Section 1 Food for Thought

CONFERENCES ON THE PRODUCTION OF LOCAL APPARATUS

There have been several conferences on the production of teaching equipment - sometimes specifically on science but sometimes more general - and the subject is frequently discussed at other conferences. As can be seen from the reports, there is a great similarity about most of them. The impression one gets is that they are often seen by the organizers as lecture presentations by foreign specialists who indicate that they have identified the local problems and know how to implement the solutions. While this is valuable on technical matters of a certain sort, surely the job of a foreign specialist is to act more in a consultant capacity - that is, to lead his 'clients' to identify and to define the problems for themselves. In the case of providing science teaching apparatus for schools, the problems are not as obvious or as easy to solve as they have generally seemed to be - as the many failures witness.

Similarly, the resolutions passed by many conferences have a naive air. There are rarely any operational proposals - no timings, allocations, responsibilities, flows; nor is there any attempt at scheduling. Though the lecturers may have referred to 'objectives' in educational discussions during the conference, the final resolutions reveal that they know little of the way a system of objectives is written for the scheduling of activities in real life. They have borrowed a jargon but not understood it. Perhaps if a businessman from the locality were to be present at all conferences on the production of teaching equipment, a more practical result would be achieved.

It may be useful here to list some of the conferences, seminars, workshops and courses which have taken place and which were directly or indirectly concerned with the design and production of school science apparatus.

At RECSAM, Penang, there was 'Production of Low-cost Teaching Materials for Primary Level Science and Mathematics' in October 1973. This was jointly sponsored by the South-East Asian Ministers of Education Organization (SEAMEO) and the German Foundation for International Development (DSE).

There was a Regional Conference on 'Problems of the Promotion and Production of Teaching Materials in South-East Asia', also sponsored by SEAMEO and DSE, in October 1972 in Singapore. This was organized by the SEAMEO Regional Centre for Educational Innovation and Technology (INNOTECH).

Food for thought

Aspects of apparatus needs are covered in the book 'Science Education in Africa' (1), which is a report of the sixth Levershulme Inter-University Conference in Africa held at the University of Malawi in March 1968. There is a section on 'Science Teaching Equipment, Materials and Facilities' in 'Planning for Integrated Science Education in Africa' (2), which is the report of a Workshop for Science Education Programme Planners in English-speaking African countries held at Ibadan, Nigeria in September 1971. There was a Regional Seminar on School Science Equipment in New Delhi in December 1972. The final report is published by UNESCO Regional Office for Education in Asia, Bangkok, 1973.

There was a course at RECSAM in June 1973 on 'The Development of Primary Science Apparatus'. It was the second of its kind and it aimed at training some key educators in the theory and practice of apparatus production in their countries and at developing some prototypes. There is a report (August 1973) and a description of the prototypes, with photographs, in a 50-page booklet ('Collection of Assignments by Participants of RME-1 (1973) Course'). It would serve as a model for similar courses which other production units might like to consider.

(1) Science Education in Africa (Gilbert and Lovegrove) published by Heinemann Educational Books Limited, 48 Charles Street, London W1X 8AH, England.

(2) Planning for Integrated Science in Africa published by UNESCO, 7 place de Fontenoy, 75700 Paris, France.

EUROPEAN PRODUCTION FOR SCHOOLS IN AFRICA, ASIA AND LATIN AMERICA

A number of European firms are aiming at markets for school science apparatus in Africa, Latin America and Asia. Most, of course, hope to sell their home style of product but a few are attempting to design realistically for the situation, seeing their long-term advantage in doing so. Their very reasonable hope is that if they come to know the real needs of the market by struggling with it at first-hand during the development stages of such educational schemes as are now beginning to get under way, and if the market gets to know them in these early stages, they will be of greater commercial advantage and value to their customers than they will if they come in later.

It is a high-risk venture. International agencies with an interest in the presence of satisfactory equipment in new curricula could very helpfully collect and make available publicly a great deal of information and advice which could assist such firms. There are, of course, difficulties in this but probably they could be overcome.

Cornelsen, Velhagen and Klasing of Berlin have produced a number of kits of considerable interest to primary schools wanting a collection of items dealing with a single subject such as Weather or Heat. Photograph 1 shows one of the more complicated kits - a class kit for eighteen pairs of children. Educationists in New Delhi and teachers in Calcutta who were shown the CVK kits made certain criticisms: that they were bulkily packed; that though they incorporated some good points (like the mounting of thermometers for pupils in a particularly neat way in a metal angle) they were in some respects flimsy; that a kit needs an accompanying text in the appropriate language; and that the price was totally out of reach of most schools in a developing country.

