LEAD PAPERS

TRAINING FOR THE PRODUCTION OF LOW-COST SCIENCE TEACHING EQUIPMENT

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Introduction

The increasing interest shown throughout the developing world in new science curricula and the local production of school science teaching equipment indicates a healthy desire to make the teaching of science more relevant to local environments and national needs. The interest displayed by Commonwealth member countries in establishing centres for the production of school science equipment can be seen in the extent of the participation in the seminars and other activities on low-cost production of science teaching equipment sponsored by the Commonwealth Secretariat (1, 2) and UNESCO (3) respectively.

There are already a number of production units in existence around the world (4) which could be used as a model for establishing one's own unit. But in any country the one with the greatest chance of success is the one that takes into account such local factors as the educational system (particularly its economics and organization), national industrial structure, availability of small scale-industries, and available manpower. The danger of taking other people's models is that all the factors used in establishing them are pertinent only to that particular country. This point is illustrated well in the brief case studies on four different centres reported in the first of this series of Commonwealth regional seminars on the theme of low-cost teaching equipment.

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

However, before looking at the components of a production unit there is a need to clarify the term. The interpretation given by Indge is appropriate here: 'Low-cost', he says, "is a relative term; it must be seen in the specific context of a particular educational system. Low-cost materials successfully developed for one situation may be prohibitively expensive in another. Thus even though in some developed countries, particularly during the last two decades, there have been major curriculum innovations that have not depended on costly traditional apparatus, these innovations have generally failed when introduced into economies which have to work with cents rather than dollars. Low-cost apparatus might also imply alternative cheaper sources of commercially produced items, teacher improvisation or local production. This is immaterial; whatever connotation the term might have, the only important criteria which should be emphasized, in the context of the objectives of this seminar, is that a particular item of equipment, preferably produced locally to serve the needs of a particular curriculum, is as cheap as possible within a given educational system."

Components of a Production Unit

When considering the production of any item we are concerned with the method of obtaining the end product. To obtain this end product we require the inputs, the production process and the outputs. Under inputs we are concerned with such items as buildings, plant, materials, finance, supervision, labour, management, orders, etc. Under production we are concerned with the manufacturing and assembly of the end product, whilst under output we are concerned with getting the goods to the classroom.

We can break down the production area into a further three basic factors. 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 an end product - in our case the provision of school science teaching equipment - is a complex business.

Ignoring at this stage the inputs factor, let us consider the production process and the outputs component. The flow charge on page 38, taken from a UNESCO sponsored seminar, (3) gives an idea of the stages involved in the design, production and distribution of a piece of apparatus.

Using this flow chart as a guide 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. The fact is that a number of efforts have been made to get teachers or students to produce science teaching apparatus in bulk. Some simple production units have been set up in teacher establishments, including universities, using existing facilities designed for teaching purposes, and in all cases the large-scale production aspect has not been realized. The reasons can be summarized by saying that a teacher can produce a piece of simple apparatus for his own needs after having acquired some basic skills in woodworking and metal-working. To mass produce the same item to an educationally 'student proof' quality requires skills and physical resources which the teacher does not possess. A science teacher's training does not normally involve acquisition of skills related to engineering production.

