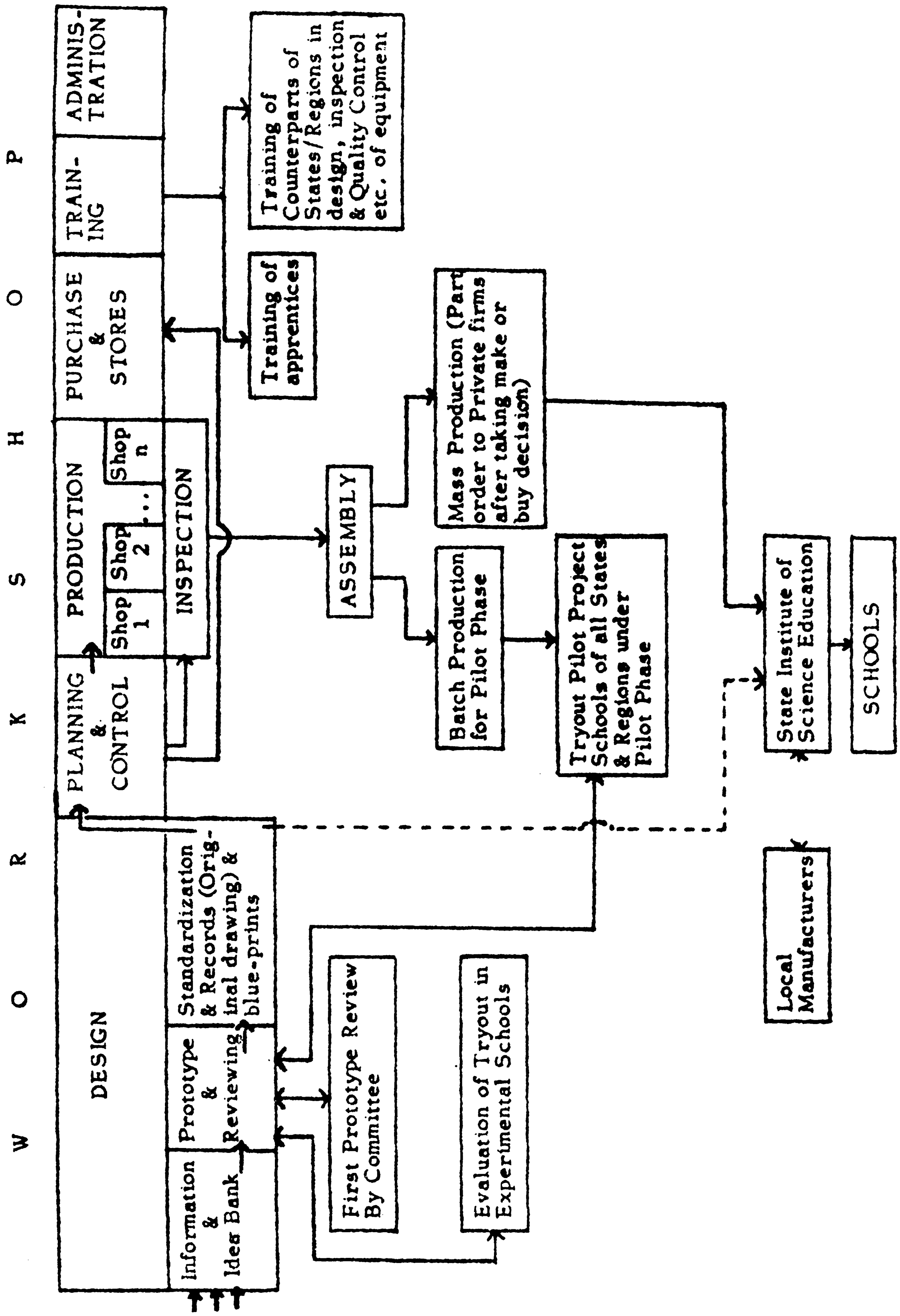
Training Courses for Production

The production aspect of educational equipment starts with the production engineer whose responsibility is to ensure the end product is produced as economically as possible. With production we are concerned with the professional engineer, skilled technicians, and craftsmen, as well as administrative staff, storekeepers and unskilled workers. Within the equipment production unit the workshop head is a professionally trained production engineer. His skills turn the designed product into an economically produced article. His training needs to be broad since a number of products are likely to be manufactured; consequently he must be experienced in such areas as design and manufacture, production technology and production management.