The German Foundation for International Development (DSE) arranged a conference (Calcutta, September 1973) at which teachers, educationists, apparatus designers, and so on, from all over India, had a look at science and mathematics teaching kits produced in Germany. The intention was to see whether the kits themselves, or modifications or ideas from them, were useful in the Indian classroom. The conference members actually used the kits with school pupils from a local bustee (slum) in the mornings over two weeks, sitting on the floor, each with some half dozen children. The resulting reports, though not edited and published, are detailed and valuable. This real attempt at testing European materials in Asian classrooms had several aims: to educate local teachers and designers as to what materials exist; to demonstrate to distant manufacturers how their products fit into the Indian context; and to indicateto the international organization whether they are on the track of a process to help Asian children, local production and European manufacturers. The impression at the conference was that this is an enormously valuable process which many international agencies should copy. What made this particular one successful was an informality which allowed truth to come out, properly-based analyses to be made (still unpublished possibly because of the informality) and the fact that people were actually influenced, not merely informed. The kits have since been sent around India as an exhibition.

During discussions about kits in New Delhi and Calcutta, one point arose that is of importance to designers of apparatus - the idea of kits rather than individual items was warmly welcomed. Indeed at Delhi UNICEF was urged to put its supplies into kits. A pre-selected collection is usually gratefully seized on by those who otherwise would have to make their own selection. Most people at the New Delhi conference averred that some dreadfully poor selections and omissions were commonly perpetrated by administrators or by sincere but inexpert or rushed officials. There was a strong feeling in favour of kits because of this great risk; the possibility that a ready-made kit might contain an inappropriate selection seemed to be less feared. Of course, in practice it is unlikely that anyone would consider attempting a totally international kit for a wide range of levels. Nevertheless, large manufacturers do need to bear in mind that a grade 8 level kit for a Bengal village is unlikely to be appropriate for, say, the same grade in a Mexican city school. How it would need to differ is a matter for research in the locality.

That some kind of warning is necessary, however, is evident from the proposal of a European firm to market, in countries poor in school apparatus, a large, expensive universal science teaching kit - photographs 2 and 3. Though handsome and excellently designed for Europe, several factors put it right out of consideration: for instance, the irreplaceability of its multi-use parts; the need for access to some repair skill and facilities; the fact that it does not fit a local syllabus and needs local-language software and an optimistically well trained-teacher; and its general air of sophistication. The international organizations can already blushingly tell us of the many European science kits standing unused on shelves in Nepal, Indonesia, Jamaica....

A further advantage of a kit is that it can have a box which serves as the store-cupboard for the items in the classroom. Most classrooms, certainly in primary schools, have no storage space at all. The NCERT kit has a metal case which can lock with a padlock - photographs 6 and 7. When making new designs, production units will need to bear in mind this lack of storage space or their apparatus will not last a year. (Though what they can do to cater for those schools in Vietnam without roof or walls, or those in Malaysia which are occasionally entirely submerged by water, is not so easy to decide.)

APPARATUS FOR THE FEW OR THE MANY

If ninety-nine per cent of the school population are not going to be academic scientists, it might be expected that only one per cent of the apparatus manufactured for school science (in a country where manufacture must not be wasted because of its difficulty) would be of the conventional standard type. Suprisingly the opposite is usually found to be more nearly the case. Consequently the majority of the children are starved of relevant practical scientific experience. This grossly undemocratic practice comes about for three reasons: a policy of elitism (usually not expressed); a tradition from the days when science teaching was given only in superior secondary schools (or, in the case of a country newly undertaking science teaching, by accepting advice from people in whom that tradition was ingrained); or a belief that low level science needs no apparatus.

This review does not contain much primary school science apparatus made outside Europe and the USA because there is good justification for supposing that in the early primary school very little manufactured apparatus (apart from scissors, containers, string, rulers, and a balance) is needed. It is actually better for the pupils to make simple things with their own hands. Such a policy remains a good one for the later primary and early secondary school, but in a much smaller part. Children cannot make flash lamp bulbs, or reasonably good weighing devices, or the 'clip together' blocks they need for number theory. Ten stones or a handful of maize seeds are just not suitable.

BAD DESIGN FOR THE SITUATION

If there were a record of attempts to get suitable science teaching apparatus used in schools, it would show a great proportion of failure and waste of money. Only too often dusty piles of unused apparatus at the backs of cupboards, bills at the headquarters of an international organization, perhaps a bland report or two written near the end of a project - and untaught children - make up the only sad record.