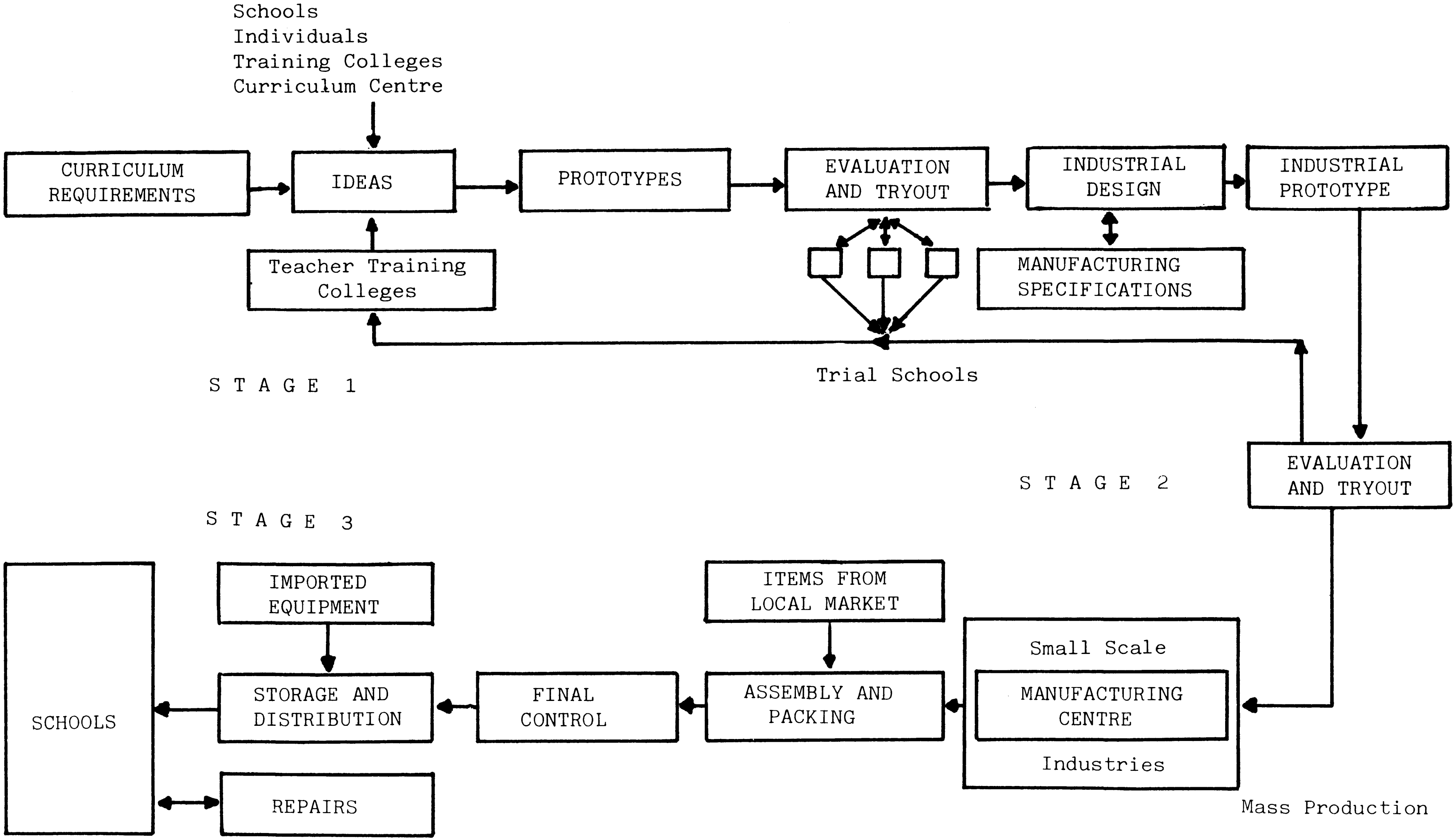
Nevertherless the teacher's role in the development of a piece of learning apparatus is extremely important since his pupils are the most important beneficiaries. It operates at the beginning when prototypes are being designed and field tested, and at the end when the finished product is being used in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

To return to the flow chart we can break the flow into three fairly clearly defined stages. The first is the 'ideas' stage when a prototype linked to the curriculum is produced and tried out in the 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'. More will be said about this later, but let us now look at each of the three stages in turn.

SUGGESTION FOR

A GENERAL SYSTEM FOR THE DESIGN, PRODUCTION AND DISTRIBUTION

FOR SCHOOL SCIENCE EQUIPMENT



STAGE 1: THE DESIGN AND DEVELOPMENT SECTION

Curriculum Requirements

The two previous seminars on this theme have outlined the changes taking place in the science curriculum. The changes are mostly towards an inquiry-based approach to the learning of science. An important point mentioned is that 'successful science curriculum development necessitates the collaboration of many educational institutions'. Curriculum units or centres, teacher training institutes, and university education facilities must join forces 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 (i.e. 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 on page 78.