The Education and Training of Production Engineers

There are many universities and polytechnics offering graduate training for production engineering. Courses are generally of three years duration on a full-time basis or four years for sandwich courses, and are generally made up of compulsory and

Suggested Activities of the Design, Production and Evaluation Centre at the National Level



option subjects, the latter catering for the many facets of production engineering. One year Masters degree courses are also available at some universities which can cater further for a particular area of specialisation.

When selecting individuals from a production unit for further training as production engineers, it is essential for the individuals concerned to have an engineering background. This may mean selecting a good technician or technical teacher who has the necessary certification to gain entry into a degree programme. Naturally if a qualified mechanical engineer were available he or she would probably be able to proceed to a one or two year Masters degree course, but it is unlikely that a science degree would be accepted due to the deficiency in basic engineering principles.

Some 20 plus institutions in the UK offer degree courses. A short list of five who could provide suitable programmes are: University of Aston in Birmingham; Brunel University, with the possibility of a work experience project in conjunction with CLEAPSE, (see page 53); University of Birmingham; Leeds Polytechnic; Sheffield City Polytechnic; Teeside Polytechnic; and Trent Polytechnic, with the possibility of a joint programme with the National Centre for School Technology.

A number of universities in the industrialised countries have degree programmes in production engineering. For specific courses reference should be made to the Commonwealth Universities Year Book.

Each component in the production unit will have a staffing structure of unskilled, semi-skilled, labour, craftsmen, technicians and supervisors (head of section). The traditional path to a Workshop Supervisor was many years of experience on the shop floor with gradual promotion to an eventual position of responsibility. With the increasing complexity of technological processes the supervisor in a modern production unit may have a degree with the relevant practical experience, or a Higher National Certificate Diploma or City and Guilds qualification. A component in his or her education and training would have been on managerial/instructor skills.

Training for Heads of Sections (Supervisors) for the Various Workshop and Other Facilities

In a country where newly qualified technicians (or experienced technical teachers) are recruited to supervisory positions it may be necessary to provide them with training in supervisory/instructor skills. If the individual is receiving fellowship training related to his or her basic skills a check should be made that the course of study includes studying supervisory roles. If not a short course of training should be allowed for. For individuals who are being sponsored for specialist short-term study awards related to a specific skill, again an additional short period of study should be included.

An educational equipment development and production centre is likely to be called upon to participate in in-service courses for teachers and laboratory personnel. In addition the semi-skilled and unskilled staff of the centre will require basic training and refresher courses. If the workshop supervisors have received a basic training in instructor techniques then the instructor requirements for such courses can easily be met from within the centre.

In the UK such training can be provided at one of the Instructor Training Colleges of the Manpower Services Commission, Training Services Agency. Details of the programmes of this Agency are given below.

The Education and Training of Technicians and Craftsmen in the UK

A wide range of skilled personnel are required in a production unit although the numbers and range will depend upon the items to be produced and the size of the unit. Areas where skilled personnel are likely to be required are: mechanical engineering, electrical/electronics engineering, sheet metalwork, welding, foundrywork, jig and tool making, fine instruments, plastics, woodworking and cabinet making, scientific glassworking, electro-plating and metal finishing, quality control and inspection. Within these areas a number of sub-divisions may be needed.

In the UK the TEC and SCOTEC courses would be appropriate for technician training programmes. For technicians and craftsmen requiring additional training in specific skills the courses offered by the Manpower Services Commission, Training Services Agency at their Skill Centres are likely to be appropriate. Training can be arranged for craftsmen, supervisors, instructors, chief instructors, training techniques officers, tutors, safety officers, manager or director of a training centre, and manager or director of an instructor training college. Attachments for an individual can be made to cover training in a number of the above disciplines.

Training in Skill Centres can be arranged in over 40 different trades and can be made to suit individual training needs. Courses are designed such that 80% of a course is of a practical nature, the remainder consisting of the necessary theory for developing the skills.

There are some 77 Skill Centres in the UK which, unlike other training institutions, operate on a year-round basis. Consequently placement on courses can be on a continuous basis and not necessarily on a once-a-year basis as with academic institutions. A further advantage of the Skill Centres is that relevant training programmes for skill development can be incorporated in the study programmes of individuals following more formal academic courses, for example, in the long vacations.

