THE USE OF LOW-COST SCIENCE EQUIPMENT IN SCHOOLS

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According to the Commonwealth Secretariat publication, The Production of School Science Equipment, there are over a hundred bodies and organizations working on the production of school science equipment. Most of them merely turn out prototypes, but a few are engaged in mass production. It is clear that blueprints and good ideas on equipment production exist in plenty. What appears to be needed is knowledge of how the items of equipment made by these production units are received by the teacher and used in the classroom.

The absence of any systematic studies of evaluation of school science equipment is common knowledge. Professor Rais Ahmed, Director of the National Council of Educational Research and Training (NCERT) in a paper presented to the 1975 New Zealand Conference on "Materials for Learning and Teaching", admits that NCERT, a leading organization operating in this field, has not "undertaken any studies on cost-effectiveness of educational materials". Also, in the Secretariat publication already cited above, Warren and Lowe note that in the South-East Asian regional body, RECSAM, "work is seen as involving engineering and educational effort but without systematic analysis of the varied classroom situations into which the apparatus must fit ...". My own experience in the Science Equipment Production Unit (SEPU) confirms the above observations: no evaluative studies have been carried out on how the locally produced kits, numbering over two thousand, are being used in schools. The content of this discussion paper is therefore necessarily general.

Individual Student Experimentation/Teacher Demonstration

School practical work is often divided rather rigidly into categories - individual student experiments, and teacher demonstrations. Current curriculum development favours work on an individual basis and much effort is being made in many developing countries to persuade teachers to move away from the more traditional and familiar method of demonstration. We should not forget that we are considering a group of very inexperienced teachers, a high proportion of whom are generally untrained and whose approach to science teaching usually consists of a series of lectures with the occasional demonstration. This pattern of teaching is further encouraged by the extremely limited budgets on which schools run. We are faced, then, with a dilemma; on the one hand it is educationally desirable to move towards student experimentation, but on the other there are the constraints imposed by lack of money and experience.

This dilemma is of fundamental concern to those involved in the production of low-cost science equipment. Production units are, we hope, closely associated with other curriculum development projects and so are involved in implementing new teaching strategies. As an example, one of the practical aims of the SEPU kits has been the encouragement of an investigatory approach which will improve both the general standard of science teaching and the interest displayed by students.

Quite apart from any educational considerations, it is necessary to look at a purely business factor. For local manufacture on a commercial scale to be economically viable, there must be a sizeable market. Let us consider India as an example. Middle schools alone number over 100,000. NCERT, therefore, has no problems as far as size of target population is concerned. In fact, the market is so large that NCERT is able to afford to put up two categories of kits; one for teacher demonstration and the other for individual student experimentation. In the case of Kenya, however, there are only 1,250 secondary schools. For SEPU to consider the manufacture of any item of equipment it is necessary to have a production run of at least 1,000. In this case it is obvious that the market is simply not large enough to justify the development of a demonstration kit. Thus SEPU is at present concerned mainly with the production of individually-based science kits.

SEPU recommends that students use kits working in small groups (four represents an ideal number) but, at the same time, it acknowledges the fact that many of the poorer schools are forced by their financial situation to limit themselves to a single kit. This means that any teachers' manual designed to accompany the apparatus must take into consideration the fact that some of these kits are being used for demonstration purposes; adequate instructions need to be provided both for work in small groups and for teacher demonstration exercises.

Storage

Little thought appears to have been given in the past to storage although many teachers see it as a major problem. A high proportion of rural schools have a science room rather than a fully furnished laboratory. Such rooms are not only devoid of apparatus but also of storage facilities. One of the objectives, then, must be not only to design a kit but also something to put it in. Wood is the obvious material. It is usually obtainable locally, and labour presents no problems. Most units do design and build boxes from wood and hardboard, but occasionally experiments are carried out with other materials. SEPU at one stage packed their kits in plastic moulds in a cardboard box but this turned out to be no cheaper than a wooden box, and far less durable.

A second consideration is that many science kits, by their very nature, contain a lot of separate parts. Losses are very likely and a kit in which half of its components is missing is of little use to anyone. Thought needs to be given to this. A solution that has been tried is the design of special fixtures to hold individual items. NCERT had this to say concerning a biology kit in one of its reports. "There will not, therefore, be any mix up once the teacher knows the position of various pieces of equipment." Experience in Kenya does not confirm this. The more specialized fixtures and compartments there are, the less likely it is that a teacher will put everything away. This is particularly apparent when dealing with kits on individual basis.

A third point concerns sales. In Kenya, kits are sold on an individual basis. A school may buy as many as ten kits, each being a complete set of apparatus from which the pupils need to select appropriate items for each investigation. Such a selection is not necessarily a delicate operation, and constant rummaging in kit boxes tends to damage the more fragile components. SEPU staff have, during in-service courses, suggested to teachers that in cases where a school possesses several kits, teachers should consider repacking them in such a way that a small number of items may be withdrawn so that checking for loss becomes easier.

Although the whole area of storage is very much a problem for individual teachers in individual situations, production units do have a responsibility to design suitable containers which offer flexibility in use and are durable. Perhaps the best answer is a strong wooden box divided into a limited number of smaller compartments.

Maintenance and Repair

Design of low-cost equipment must also take repair and maintenance into consideration. Many reports freely discuss local repair, but their writers rarely seem to understand what this really involves. If an item can be mended with a hammer, then local repair is a possibility; if not, then it is much more realistic to think in terms of what the teacher can do for himself. Such routine work as polishing perspex lenses with toothpaste and softening hard modelling clay with glycerine is best included in the relevant teachers guide.

In any appraisal of the possibility of repair work, it is often not the teacher's ability but his inclination which is in doubt. The best all-around solution is to produce individual items which are as robust as possible but, at the same time, are inexpensive and stocked by the production unit in adequate quantity. The teacher will then know that he can purchase replacements cheaply at any time. This would appear to be an extravagant use of resources, but experience from SEPU indicates that in practice few science kits have items that are amenable to simple repair work, and a lack of skill or motivation on the part of many teachers means that what is broken often stays broken.

Administrative Programmes to Ensure the Teachers Actually make use of Equipment and Use Equipment Effectively

The report of the New Zealand Conference already referred to made the following recommendation: "Educational authorities should ensure that teachers receive as an integral part of pre-service and in-service training, whatever instruction they need to enable them to take full advantage of the equipment and materials that may be available to assist them in their work". A survey of the literature reveals that this statement confirms the sentiment of many production units. The need for teacher training programmes accompanying the introduction of a new range of low cost apparatus is clearly seen but is the most effective use always made for the time available?

For any programme of courses to be effective and successful, it ought to be tailored to meet the particular needs of the local situation. It might be worthwhile here to describe a specific case using as the example - the teacher training programme established by SEPU in Kenya.

Some of the problems faced by the schools for which the SEPU kits are primarily intended may be summarized as follows:

(a) Academic Qualification

Of the approximately 1,250 secondary schools in Kenya, some 850 are either private or are built on a self-help basis to serve a local community. The rest are government aided. Figures published by the Ministry of Education show that all secondary schools are staffed largely by non-graduate science staff. Although many of them are enthusiastic and very able teachers, a high proportion do experience problems of an academic nature at the form 4 (East African Certificate Education) level. In the non-government sector, the teacher shortages

are acute particularly among the science subjects; vacancies tend to be filled on a temporary basis by secondary school leavers. While every opportunity must be taken to raise the academic standards of these teachers, the problem is how one could do this and at the same time, avoid damaging the little confidence they possess.

(b) Inexperience

Part of the above problem is the relative inexperience of science teachers. With the shortage of trained science graduates, promotion to non-teaching posts of responsibility is rapid. As a result, it is unusual to find experienced African science graduates as heads of science departments.

(c) Lack of Confidence

Although much pre-service training is centred on new approaches to science teaching, teachers are extremely reluctant to depart from the patterns that they were familiar with as students. Once teaching practice is over, there is a rapid reversion to what is referred to as "traditional teaching" - a series of lectures relieved by occasional demonstration exercises. Behind this is a fundamental lack of confidence in ability.

(d) Poor Motivation

However distasteful, poor motivation of teachers is something that must be accepted. A significant proportion of teachers lack the necessary commitment to their profession, and this needs to be recognized and adequate plans made to overcome it.

Aware of the problems described above, a series of interesting and promisingly useful courses were planned to promote an interest in and encourage correct use of science kits. For the benefit of participants from the non-government sector, the courses were designed to include some basic educational theory and classroom technique.

The diagram provides a summary of the scheme for in-service training devised by SEPU. Initial planning and development were the responsibility of the biology consultant at SEPU. Having been a key person in the design work related to the biology kit, his teaching experience in Kenyan schools ensured an awareness of the problems that had to be faced. The basic plan was to provide a series of one-day courses, each involving as much teacher activity as possible throughout the provinces. The courses were designed on a unit plan, combining a local adaptation of some of the material developed in the U.K. Science Teacher Education Project, with opportunities to use the science kits.