The Design and Development Section

Examples of the design and development section, and of inputs to it, can be seen in the case studies already referred to. 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 will be responsible for converting the prototype approved for production into a series of mass production components.

The role of evaluation and try-out cannot be over-emphasized. One can still find some 'ivory tower' persons who claim that trial testing is not needed since we know the requirements. It often happens, however, that the more remote we get from the teaching situation 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 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 school system. 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. Indeed, some projects employ an evaluator 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 trial testing as to its effectiveness.

Evaluation, however, needs to be more than formative, for items of equipment will need summative 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 open to exploitation and manipulation.

Teacher Training

Much of what has been said so far draws attention to need for effective teacher training. Thus teachers need to be taught how and what to order from catalogues. In countries where a limited exposure to technology exists, the author's personal experience has revealed that teachers apparently have difficulty in 'visualizing' from a page in a book what a piece of apparatus really looks like. (Some work has already been started on investigating what an individual 'sees' and interprets when faced with a newspaper picture or film.)

With the introduction of Nuffield Science and its emphasis on using investigative techniques, a realization occurred that teachers were not being trained to use apparatus in the laboratory in anything other than the manner which had existed for decades. The standard practical exercise requiring some principle to be 'verified', with pupils regurgitating the instructions found in numerous 'laboratory manuals', was the norm. As 'investigative science' curricula were being developed, enthusiastic teachers - often in isolation - attempted to change and incorporate the 'new methods' in their teaching. But the mass of teachers continued as before. So did the teacher training colleges. Eventually a realization crept in that since the 'discovery approach' to learning was with us, teachers would need to be specifically trained for the approach. The assumption that 'of course teachers can teach practical science' was found wanting: teachers had to be taught how to use their laboratory; how to use their classroom as a laboratory; how to let children perform investigations using apparatus; how to programme work over a long term; how to recognize apparatus; how to order apparatus; what to order from catalogues.

In a number of countries a change came about as new teacher training programmes were developed. The Science Teacher Education Project (STEP) (5) developed in the United Kingdom during the period 1972-74 is one example. It is notable that its development was accompanied by a strong recommendation that overseas countries wanting to use the approach should not take it in its entirety (a realization that material had to be locally developed to be effective). The Australian Science Teacher Education Project (ASTEP) (6) is an example of this kind of local approach: so are the continuing attempts to develop similar material in Nigeria.

Many countries still plod on unchanged. A visit to teacher training colleges in many developing countries show that the inputs made, often with foreign assistance and expertise, have stagnated once the 'experts' have departed. (A recent visit to one teacher training institution revealed that even the notices on the laboratory pin-board had not been changed for at least five years!) Lip service is paid to new curricula, but in the end teaching techniques remain the same. Fortunately this seminar/workshop is designed to investigate the problems of training, and another paper will deal in depth with the training of teachers. Suffice to say that if a country wishes to invest in producing science teaching apparatus it must also invest in teacher training if the investment is to be worth while.

Whatever method is adopted for marketing and distribution, a summative evaluation will be needed. This should best be carried out by an impartial evaluation group, since an evaluation unit involved in the actual development process can easily be biased towards 'proving' the product. In the United Kingdom we have 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.

In looking further at the operation and organization of the design and development section, with its need for liaison, trial testing and construction of prototypes, we find that the centre itself needs to be led by a well respected educator, preferably with a science background, who is able to co-ordinate the efforts of different specialists to provide the most appropriate material for learning. This educator in question must also be fully commited to the need for improvement in science teaching.

A job description for such an individual might read:

Position:	Director of School Science Equipment Development and Production Centre
Duties:	To establish and maintain a development and production centre for providing suitable science teaching apparatus to schools and colleges throughout the country. Besides heading the centre the director will be expected to liaise with all relevant institutions and bodies to bring about an overall improvement in the quality of science teaching with particular respect to the use of apparatus and equipmemt. The director will, in conjunction with a steering committee, establish specialist panels to assist with the development activities of the centre.
Qualifications:	A university degree in Science and Science Education with considerable proven experience in curriculum development activities and practical educational administration.
Salary:	Negotiable: depending on qualifications and experience.