The TSA are responsible for five Instructor Training Colleges and Units which provide Instructor Training Programmes for industry and commerce. A basic training course lasts for two weeks and an advanced training course lasts for one week. Special modified courses can be provided if numbers warrant such a course (minimum of 7 persons).

Relevant Courses at Skill Centres	Engineering Production	Engineering Servicing
	Automatic lathe setting Boring, setting/operating Capstan setting/operating Centre lathe turning Milling setting/operating Precision grinding Sheet metal work Toolmaking, fitting and machining Welding - electric arc	Draughtsmanship Engineering inspection Fitting - general Fitting - jig and tool Fitting - machine tool maintenance Detailed fitting and machining
	Electrical/Electronics	General Servicing
	Electronic wiring & circuit testing or industrial electronics Fitting - electrical Instrument maintenance Radio, TV and electronic servicing	Domestic appliance servicing Typewriter repair and maintenance Watch and clock repair Furniture - cabinet making Scientific glass blowing

The duration of courses range from a few weeks to a year depending upon the type of course and the point of entry of the trainee. The initial week of the course is used to identify the ability of the candidate and fit the programme to the candidate. (Of particular note, scientific glassblowing would be 26 weeks, and watch and clock repairing 52 weeks). At the successful completion of a course of training the trainee receives a Certificate of Training. In some cases, depending upon the education and background of the trainee, arrangements can be made to sit the appropriate City and Guilds examination.

City and Guilds of London Institute

Many City and Guilds technician courses (as well as their craft courses) continue to be available in overseas countries, and centres throughout the world offer these courses.

Technician Schemes retained for Overseas Needs

255 - Mechanical Engineering Technicians
257 - Refrigeration Technicians
270 - Telecommunication and Radio, Television and Electronics Technicians
271 - Telecommunication Technicians
275 - Industrial Measurement and Control Technicians
280* - Electrical and Electrical Installation Technicians
281* - Electrical Technicians
390 - Motor Vehicle Technicians
427 - Cotton and Allied Textiles Technicians - Yarn Production
626 - Construction Technicians
627 - Builders Quantities
725 - Science Laboratory Technicians
800 - Ordinary and Higher Tehcnician Diplomas in Mechanical and Electrical Engineering
801 - Ordinary and Higher Technician Diplomas in Building, Civil Engineering and Construction
803* - Electrical Engineering Practice
860 - General Course in Engineering
861 - General Course in Construction

*From 1983 these examinations will be incorporated into a single scheme entitled "Electrical Engineering Technicians" under subject number 803.

The exact details of each scheme can be obtained in the form of syllabus pamphlets. An annual publication (Form II), 'Courses and Examinations outside the United Kingdom', lists all schemes and indicates whether or not examinations are available overseas. Basic trade and craft training would not normally be eligible for fellowships hence details of such courses are not provided. The duration of study for technician training is up to three years, and courses are held in the United Kingdom and/or appropriate Third World countries.

Details of centres in other countries can be obtained from: The City and Guilds of London Institute, 46 Brittania Street, London WC1 9RG, UK.

Stage 3: Storage and Distribution ('Output')

The basic facility for this stage of the process is a well-designed area, the function of this stage being to receive from the production process a series of items which then have to be stored, or assembled into kits and then stored, for later distribution to educational institutions.

Although the production unit will have storage space, this will be mainly for raw materials, parts and tools. If, however, the final products from the centre are going to include imported items, for example chemicals, then the storage area becomes a little more complex since it requires a section which can take the bulk purchases and package them according to individual school requirements.

Mention has already been made about purchasing parts from the local market for assembly into part or complete pieces of equipment. Local purchase does not have to stop there. When looking around a village bazaar one finds a variety of expertise ranging from cloth dying and pottery to gold smithing and similar arts. In both cloth dying and pottery, chemicals and dyes are used to either colour the cloth or glaze and decorate the ceramics. Often these chemicals and dyes are obtained locally from natural resources. No doubt there are natural resources that could be used by the centre, perhaps by stimulating a local co-operative or trader to supply them and thus reduce the number of items imported from abroad. Besides, schools usually require only small quantities of such materials at any one time, and the supply may therefore be well within the capabilities of a small trader. The trader could probably package them into the right quantities for schools and so avoid further re-pakaging at the centre (quality control is important if this method is to be used). In island communities spread over a wide area one can find many techniques, originally developed for survival, which could be utilized by the centre for the benefit of schools. For example, the use of particular leaves of plants or trees for dyeing or medicinal purposes, substitutes for ropes and strings, liquid containers from bamboo, and so on. An investigation of local resources is an important but often overlooked part of the initial planning of many centres.