The diagram illustrates the training available to an individual teacher. He has the opportunity to attend an introductory course at which he will be able to examine and use some of the science kits and familiarize himself with relevant teaching methods. Follow-up courses held later will enable him to go into greater depth in some of the experimental work as well as providing him with practice in other teaching skills. Finally, if he is still interested, he can continue to gain experience and help through half-day practical sessions which are organized locally.

Part of the long-term plan was to identify and train the necessary

personnel to conduct similar courses at a later date and to follow up the introductory programme. Fortunately, an excellent relationship was established with the Inspectorate Division of the Ministry of Education. Since follow-up work to a course of this nature is absolutely essential SEPU has started to make use of provincial organizations in this aspect of its work. With finances very limited, this has been centred on existing local organization and help has been received from the Ministry of Education's provincial inspectors, the British Council and, what is potentially a very valuable link, the Kenya Science Teachers' Association. SEPU provides assistance by way of personnel and equipment.

Unless attendance during in-service courses is made compulsory (and this is not the policy in Kenya), it is impossible to reach every teacher in this way. Alternative strategies are necessary. Most important of these is an adequate teachers guide. The biology kit guide, the latest in the line of SEPU teachers guides, tries to meet the same objectives as the courses. It is in two sections, a short introduction which puts in simple language some advice on teaching method and a main part which discusses each investigation in turn. Throughout the booklet, a compromise has been made between providing full information and at the same time keeping the guide brief enough to appeal to readers.

Experiments have also been made in conjunction with school's broadcasting. Radio programmes have been produced which, although directed at the students, incorporate an element of teacher training. Because these programmes have not been broadcast at the time of writing this paper, further comment is not possible at this stage.

The in-service training of teachers is expensive. A brief examination of the financing of the SEPU programme may be of interest here. The largest items on the budget are the transport expenses and accommodation for teachers. These have usually been kept to a minimum by running identical one-day courses on a provincial basis. The cost of a teacher's transport and subsistence is met from the appropriate vote by his school. SEPU pays for staff accommodation and transport In a series of six introductory courses for which full records were kept, it was found that SEPU spent approximately 3,000 Kenya Shillings. It is of interest to note, however, that in the month immediately following these courses, sales resulting from orders made at these courses amounted to 35,000 Kenya Shillings!

The situation with pre-service training is not satisfactory. Progress has been poor but it is hoped that better liaison between institutions that train science teachers and SEPU will lead to closer co-operation in future. Outside of this experience, it must be remembered that once a production unit starts manufacturing science apparatus in quantity, note must be taken of this fact by training colleges and universities preparing science teachers, whether or not they are in full support of the scheme.

Evaluation of Equipment by Teachers

Formative evaluation should be a basic concern of any production unit. It is essential to have continuous assessment and feedback from the classroom. Much has been written concerning this subject (see the New Zealand Conference report on "Materials for Learning and Teaching") already and so, here only the importance and role of the teacher in evaluation is considered. Close co-operation between the evaluator, however experienced, and the teacher, however inexperienced, is vital. The fact that this is not recognized probably leads to more failures than any other factor in attempts to gain information at

the school level. A look at some recent, small-scale evaluations reveals a number of points worthy of note:

(a) Teachers are busy. They have many more important jobs to do than fill in circulars. It is reasonable to ask a teacher for ten minutes of his time, but questionnaires that take an hour or more to complete are unrealistic. Similarly, a teacher is more likely to return the information promptly if he has to tick the appropriate box rather than supply a detailed report in answer to every question. A further practical point that is easily forgotten is that certain times in the school year are much busier than others. Avoidance of the examination period period, for example, will be much appreciated.

(b) The aims of the evaluator are often not clear. The teacher should know why he is being asked to supply particular information and to what use it will be put.

(c) There are obvious advantages, mainly in terms of a saving of time and money, in conducting an evaluation by means of postal circulars. Unfortunately, the number of such circulars that are returned can be depressingly low. If circumstances permit, it is better to establish personal contact. A structured interview can produce more satisfactory results since points can often be clarified where necessary.

(d) It is important that the evaluator asks his questions in the correct way. In the early work of SEPU, an attempt was made to determine the needs, in terms of apparatus, of science teachers. Teachers were asked a question like, "Would you like a model of a DNA molecule?". Obviously, no teacher was going to look a gift horse in the mouth. When the results were analysed it was found that "95% of teachers would like DNA model". In this way, an item completely unjustified in terms of cost-effectiveness was included in the prototype kit.

SUMMARY OF SEPU IN-SERVICE TRAINING SCHEME