Since it will be difficult for the functions of the director to be carried out by one person, it is likely that a committee will be formed to assist the director and guide the work of the centre. Such a committee should consist of invited and/or appointed members from across the whole spectrum of education as well as from outside education. One of the functions of the committee should be to approve the production of successfully developed prototypes. In other words, members of the committee would operate as the Board of Directors of a company. DAYM in Turkey uses this system. And it appears the Regional Seminar Workshop held in Tanzania in 1977 thought along similar lines when it recommended that: 'It is important to establish an institutional framework which will facilitate communication and collaboration across government ministries or departments as well as across educational institutions and agencies, including curriculum development units and teacher training institutions.' Thus, it was suggested at the seminar that a consultative group forming a consortium of relevant institutions might serve as a useful resource for the production unit. Such a group should include curriculum developers, practising teachers, representatives of those government ministries with direct interest in education, teacher training colleges and science teacher's association. 'On the matter of this committee it concluded by saying' ... the consultative group envisaged should be involved not only in initiating the production process but also in evaluating the finished product'.

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 trail testing apparatus flexible budgeting arrangements are needed for travelling and per diem allowances, 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.

STAGE 2: THE PRODUCTION PROCESS

Industrial Design and Manufacture

In Stage 1 we referred to the industrial designer as the man responsible for turning the prototype into a mass produced entity. 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 will be asked to trial test the pilot production model before it is mass produced, but if the designer has been functioning properly during the prototype stage, very little difference should exist between the finished prototype and the production model or the end product. It is likely that the difference will be 'cosmetic' rather than functional, that is, only in choice of suitable materials, colour, scale, etc.

The design team will probably consist of the team leader (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 factor of most importance 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 experience in programming work through the various workshop facilities is utilized in order to integrate the new item into existing production schedules. Besides programming he will also assist with the advance procurement of the necessary materials needed to make the components; he will also indicate which items have to be sub-contracted out for manufacture by local industry.

The report of the regional seminar in the Bahamas indicates that the NCERT in India utilizes some twelve commercial manufacturers which tender for the batch production of certain items for inclusion in the kits. These suppliers work to the strict requirements of the workshop department.

In the case of sub-contracting, the standards of 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 form a component of the production process functioning under the directives of the head of the production process.

The Production Facilities

Having completed the process of turning the original design sketches into working drawings for the use of the various sections of the production workshop, a number of steps have to be taken before any components can be manufactured. An important area is one involving 'tooling'. This is the process of making any necessary dies, moulds or jigs for, perhaps, plastic injection moulding, castings, 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 examples 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 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. With expert advice from the Centre, the States draw up their plans and arrange for the necessary fund to meet the equipment needs of schools over a specified period. A region which does not have any local industries may prefer to request the Centre to undertake the mass-production for them, whereas a region located in the industrial belt may prefer to get the equipment manufactured locally with or without modifications as shown by the dotted lines in the diagram. The Centre can provide the design specification and necessary information for them. In addition, the State may ask the Centre to train their technical staff in the inspection and quality control aspect of equipment production".

Workshop Staff

The workshop department has approximately 100 members of staff and, depending upon demand, also employs a daily labour force as required. The following

SUGGESTED ACTIVITIES OF THE DESIGN, PRODUCTION AND EVALUATION CENTRE AT THE NATIONAL LEVEL

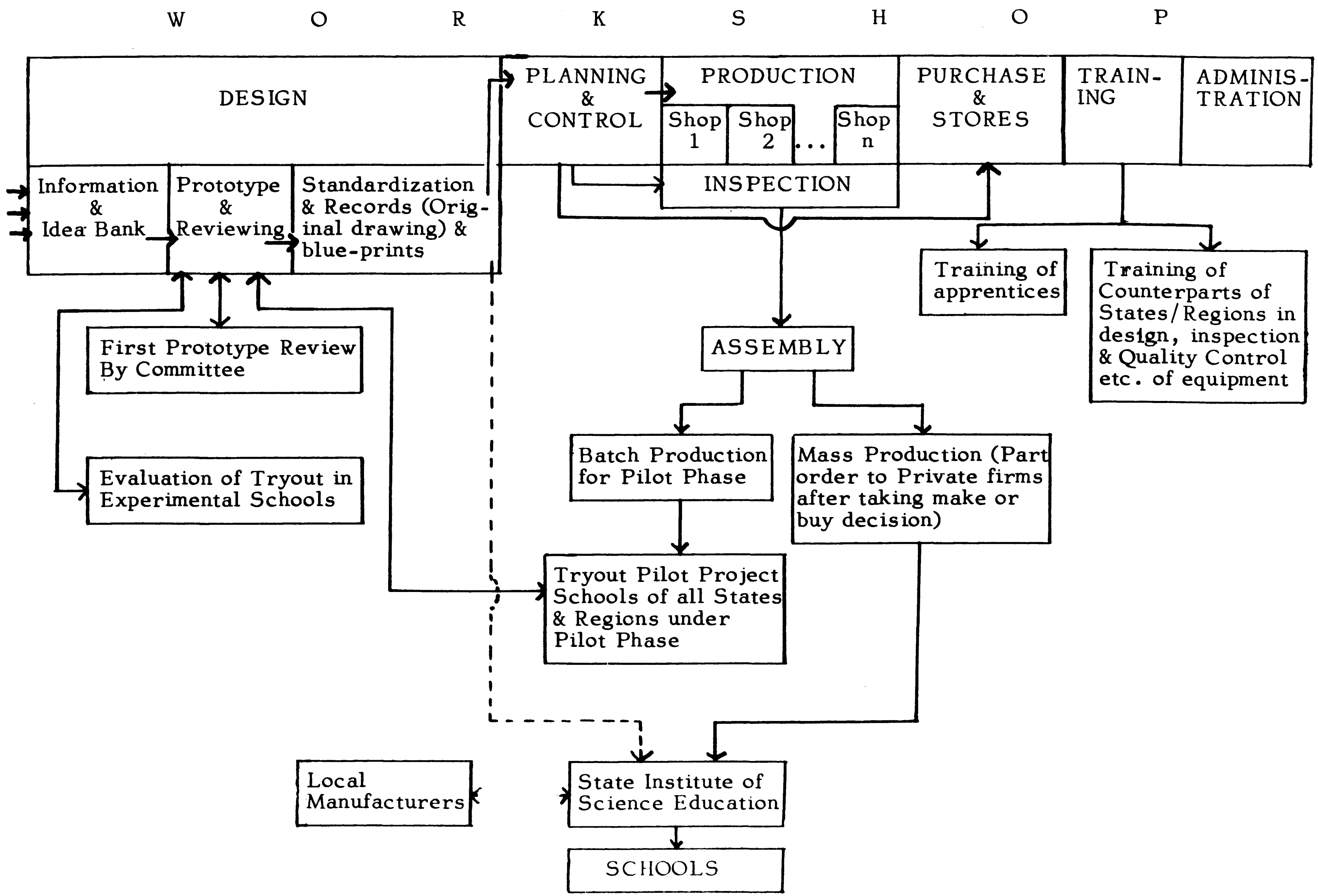


chart outlines the structure of the staff, but a particular title does not necessarily reflect the actual duties of the individual. For example, of the technical officers, one is responsible for office administration; in the fine mechanic grade, two are in the packing section.

Head of Workshop Department

Principal Assistant

Technical	Stores	Administration
Technical Officers (5)	Assistant Stores Officer (1)	Office Superintendent (1)
Foreman (1)	Senior Storekeeper (1)	Assistant Superintendent (1)
Junior Foreman (4)	Junior Storekeeper (2)	Upper Division Clerk (1)
Senior Draughtsman (1)		Lower Division Clerk (2)
Junior Draughtsman (2)		
Senior Laboratory Technician (2)		
Fine Mechanics (15)		
Mechanics (42)		

Peons (General Staff, e.g. messengers) (17)

Daily Labour Force

Recruitment of staff is done through national advertising, and the successful applicants are appointed to their appropriate grade and duties. A system exists whereby any individual who shows aptitude can apply for the relevant trade test and be upgraded.

The foregoing provides a concrete example of the sections contained in a production unit; the machinery required for its particular role is as shown on pages 79 to 82.

Not all productive units are as large as the example given; generally they are much smaller, since their size is appropriate to the market. For example, in India there are some 452,000 primary schools (the school level for which the production unit was producing apparatus in 1976). A country with, say, 100 secondary schools and about 2,000 primary schools would have a much smaller unit. An example here would be, say, Papua New Guinea. Here it might be possible to set up a viable organization to produce apparatus using a workshop staff of about 10 persons working with a curriculum development group who generates the'ideas'. Such a production unit might make use of daily recruited staff to meet its extra requirements when a bulge of work is passing through the workshops. Such a facility highlights a need for a flexible budgeting arrangement which can hire extra personnel when required.

In referring back to the staffing structure of the production unit shown on page 3 , 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 specialized 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 dyes required. One consideration is the compatibility of machinery which would facilitate the interchange of dyes between countries. Another consideration is the material from which the die is made. A dye 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 country. 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. with only minor differences which could probably be standardized to one design (perhaps requiring regional co-operation). In using plastics one requires some new skills, whereas in using indigenous raw materials it is likely to find personnel already skilled in their use, such as local craftsmen. The employment of such persons would naturally require considerably less investment in training. More will be said about this later.