The location of the stores in the centre should be in close proximity to the production unit to reduce handling and movement to a minimum. However the final storage in the warehouse does not necessarily have to be integrated with the other units and could be located in a separate building depending upon the distribution methods to be used. For example, a ministry of education might already have a warehouse for other educational materials, such as paper and writing materials, and it might be desirable to store the finished produce from the centre in this store so as to integrate them into the existing distribution system.

Particular attention needs to be paid to packaging and distribution, since it has to be remembered that the final destination of the output from the centre may be a week's travel over bad roads. Roads, though, are not the only transportation problem. Island and river communities may have problems related to water transport. To deliver equipment to these communities requires particular attention to packaging. The effect of sea water, corrosive atmospheres and humidity, the complete immersion of a package in water, may have to be considered. An unseen hazard is the reaction of one or more chemicals if sea-water seepage occurs. Again, the packages will probably be handled a number of times by unskilled, sometimes illiterate, labour on route. Packaging therefore, must be properly done to prevent breakages and deterioration from the environment, factors to which too little attention is paid.

When considering distribution to schools, one has to weigh up the alternatives. Some questions that should be answered are: Which are more reliable, local or national carriers? Is it more economical to distribute by commercial hauliers or to have a fleet of vehicles belonging to the centre for this and other purposes? With this latter possibility in mind, the procurement of multi-purpose vehicles would give flexibility to the centre's operations, remembering that materials need to be trial tested (hence distributed) during development. In addition, staff need to be transported during trial testing (and also during in-service training work), and the repair and maintenance section needs transport to operate effectively. We need to be warned that using a central pool belonging to a government ministry is often not advisable due to possible non-availability when actually required. The important point is that the finished products from the centre should not be left for long periods awaiting distribution from the warehouse. The aim should be for a quick turnover. The period spent on the shelf in storage means that children somewhere are receiving second-rate education and the capital investment in the end product is being wasted.

The Education and Training of Personnel for Purchasing and Supply

For any production unit to operate effectively it is necessary to have the raw materials and components for manufacture at the right place at the right time. Similarly, the end products must be effectively stored, and distributed, to their final destination. It is important therefore that suitably qualified personnel are employed to carry out these functions.

The Institute of Purchasing and Supply in the UK have a diploma course which leads to graduate membership/member status of the Institute. Parts I and II are available on a full-time study basis at the West Bromwich College of Commerce and Technology, whilst Part III is available at the Polytechnic of Wales, the full course lasting for three years.

Higher National Diploma Courses in Business Studies are also available, some of which have a purchasing bias. The HND in Business Studies: Purchasing Bias, is available as a two-year course at the Distributive Trades College, Hammersmith and West London College, Stockport College of Technology, Slough College of Higher Education, and Hull College of Higher Education. A College Certificate in purchasing is offered at the Central College of Commerce in Glasgow, and a College Diploma Course in purchasing and supply is offered by the North London Polytechnic, both on a one-year basis. For training in other Commonwealth countries enquiries should be made in the country of choice.

The Education and Training of Personnel for Storekeeping

The Institute of Purchasing and Supply have a certificate course in stores supervision, and a number of endorsement studies courses related to stores management exist, connected with the HNC in business studies. The National Examinations Board have a certificate in supervisory studies, and the Royal Society of Arts provide examinations for storekeeping, stage I and II. All these schemes are part-time study courses in the UK. The Training Services Agency sponsor a course in storekeeping which is held at the Stevenson College of Further Education (Edinburgh), and at Aberdeen Community College. This is a full-time course.

For training in other Commonwealth countries, a number of colleges offer storekeeping courses which are examinable by the Royal Society of Arts; the Part II would roughly equate to GCE 'A' level standard. Enquiries should be made to colleges and polytechnics in the country of choice.

The Education and Training of Personnel for Marketing and Distribution

An important aspect of the equipment production unit is the marketing and distribution activities. The market for a product needs to be decided before the product is made and then distributed to it once production has taken place. The administration of a unit requires individuals trained in this field.

For initial training a degree programme in business studies would seem appropriate. Some centres which can offer specialisations in this field in the UK are Sheffield City Polytechnic, Trent Polytechnic, Sunderland Polytechnic, and the City University. The four-year sandwich course would lead to a first degree. The City University course is a three-year, full-time course.