Yet most science teaching equipment has been excellently made. It is strong; its joints work freely; everything fits together properly; it does not leak; it is well finished. In proper hands it can demonstrate exactly what it has been made to demonstrate. Usually it is wellnigh perfect except in one very important respect - it is not usable in the situation into which it has been put. It lies totally ineffective on a shelf. Nobody checked whether the teachers could and would use it, and it was found too late that they could not or would not. It is irresponsible on the part of the designer to blame the teachers for this. The designer of a dam must first study the site on which the dam is to be built. Should the dam fail, the designer cannot escape responsibility by asserting that the design was good but the earth on which it was built was not suitable. It is in this sense that the failure of a science apparatus project can be attributed to poor design. The reasons are usually clear and discoverable.

Much of the apparatus in this review is excellent in many ways, though it may not be well-designed in its most important aspect - its real suitability for the teacher, the children and the classroom situation in which it is to be used (see photographs 4 and 5). The primary job of the apparatus designer is therefore to watch the operation of some examples of his proposed apparatus in a genuinely average class, undisturbed by his presence. To find a person with the necessary empathy and acuity for this task is not easy, but the ability to do such research is essential. The natural choice, particularly for a primary school, is probably a woman. She must also have good mechanical design ability or work with someone who has.

These paragraphs are intended as a warning against an easy misuse of this review.

CONVENTIONAL VERSUS NEW DESIGNS

Some apparatus makers see their job as reproducing conventional American or European items; for example, the commercial manufacturers in Ambala, India. They are supplying the needs of schools which work from essentially pre-1960 texts.

In the 1960s however, school texts and apparatus began to change rapidly in countries with sophisticated school science systems. The change came first in secondary then in primary schools. At the same time countries without much tradition for teaching science with apparatus were changing to new curricula. Sometimes these demanded new styles of apparatus. For instance, UNESCO helped initiate curricula in Africa which needed the English 'Nuffield' equipment. The Nuffield system needed complete class sets of items, but countries found they could not afford the apparatus, particularly if it was to be purchased with foreign currency. They therefore considered local construction of one sort or another - such as teachers' do-it-yourself construction, science centered protoytpe making, and teachers' college small-scale production units. (Full-scale local manufacture has been talked of in several conferences but rarely undertaken.) In most cases the aim seems to have been to copy existing items. The result has been massive wooden ticker-tape timers and bamboo test-tube racks - simple copies in local material of new-style and old-style items - in batches of 100 or less. That teachers in general have little time or ability to construct these things has been a major problem.

The Science Education programme for Africa has had a different method for primary school teaching. It uses common objects such as grass, bamboo, automobile tyres, and cooking pots which the children manipulate for themselves and do their own construction as part of the lessons (see photographs 16, 17, 18). This method needs its own special texts. Other projects, for example FUNBEC in Brazil, have created entirely newly-designed apparatus and their own system. They manufacture (and seem to be commercially successful with) some fifty pocket-sized packs of very simple experimental kits with small accompanying books and a larger text (see photograph 58).

Most school systems in the world work with conventional apparatus and do not envisage much change within the next ten years. Their need, presumably, is for such equipment. Most of those secondary schools that teach science with apparatus in Britain, Thailand and Colombia, for example, use types of equipment hardly different from that used in a German secondary school in 1900. By far the largest proportion of the science apparatus manufactured in the USA, India, or in the newly-started production unit in Burma, is of the ordinary, standard, old-fashioned kind. In great part, this is quite natural. Standard academic physics is the same the world over and, if this is to be taught in the secondary schools, the same apparatus will be suitable, more or less, even if it is a bit pedestrian to the eyes of a technologically highly-developed country. Computers, quick-fit apparatus and photographic microscopy are not inherently superior for teaching: the academic stream of the secondary school in a less technically advanced country is as well provided for with slide rules, test tubes and magnifiers.

DESIGNING VERSUS COPYING

There is ample evidence that many so-called designers are merely copyists who have opened another manufacturer's catalogue and made what they saw there. This can be futile. Many educational analysts believe that though the introduction of a piece of machinery or a new technique into an educational system may seem straightforward, it can have deep social, religious and political effects (through an inevitable process of contingent texts, training and other influences). Thus the British have introduced intellectual elitism with their school apparatus into some countries, and the Americans have introduced a questioning of parental and religious authority as a concomitant of their approach to science.

In most countries mechanics are social engineers, whether they know it or not. They should therefore beware of copying Japanese, European or Brazilian items without due thought. When any of the items in this review are being considered this warning should be borne in mind. They are presented here not for copying, but as an encouragement to designers to be inventive and to make their own modifications to meet the needs of the teachers and children with whom they are specially concerned.

CURRICULUM/APPARATUS LIAISON

Collaboration between curriculum designers and apparatus designers should be very close. A sequence of experiments which an apparatus designer may have discovered to be possible, given the manufacturing capabilities which he knows of, might well be a useful suggestion to incorporate in the curriculum. On the other hand, an activity which an apparatus designer knows cannot be instrumented in the given situation will have to be modified if the curriculum designer wants it to be done practically. There are numerous similar situations where collaboration is necessary. A much larger general question which has to be settled between the two designers is which experiments are for demonstration by the teacher and which are to be done by the pupils.

Most of the apparatus in this review would not fit most textbooks: one or the other would need to be modified, for the text and its pictures must be compatible with the apparatus. Cases have been known of apparatus being manufactured without the makers knowing what text or curriculum it was to be used with. Frequently, too, textbooks are written without the required apparatus being available. Poor planning of this kind is particularly apparent in countries where there is no wide and varied supply of apparatus and texts. And the children suffer.

THE NEED FOR SYSTEMATIC OVERALL PLANNING

Rather distant from the task of this booklet, seen as a review of apparatus, are two important aspects of apparatus production: organization, and financing.

Many production units are conceived without a clear policy, particularly if they are set up by an international bilateral organization. The danger is that a project proposal is made out in rather general terms and is funded without an analysis of the 'market' being undertaken. The market is the school system whose needs (by reference to curriculum and ministry policy) are presumably fairly easily assessable. No estimation of production flow, costing, permitted amortization of capital, and so on, is undertaken. It is unclear what the long-term operational problems are, who the imported machinery belongs to, and who is responsible for servicing. No analysis is undertaken of the whole system into which the production unit fits. Items for production are selected ad hoc, and often the organizations concerned do not know whether they are making prototypes, pilot batches or are mass producing. Consequently things are likely to go wrong, and when they do it is difficult to see what the error was and how to avoid it next time. There may even be no contingency plans to meet the present difficulty. The international organization may be hoping that the unit will eventually become self-supporting, while local government - perhaps by failing to provide counterpart staff to take over from foreign experts - may not be contributing to this aim. The ministry may, by mere lack of understanding, permit the unit to be elitist in its production (in the sense described earlier) in opposition to the government's educational policy. As a result of this lack of systematic planning, enterprises may founder altogether.

As far as the workers and advisers are concerned, the reasons are understandable and forgivable. It is less easy to forgive the higher echelons. Planning is their reason for existence.

A further moral for the use of this booklet is obvious. The ideas to be found here are often in the nature of single bright ideas. They are useless unless they enter as part of a system.

PROFIT-MAKING AND NON PROFIT-MAKING PRODUCTION UNITS

Some economists divide all human enterprises into a mere two categories: those which make profits and those which educate. It is necessary for any organization which wishes to get science equipment used in schools to decide in which category its intentions lie.

Food for thought

If a producing factory is set up in a country which permits private enterprise, and if that factory makes a real profit for the owners, there is a strong likelihood that it will continue to exist and to supply science apparatus. The managers are likely to respond to market demands quite sensitively since their income depends on it. If, however, the factory is an educational enterprise making a financial loss, its continued existence depends on an external budget. In this case its educational effectiveness depends on planning according to external criteria, such as researched needs of the classroom. The educational effectiveness can be zero as easily as can financial profit. The physical existence of a unit in these circumstances is assured as far into the future as the certainty of a budget. If the unit is small and the funds are directly from ministry of education sources, the certainty may be one year or less. This is particularly likely when the unit is isolated from some kind of mother-body, but if it is within, say, a teachers' college, it is likely to have a much longer lasting budget.

If the funds are from some other agency, the intention will usually be to get the unit going and then for the government to take it over (assuming it is a non-profit making unit). This has happened in Burma. Alternatively the unit may be set up to demonstrate possibilities, processes, costing, and so on, to local (small-scale) industry. The intention to make it really profitable is rare; though this is intended for the unit in Sri Lanka and it has actually occurred with FUNBEC in Brazil.