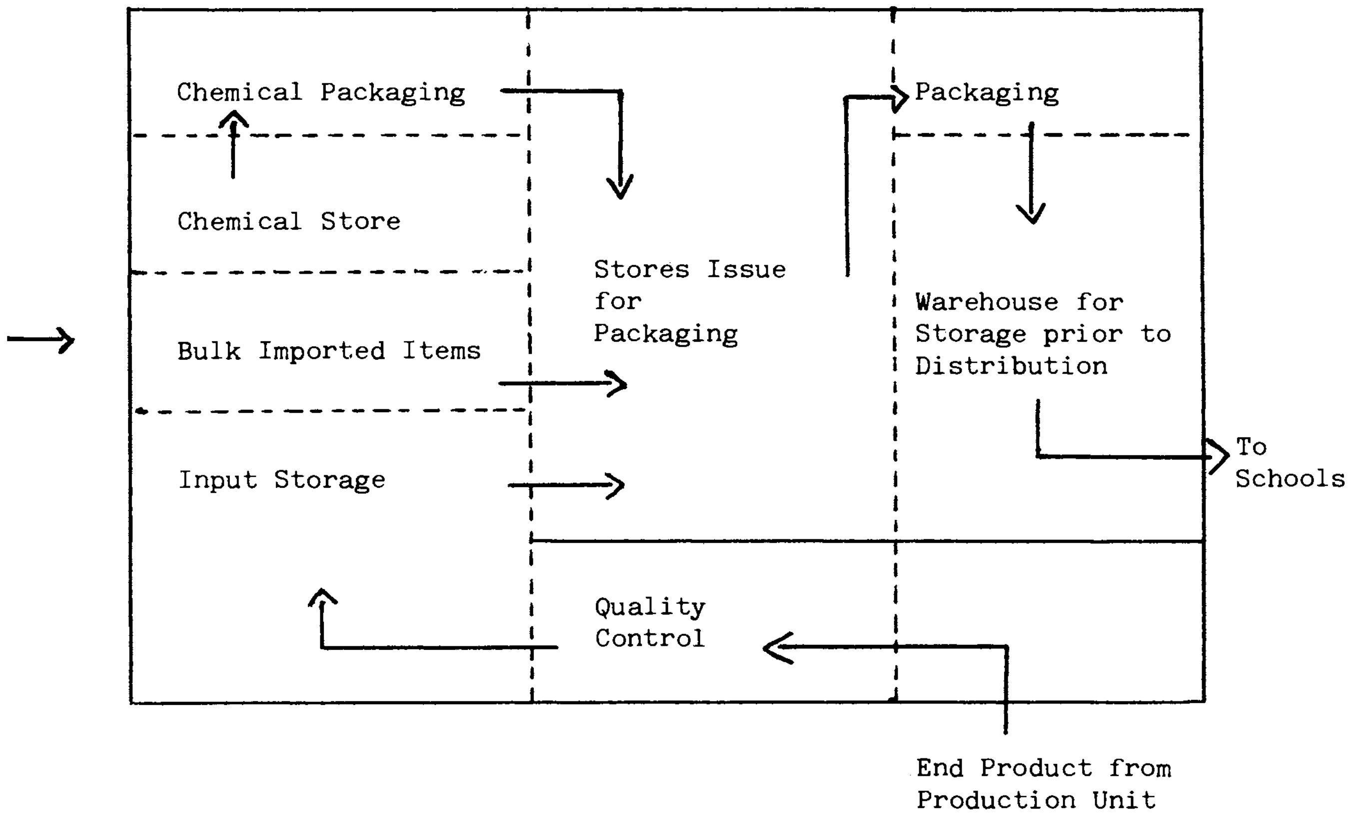
STAGE 3: STORAGE AND DISTRIBUTION

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

Although the production unit will have storage space, this will be concerned mainly with raw materials and parts for assembly of the end product as well as for tools. If, however, the final products from the centre are going to include items imported from abroad, 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 for assembly into a piece of equipment or whole pieces of equipment from the local market. Local purchase does not have to stop there. When looking around a village bazaar one finds a variety of expertise ranging from cloth dying through pottery to gold smithing or 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-packaging 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 would 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 string; 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.

FLOW PATTERN FOR STORES



From the flow diagram on page 38, we see that items from the local market are fed into the production workshop. One reason for this is that they are then fed into the store through the inspection department either as parts of the finished product or as individual items in their own right. The diagram on page 3 indicates a flow pattern for the store, indicating some of the sections which may be needed in a store.

The location of the stores 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 integral with the other components 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, packaging requires particular attention. The effect of sea water, corrosive atmospheres and humidity, as well as 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.

To conclude this section, 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 somehwere are receiving second-rate education and the capital investment in the end product is being wasted.

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 ramifications 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 seen as 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. As previously mentioned 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.

The skills required by the personnel who will staff this section will be basically engineering ones, with some degree of specialization depending upon the sophistication of equipment in the educational institutions. If specialization is necessary, this is best provided within the country as on-the-job training. This will encourage the trainee to develop ingenuity in tackling problems, and in making good use of simple tools. Training given abroad (e.g. at the place where the equipment is manufactured) exposes the trainee to a variety of specialized tools and test equipment which he cannot expect to find in his normal day to day work. Naturally, if the centre is to produce fairly sophisticated apparatus, its staff must be trained in the specializations involved, and training may have to be given abroad. On their return these individuals can be used to train the repair and maintenance personnel and to provide back-up expertise when required.

An example of the inadequacy of teachers and their limited knowledge of equipment can be seen from the experience of one centre which was asked to examine some new balances reported as being 'broken on arrival'. In examing the balances it was found that the clamps fitted for transportation purposes, and which locked the mechanism, had not been removed. The instruction manual was available but the teachers in the school had not been able to appreciate (and locate) the clamps. An additional problem was that the balance required an electrical supply to illustrate the optical scale, but the school only had electricity in the evenings, outside of school hours. The repair and maintenance team were travelling with their own vehicle which had its own petrol-driven portable generator and so the setting up and operation of the balances could be demonstrated and tried by the teachers. Two points are highlighted here - the support the teacher needs, and the type of equipment which a repair and maintenance team may need.

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 his equipment and apparatus in good order, but he has to be taught what to do and how to do it. This does not mean that he has to become a trained repair man in addition to being a teacher. It means that in understanding how to use equipment, he will be concerned with setting it up, checking it regularly for serviceablity, and knowing when to call in the specialist to correct something what has gone seriously wrong. The provision of <u>adequately</u> trained school science laboratory technicians will, of course, allow the teacher to be relieved to a great extent of the maintenance and repair responsibilities.