For individuals with some administrative experience who require further training a number of specialist courses are available, for example, a five-day residential course at the College of the Institute of Marketing, Moor Hall, Cookham, Maidenhead, Berks SL6 9QH. Special tailor-made programmes can be arranged at the Coventry Management Training Centre, Woodland grange, Leamington Spa, Warwickshire CU32 6RN. The advantage of these programmes are that they are not fixed to an academic year and would be suitable for inclusion in short-term study tours. Alternatively, a one-year diploma in marketing is available at Kingston Polytechnic and Newcastle-upon-Tyne Polytechnic.

Training for Administrators

Mention has already been made of the need for training for personnel concerned with purchasing, supply, marketing and distribution. The whole spectrum of training for management is an area which is often neglected when a ministry or government body ventures into the field of equipment production. Usually a competent educationalist is appointed to direct the work of the centre without appreciating the extra skills required to perform that task.

For a production unit to be successful, the senior administrative personnel must appreciate all aspects of the unit. Equally important is the need for those in the Ministry of Education who are directly responsible for the unit to gain an insight into factors which affect their policy decisions when allocating large sums of money for equipment for schools.

Probably the most suitable course for a junior management level is the diploma in management studies. Some 25 centres in the UK offer this course, which usually requires six months' of full time study.

For more senior personnel a masters degree in management studies would be an appropriate higher degree. Suitable centres for study are the University of Aston in Birmingham, Brunel University, the City University and the University of Wales. Such courses require one year's full time study.

For those on a short-term study tour the short courses at the Coventry Management Training Centre would seem appropriate. Alternatively courses such as engineering and management in some Commonwealth universities may have a suitable component as distinct from pure management courses.

Repairs and Maintenance

Any investment in apparatus and equipment is wasted unless consideration is given to the regular maintenance and repair of broken items. The instances of apparatus lying around in schools for want of some simple repair are appalling. Unfortunately this problem appears to increase as countries receive equipment under various aid programmes.

One of the problems of providing any piece of apparatus or machinery is 'return on investment', or in other words the working life of the item. If an item is broken during distribution, the effort and cost of producing it has been wasted. Similarly if the item breaks down due to neglect, the original investment has been lost. No education system can afford to waste money since, in the long term, it is the national development of the country which will suffer through the lack of relevant educational facilities.

Repair and maintenance services should therefore be linked to the production and distribution process. The facility required for this section is a small workshop in fairly close proximity to the production workshops, enabling easy access to spare parts and shared use of some resources so as to avoid duplication. The repair and maintenance section will require transport to visit schools for on-the-spot repairs, as well as for collecting and delivering items which have been repaired in the centre.

Mention has previously been made of local resources, in terms of chemicals and equipment. Expertise is another local resource which can be exploited. The village jeweller may be able to repair some apparatus as may the 'clock doctor' and radio repair men.

There is much that a teacher can do to keep equipment and apparatus in good order, but he or she has to be taught what to do and how to do it. This does not mean that the teacher has to become a trained repair person. It means that in understanding how to use equipment he or she will be concerned with setting it up, checking it regularly for serviceability, and knowing when to call in the specialist to correct something which has gone seriously wrong. The provision of adequately trained school science laboratory technicians will, of course, allow the teacher to be relieved to a great extent of the maintenance and repair responsibilities.

Training for Repair and Maintenance of School Science Equipment

The education and training of Science Laboratory Technicians has already been discussed, but for technicians who are to be specifically concerned with the maintenance and repair of equipment, a greater in-depth training is needed. In-depth training on specific items of equipment can often be provided by the manufacturers of equipment, but it must be remembered that such services normally have to be paid for. For example, a one-week training programme for a technician to learn about the operation, maintenance, adjustments, repairs and calibration of a plastics injection moulding machine was costed at £500. A specialised four-day course for nine technicians on vacuum techniques and equipment was budgeted at some £1,000 plus.(3)

In addition to the trained science laboratory technician, who would be concerned more with the school situation regarding use, care and maintenance of equipment, as well as assisting the teacher, the repair and maintenance section of the production centre would need the in-depth trained technician for particular specialisations. Other than works-trained technicians, as indicated above, special courses exist, or can be provided, if the numbers for training justify holding a course in the country requiring the expertise.

For basic training in Scientific Instrumentation, Paddington College and Bristol Polytechnic in the UK offer such courses.