INTEGRATION OF THE UNIT INTO THE COUNTRY'S SYSTEM

The risk, of course, with any size of production unit is that it may absorb funds over a long period while having only a small or insignificant effect on actual classroom practice. It may have excellent ideas and produce some useful items but unless it is well-designed as part of the system into which it must fit - that is, into the educational set-up of the ministry, the social reality of the classroom, the commercial environment, and so on - its effect will almost certainly be merely local.

Any relatively modest enterprise intended to help to get apparatus into schools would therefore be well advised to avoid any risk of isolation from the system. Quite apart from what this means in terms of planning, it probably means that the effort should go into an existing institution, such as a teachers' college or a science or curriculum centre. There is also a good chance that this will decrease certain overhead and capital costs. Space and skill will be at premium but almost certainly there will be the access to valuable informal knowledge and existing channels through which to feed out information and apparatus. Isolation and fragmentation are likely to be ineffective.

SUITING THE APPARATUS TO THE CHILDREN

There are other considerations besides those of management, organization and item design. A major one is curriculum, and as the apparatus designers and curriculum designers are both parts of the design system, they should work closely together. In doing so they should be aware of the profound effect their work will have on the whole society. There is a big move, particularly among the younger engineers of Britain and the USA, towards social responsibility for the use and potential of the equipment they make. In an equipment production unit in a poor country there should be (and increasingly these days, there is) someone who understands the arguments presented in such publications as: 'Pedagogy of the Oppressed' by Paulo Freire (1); 'One Hundred Countries, Two Billion People' by Robert McNamara (2); 'The Wretched of the Earth' by Franz Fanon (3); 'Education in Rural Areas' (4); Charles Silberman's 'Crisis in the Classroom' (5); 'Modernizing Peasant Societies' by Guy Hunter (6); 'The Age of Discontinuity' by Peter F. Drucker (7); and the monthly 'New Internationalist' (8).

A review of much relevant literature up to 1969 is 'Preparation of the Child for Modernization' (9), a very helpful working paper constituting a report on a study by the UN Research Institute for Social Development. It gives brief comments on original papers (which it lists) concerning developing countries, children's problems, abilities, experiences, intellectual development, traditions, and so on, under various headings. All are of great interest to a school science apparatus designer, being such matters as: childhood experiences in technological and non-technological environments; living and learning; conditions of children; skills and intellectual requirements of modern technological activity; the use of tools by children in what it calls 'traditional' environments; two-dimensional representations of reality; absence of technical words in a traditional environment; scientific thinking and development; transfer of traditional physical capacities to modern tasks; formal and informal training of the pre-school child; the penalization of children's questions by parents; the use of toys and games and household objects for play, and so on. Much of the bibliography is on Africa. The review points out how little is really known and how little research has been done. More may be available now that a number of child development institutes have been established, such as the one initiated by UNESCO beside Prasarnmitr College in Bangkok.

An unusual and valuable book which demonstrates how clever children are if they are allowed to solve problems in their own way, particularly when adults sympathetically attempt to understand the elements of what the child - lacking appropriate terminology and wide experience - is trying to say, is: 'Children Solve Problems' (10).

(1) Pedagogy of the Oppressed (Freire)
published by Sheed and Ward Limited, 33 Maiden Lane, London W.C.2., England.

(2) One Hundred Countries, Two Billion People: the Dimensions of Development (McNamara)
published by Praeger Publications, 111 Fourth Avenue, New York, N.Y.10003, USA.

(3) The Wretched of the Earth (Fanon)
published by Penguin Books, Harmondsworth, Middlesex, England.

(4) Education in Rural Areas: Report of the Commonwealth Conference on Education, Ghana 1970
published by the Commonwealth Secretariat, Marlborough House, Pall Mall, London SW1Y 5HX, England.

(5) Crisis in the Classroom (Silberman)
published by Random House, 201 E. 50th Street, New York, N.Y.10022, USA.

(6) Modernizing Peasant Societies: Comparative Study in Asia and Africa
published for the Institute of Race Relations by Oxford University Press, Ely House, 37 Dover Street, London W1X 4AH, England.

(7) The Age of Discontinuity (Drucker)
published by Heinemann Educational Books Limited, 48 Charles Street, London W1X 8AH, England.

(8) New Internationalist (monthly)
published by Research Publications Services Limited, Victoria Hall, Greenwich, London SE10 0RF, England.

(9) Preparation of the Child for Modernization (Mandl)
published by UNRISD, UN Palais des Nations, Geneva, Switzerland.

(10) Children Solve Problems (de Bono)
published by Penguin Education, Harmondsworth, Middlesex, England.

THE USE OF TOYS AND DOMESTIC OBJECTS

Something which teachers have always done to some extent is to use common objects and toys to illustrate scientific principles. Several apparatus projects throughout the world have used this principle too. It is possible to avoid special manufacture if there is an object already available within the country which can illustrate a concept, or replace a chemistry beaker, and so on. Indeed, it may be an educational advantage to use an object which the children recognize rather than a foreign-looking object remote from their experience. Cheap plastic roller skates may replace a special dynamics trolley; a local flute may serve as a source of sound much better than a tuning fork; even a mouse-trap may serve to teach several ideas about mechanics. Of course, these will need testing by children and by teachers as well as from the economic point of view.

For teaching a whole range of projectile mechanics, a toy in England called a 'flikball' - which flings a pierced ball off a stick - is remarkably versatile. Many electrical items are obtainable, as wholes or as parts, from quite small hardware stores, radio shops or garages. Examples are torch bulbs, rectifiers, and power supplies bought as battery charges. Bicycles are a prolific source of material for experiment. (Photographs 8 - 12 illustrate some of the things mentioned so far.) Objects of use in teaching may not only be found but modified, or assembled from parts, or wholly constructed. These processes may be undertaken by pupils or teachers, local craftsmen or a central manufacturing concern. The practical limits are set by local conditions.

Toys which exist in many cultures may be more suitable pedagogically, culturally and mechanically for helping children to understand science than specifically manufactured educational apparatus. For example, the Indian

NCERT primary science kit contains a large plastic wind direction indicator. This is expensive to make, occupies a lot of space in the small cabinet, points upwind which confuses the children, and, to make things even more difficult, has a base to stand on a table instead of a hand-grip to suggest its being held high outside. In fact it is unnecessary to have a specially constructed wind vane in India since children there commonly fly flags, pennants and kites, all of which indicate wind direction. Moreover, before launching a kite the young boy usually throws up some dust to see which way it drifts. From this he gets not only an indication of the wind direction but an estimation of wind speed as well.

Thus it will be wise for apparatus production units to investigate local toys and games so as to avoid unnecessary manufacture.

GAMES AS TEACHING APPARATUS

The difference between games and toys is that games are competitive and operate with symbols while toys represent real things for individual play. Although a number of games are claimed by their makers to be educational, few of them really teach much of significance. However, there are some good ones, and production units might like to consider them. Invicta Plastics (1) make several which teach elements of logic and mathematics. One which develops children's sense of strategy and gives much enjoyment is called 'Master Mind'. This is a simply manufactured device (pegs and peg board) and a model of what can be done. Of course, such games should not be copied too closely; all countries have their own idiom in games and this should be incorporated in the design of educational games if they are to work effectively (see photograph 15).

Nowadays, management training in industry makes use of games to simulate real situations. There is no reason why this should not be done in schools, though there is always a risk that it will make a subject theoretical instead of practical. It is of obvious use in non-formal education to teach about social matters and it is also applicable to subjects such as health, family planning, agriculture and similar topics which involve both science and social matters. A very interesting project which approaches this area is the 'Ecuador non-formal education project', being aided by the Centre of International Education, Massachusetts (2). Photographs 13 and 14 show a game-board and some cards from a Monopoly-like game from the project. The games are not manufactured but are made by those who want to use them; they are made to simulate the local situation about which participants want to learn.

(1) Invicta Plastics, Oadby, Leicester, England.

(2) Centre of International Education (School of Education), University of Massachusetts, Amherst, Massachusetts 01002, USA.

DESIGNING FOR THE TEACHERS' ABILITIES - TEACHERS' GUIDES

To help the teacher and the children to use apparatus, a guide of some sort is necessary. Most textbooks assume that the teacher can assemble and use equipment, although in fact most teachers cannot. Teachers' courses may endeavour to provide the necessary training but it is as hard for the average teacher to learn to handle science teaching apparatus satisfactorily as it is for the average person to learn to play the piano. If the apparatus designer discovers - and it is an important part of his job to research this aspect - that not more than half the teaching population will be able to use his proposed new apparatus in the next ten years, he must realistically plan for that fact.

Probably no one knows how much or how well a teacher will use a guide book. Common sense suggests that a small book is more likely to be read than a big one and that pictures are better than words. In many countries photographs are much more understandable than diagrams. Some examples of guide pages have been included to show some of the 'software' that apparatus makers put out with certain kits. It is certainly more the task of the apparatus designer than the textbook writer to describe the practical use of his apparatus. Often it is quite small matters which puzzle a teacher who is unpractised at handling physical apparatus and, naturally, any unusual aspects of design need explaining fully.

TAKING ACCOUNT OF AVAILABLE MATERIALS AND OF PREJUDICES

This review attempts to search out new ideas in methods of production. An important one to consider is the use of readily available materials for production wherever possible. For instance, the use of common mild steel stock sizes, half-inch iron piping, and so on, instead of special materials, will bring great advantages to the producer who must otherwise import stock or use skilled operators on expensive milling machines. Though this kind of designing is now common in industry, it is unfortunately less widespread among science teaching apparatus production units. Allied to it is the art of not over-specifying (for instance, on accuracy or surface finish).

A disadvantage of modifying an engineering specification to suit available machinery and skills is that it does tend to give the manufactured item an unusual, simple or even crude appearance. Though this may make an item less acceptable in the eyes of a country's educational officials and secondary school teachers, it rarely influences primary teachers and never affects their pupils. However, if prejudice exists it must be discovered and taken into account in designing the system.

KITS AND STORAGE BOXES

Much locally-produced apparatus is conceived as a kit to suit a curriculum. It is a ready-made collection for presentation to a teacher and often fits in with a text. Sometimes it is a collection of items for a particular teaching topic of very limited extent - such as a clip-together style of microscope or electric motor, or a little set of chemicals and test tubes together with a booklet for discovering pollution in streams. It may even comprise a whole set of items for several years' experiments or a complete primary science course (for teacher demonstration) in one box. Since teachers' storage problems need to be thought of, ideas for solutions are worth noting. There are not many solutions in this review.

SAFETY

Production units and others concerned with putting into schools apparatus with which teachers and children could have accidents, might consider their responsibility for providing suitable advice on accident prevention. Useful booklets are 'Safeguards in the School Laboratory' (1), and 'Safety in Science Laboratories' (2).

(1) Safeguards in the School Laboratory
published for the Association for Science Education by
John Murray Limited, 50 Albemarle Street, London
W1X 4BD, England.

(2) Safety in Science Laboratories - DES Safety Series No. 2
published by H.M.S.O., Head Office, Atlantic House,
Holborn Viaduct, London E.C.1., England.

WORKSHOP STAFF SELECTION

Selecting the right workers for the various jobs in a workshop is very important, and production units may find some of the publications of the International Labour Office of help to them in undertaking the task (1). A review of available tests (which might suggest some equivalent home-made versions to the selection staff at production units) is 'Personnel Selection and Training' by R. Goldstein of the ILO (2).

The trained science laboratory technician is invaluable in the school equipment production and development unit. The appropriate course of study for science laboratory technicians is the City and Guilds of London Institute Course 735 Parts 1, 2 and 3. Advice on the availability and training of such personnel can be obtained from the Institute of Science Technology (3).

(1) ILO Publications, Sales Service, 1211 Geneva 22,
Switzerland.

(2) Personnel Selection and Training (Goldstein)
a mimeographed book produced for the Jamaica National
Industrial Vocational Training Programme (Kingston 1973),
available through the Ministry of Labour and Employment,
112 East Street, Kingston, Jamaica, West Indies.

(3) Institute of Science Technology, 345 Grays Inn Road,
London WC1X 8PX, England.

LOCAL REPAIR

Apparatus should obviously be designed in such a way that it can be kept in working order. For primary schools which are mainly located in country areas and shanty towns and which lack funds for apparatus and skill in repair any possible breakage needs to be replaceable or repairable locally. There is plenty of glib reference to local repair but little realization of what is implied - such as a hammer and wire job by an itinerant tinker (see photograph 5). It is the designer's job to discover the realities here as well as in the classroom.

INFORMATION NEEDED BY COMMERCIAL FIRMS

The initiative towards producing sets of items, or indeed individual items, to fit curriculum developments need not come only from government ministries or educational agencies. In many countries it will seem appropriate for production to be undertaken by private enterprise. Even if they are not themselves the originators, it seems essential that (where the form of government permits) commercial firms should eventually undertake production and marketing. If a product is viable, they will undertake it and thereby provide an assurance that production is likely to continue. For this reason potential manufacturing firms should have early access to as complete a range of information as they need for their planning - from clear help with teachers' apparatus guide publication to firm offtake numbers for items over the next few years. This is especially necessary with kits - and it is largely with kits, in one form or another, that most production units will be concerned.

This is an area in which the international organizations could and should help. To what extent, at present, do production units who are contracting for production with other firms, let those firms know what is to happen in the future, or try to draw them into the marketing procedures in any way? If this is not done, an international organization that conceives and nourishes a new enterprise will find itself holding a baby that should long ago have grown up.

UNWISE RETICENCE OF AID RECIPIENTS

External aid, through bilateral or multi-lateral arrangements, is, of course, often given to production units: for example, UN aid to Sri Lanka and Nigeria; German aid to RECSAM; Japanese aid to South Vietnam. Naturally the organizations receiving this aid are grateful. At times, perhaps, their gratitude disinclines them to make useful criticisms lest they be misconstrued. This may be compounded by a somewhat insensitive donating agency which, without having really taken the trouble to understand the real needs of the situation, assumes that what it gives is certain to be useful. It may accept unsuitable advice; it may tie its funds to purchases from the donor country; or it may for other reasons provide unsuitable items, production machines or other facilities. The outcome may be worse than a waste of effort: there is a real likelihood that the effect will be negative, concreting the enterprise into the wrong path.

To avoid this it may be necessary for the donating agency to use people of exceptional sensibility to research the local situation; it will certainly be essential carefully and sympathetically to encourage local educators, administrators and others to reveal their needs, hopes and doubts. In any situation this is not an easy thing to do. In much of Asia for instance, people's natural courtesy, reticence towards foreign experts, and gratitude for foreign interest and funds, can lead to the setting up of poorly-based projects. I have heard a senior UNESCO expert say in a large conference that UNESCO has too often found that its pilot projects have ended in failure because of lack of maturity in the necessary supportive services of the country involved. It is clear that this is an indication of badly-designed projects, yet the same kind of mistakes are still being made. Aid recipients can help by striving to eliminate unwise reticence so that aid from donating agencies is never wasted but channelled into well-designed and fruitful schemes.

A SUCCESSION OF ADVISERS

A problem allied to that of bad advice is too much varying advice coming from a succession of visiting or short-term advisers, resulting in the lack of a single coherent policy. It is not at all unusual for this year's adviser to denigrate the work of last year's adviser, set it aside, and start almost anew. The unfortunate ministry or other authority concerned can recognize the evil of this in general terms but can hardly see what to do about it since the man is paid by the agency funding the project. It looks ungrateful to criticize him for many reasons, not least because the agency has approved him - even though it failed to vet his intentions and ascertain whether they were concordant with previous policy. A further difficulty is that the ministry usually cannot be sure which adviser's policy is the right one - or it would not have needed an adviser in the first place. A study of some projects which have failed for these reasons, and of others which have been successful in spite of them, would be valuable. Such a critical analysis could help subsequent designs.

A very small project, which is reported as successful, is a CEDO (now British Council) laboratory/workshop at Prasarnmitr, the principal teacher training college in Thailand. This gives teachers-in-training experience in the use and construction of science teaching apparatus and originates some new designs. A senior adviser went out to look at the needs, and advised funding after a country-wide inspection of schools and colleges. A second adviser did a feasibility study showing specifically how the project would fit the system and how the system would integrate it and run it as the aid phased out. A third adviser, who was sympathetic with the intentions of the feasibility study, then ran the project for two years. The courses - now part of the college's system - are being run by local staff; the new apparatus and the tools are in full use; there is a store of apparatus made by successive courses; and the course is now also established at the sister college of Bangsaan, 45 miles away, and is likely to spread further. This small success story is worth critical analysis as suggested in the foregoing paragraph. There is a report - full of insights - in the now defunct British Council publication 'Educational Development International' for January, 1974.

PROPOSAL FOR AN INFORMATION AND PLANNING SERVICE

A potentially valuable service, which could be offered by an organization wishing to help a school system to initiate or improve its production of apparatus for schools, would be the provision of a wide range of information, with ideas for designers and administrators on how to make the most successful use of it. This might be run at two linked levels: one concentrating on the design of apparatus, the other on the design of systems. The information could be presented, perhaps in an existing journal, in the form of reports, critical analyses and sources. It would be accompanied by courses in the theory and practice of all that pertains to design at these two levels. The scope might thus extend from bright ideas about teaching chemistry with plastic bags to how to amortize capital; from large-scale production of toys in Turkey to a one-man production unit in Colombia. There is a great deal of information available on such matters and equally evident need for its propagation. No less is there a need for its analysis, followed by some practical use of the results; potential apparatus producers and users could be helped to benefit their own societies by searching out some of the reasons behind the various successes and failures.