APPROPRIATELY TRAINED PERSONNEL

Overseas Training Considerations

The specialization required by the staff of an equipment production centre are not generally found in employees of a ministry of education, except in technical institutions. So to obtain the individuals with the necessary skills one has to look for persons employed in industry. Often, however, the scales of salary within government service are unattractive and the recruitment of skilled personnel to the government service is not possible. In these circumstances the provision of specialized training for selected individuals is necessary. In many instances, this training has to be given overseas where the particular specializations are an established factor. All too often such training is given to the wrong people, for the wrong reasons, and for far too short a time. Consider, for example, a workshop technician whose work it is to produce the dies for a plastics injection moulding machine. Local recruitment may obtain someone who has been trained in the use of workshop machinery at a technical college. It is most likely that his knowledge of materials will not extend far into plastics materials. His recruitment has probably been undertaken by non-technical personnel. The individual concerned may then find himself in a situation where he is expected to produce dies to close fitting tolerances using techniques of toolmaking for which he has little training.

Because he is a member of the technical staff, the priority for fellowship training for periods of two years or more is low, since it is often accepted that 18-month to two-year programmes are intended only for "academic study". Yet the training may involve his being attached to a manufacturer where instruction will be given in the use of certain machinery, or it may involve attachments where particular manufacturing skills could be developed. Unfortunately at the end of such training there is no academic certificate awarded and no advanced qualification obtained. Yet, unless the technical skills in whatever discipline needed, are available to provide the base of operations, any investment in "academic"education is lost since there is no one to put into practice the theoretical design.

Local Recruitment Considerations

The recruitment of staff does not, of course, have to rest with looking for personnel already trained. After establishing a suitable nucleus of capable personnel it is possible to recruit unskilled personnel and train them in specific tasks. In many ways this approach has much to commend it. Whether production of apparatus and equipment is capital intensive or labour intensive, most of the time the work is repetitive. By recruiting semi-literate labour and providing the training in the particular skill required, the centre is likely to be more efficient since it provides regular work for persons whose expectations from life are not unnecessarily too high and hence the centre may not suffer from the unrest and dissatisfaction often brought about by employing an over-trained individual for routine mundane tasks.

It is worth pointing out the need to attend to ergonomics as a cost and training factor. If the traditional method of, say, working with sheet metal is at ground level rather than working higher up on benches where the feet also may be used, then this factor should be taken into account when providing the facilities to be used. If the labour force is to be recruited from the village where the individuals may have already been working with sheet metal making bowls, stoves, cooking utensils, etc., then, by matching the traditional facilities, less re-training would be needed, with the attendant reduction in costs. In the situation where small-scale industries are to be used to manufacture apparatus, particularly if they are to be set up as part of a national development plan, then the traditional methods of working should be the foremost criterion for consideration when deciding what support material is needed to establish (or improve) the production unit. The establishment of small-scale industries is very pertinent to island communities and should receive particular attention when considering the establishment of a production unit.

What to Make and Where to Use it

To conclude this paper we need to think about what the centre is going to produce - kits of apparatus, individual pieces of equipment, or both? Naturally, this problem will have been resolved during the initial planning stages for the centre after the appropriate "market research" has been carried out.

We are, unfortunately, conditioned to have a "laboratory"to teach science in. Fortunately this idea is breaking down in some countries where new curricula for primary and early secondary schooling are tending to deal with science as a whole and not as artificially separated disciplines. Life itself is a laboratory - the place where things happen. Life occurs both in the school and outside of the school, hence the need for a specific area to be used as a laboratory is questionable, perhaps even undesirable in a primary school. The classroom and school compound make an admirable base for practical science learning, but consideration needs to be given as to where and how apparatus should be stored when not in use. Here the self-contained topic kits with their own storage containers have an advantage. Whatever the case, the teacher needs training as to how to use the learning facilities available, be it a classroom or a class under a tree (what better environment to start learning about science!). Since this is the topic of the next paper I shall conclude by quoting an old Chinese proverb: I hear, I forget; I see, I learn; I do, I understand.

There is no substitute for "doing".

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