Paddington College

To meet the needs of overseas students Paddington College introduced, some years ago, a scientific instrumentation course which most full time students participated in alongside their C & G 735 Part II course. Successful course participants received a certificate awarded by the Scientific Instruments Manufacturers Association. This eventually led to the introduction of C & G 735 Part III which consists of scientific instrumentation and laboratory administration.

Bristol Polytechnic

Bristol Polytechnic were asked to provide a special course on scientific equipment for a Third World country in 1976. This course led to the establishment of their 'Polytechnic Certificate in Science Laboratory Instrumentation - a One-Year Full Time Course'. Commencing annually in September, the course concentrates on practical work in the laboratory with the theoretical studies designed to support this work, and consequently it is particularly suitable for technicians from developing countries who require considerable practical experience during the twelve month period. The course aims to give technicians a good appreciation and working knowledge of their equipment. Proper laboratory procedure and accurate working are treated as essential ingredients in this development. Routine maintenance, and identification and repair of simple and common faults are included in the course, but within the time available it is not possible to give a complete training on the repair of scientific equipment in general. The latter can only be obtained through many years of experience, although it is anticipated that technicians on this course will develop an ability that, with encouragement and support at home, will grow with further experience.

There are no formal entry qualifications but it is recognised that the students will normally be in-service science laboratory technicians with several years experience. The class size will be limited to about ten students each year, and it may sometimes be necessary in any given year to show preference to students whose field of work is most appropriate to the common interests of that particular class. All students are expected to possess an adequate working knowledge of written and spoken English. They will also be required to understand scientific terminology appropriate to their field.

Skill Centres

The work and courses available at these centres has been outlined on pp.61-2, 'The Education and Training of Technicians and Craftsmen in the UK'.

Other Commonwealth Countries

The Vocational Training Centres in Singapore operate a number of courses (similar to UK Skill Centres) some of which may be suitable depending on the speciality required. The Singapore Technical Institute also operates a number of courses. Placement for certain specialisations can be made at existing production centres, or research establishments. For example, the Central Scientific Research Organisation in India has provided training for glassworking skills.

Lastly the Swaziland College of Technology operates a sub-regional course in the use, care and maintenance of laboratory equipment.

<u>Notes</u>

(1) This point is well illustrated in the brief case studies on four different centres outlined in the publication <u>Development and Production of School Science Equipment: Some Alternative Approaches</u>. Commonwealth Secretariat, 1979.

(2) The International Council of Scientific Unions (ICSU) have recently completed a survey of technician training courses world-wide. This survey is due to be made available in 1982.

(3) When arranging the procurement of sophisticated equipment a manufacturer can be asked to include in his quotation the cost of a suitable training programme and this should be considered. There are many examples in universities etc, of science equipment lying idle because no one was trained to use it. Once it has 'gone wrong' no one is available to correct what may only be a small fault.

Appendix 1

QUESTIONNAIRE FOR PROBE OF APPARATUS MARKET, DEVELOPED BY SEPU

Part 1

(1) Name of school:

(2) Name of person to whom correspondence should be addressed:

(3) Telephone number:

(4) Type of school:

(5) Number of pupils in school:

(6) Level to which pupils are taught:

(7) Number of parallel streams:

(8) Are the following subjects taught separately? Physics; chemistry; biology:

(9) Is general science taught as well as, or instead of, above separate subjects?

(10) Average number of pupils per class:

Part 2

(11) How much money, if any, is spent at present on apparatus annually for (a) physical sciences? (separate into physics and chemistry, if possible) (b) biology sciences? (c) general science?

(12) Are you interested in the samples of apparatus shown?

(13) At the prices asked, how much would you buy?

(14) How much would you spend annually if told/shown what was available?

(15) Is there any particular time of year when it is easier to buy apparatus because of availability of funds?

(16) If there were an apparatus fair at some accessible centre once a year, would you (a) find it useful? (b) attend?

(17) Could you, under any conditions, pay cash on delivery? If not, what period would be needed for payment?

(18) Would you welcome, and use, a periodical pamphlet saying what apparatus is available and outlining its uses, and giving prices and availabilities?

(19) For expensive apparatus which is beyond your financial reach, would you welcome the establishment of a pool of apparatus at some local centre from which you could borrow?

(20) For the use of the pool outlined in 19, would you be willing to pay a small annual charge to cover the cost of maintenance?

Part 3 Comments and additional information: