LOW-COST SCIENCE TEACHING EQUIPMENT : STRATEGIES FOR PRODUCTION

The importance of science to national development has been recognized by all governments in Commonwealth Africa. In most countries, therefore, efforts are being made by the authorities responsible for education to make a knowledge of science available to as many school pupils as possible. In order to do this effectively, curricula are being developed that emphasize the relevance of science to environmental conditions and which stress active student participation. These programmes inevitably require an adequate supply of equipment, often of equipment that is peculiar to a particular curriculum. However, some curriculum projects are approved without any certainty that the equipment required will be provided. As a result the close relationship that ought to exist between curriculum and equipment is absent. Even where the latter is recognized as being an integral part of curriculum development, the prescribed apparatus may prove to be beyond the manufacturing capability of local manufacturers and too expensive to import.

For a number of years Commonwealth countries have relied upon foreign aid, importation, and improvisation by teachers to provide the necessary equipment. Such means of supply have, however, proved inadequate. Foreign aid can only meet a small fraction of the ever-increasing demand for school science materials, and imports have suffered with the increasing scarcity of foreign exchange. As for improvisation, only a fraction of teachers have the facilities and the ability to make equipment which fulfils the needs of the new curricula, and only the most interested will be motivated to do so - and then only in their fields of special concern (e.g. electronics or electricity). Consequently, most teachers make no significant use of the resources of the local environment in the teaching of science in schools.

During the earlier plenary sessions, papers were presented on the status of science education in the various countries represented at the seminar. It was noted that plans exist in most countries to alleviate the problem of inadequacy in the supply of equipment through efforts in production at the local level. Indeed, it was observed that in Kenya, mass production of science equipment which meets the needs of secondary schools has already begun.

Rationale for Setting up Local Production Units

Participants agreed with the writer of the lead paper that the strategy for producing school science equipment should begin with a philosophy that recognizes education through science contributing to the fulfilment of national aims and objectives. It should be a philosophy that stresses the need for Africans to see themselves "as living perfectly normal scientific lives at their own level of development". Thus, in addition to monetary considerations, it was felt that local production efforts based on a clear policy would meet certain hidden costs - psychological, social and cultural. Specifically, such efforts would instil confidence and pride amongst peoples; enable students, teachers, technicians, and the community to develop skills that would promote much-needed technological development; provide economic and other social advantages such as employment; and encourage regional co-operation, where necessary.

Besides taking into account all the "costs" involved in production, participants gave their support to the lead paper writer's concluding remarks on foreign aid. In particular it was agreed that technical assistance personnel are still necessary in Africa but that their deployment must aim at, and achieve the elimination of, the foreign specialist. It was further pointed out that foreign technical assistance personnel do not necessarily have to be non-Africans.

Organization of Production Units

The design and production of low-cost science equipment must be determined on the basis of a country's needs, which in turn would reflect the objectives of the science curriculum. An implication of this starting point is that it is essential for production units to be in close liaison with curriculum developers, teacher trainers, and all who are responsible for school syllabuses.

It was pointed out that it would be unwise to link a production unit too closely with an academic research institution. Case studies of equipment production schemes in Nigeria, Kenya, Sierra Leone and elsewhere revealed problems where this had happened.

Regardless of the siting of the production unit, training facilities should be separate from production facilities. It has been found that mass production is seriously hampered when subordinated to a training time-table; also that the training received by teachers is too limited when it depends upon the chance requirements of a production programme from month to month. Further, involvement of teachers in the production unit should be restricted to short courses for serving teachers and to the use of the unit's products in the teacher training courses in the various departments.

If the syllabuses are uniform throughout a country, the production unit should be nationally based. This will increase the output of each item and hence improve the prospects of production being economically viable and efficient. However, geographical and other factors which might create problems of communication should not be overlooked. In the case of regional variations in syllabuses, it is best to make flexible kits on a regional basis. Alternatively, a basic kit suitable at the national level might be designed with additional items provided to suit the regional variations in syllabuses. The advantage of this arrangement lies in the fact that the complete set of science equipment for a given locality can include not only the basic national kit but also those local materials which have been found to be relevant to the pupil's environment and which are recommended for the regional curriculum. Thus a closer fit with the environment - geographically, sociologically and culturally - will be encouraged.

Training should include designing and constructing prototype equipment and learning about organizational strategies for making use of science equipment. This is illustrated well by the activities of an organization such as JETS (Junior Engineers, Scientists and Technicians) which operates successfully in Zambia.

Guidelines for Setting up Production Units

When planning the level of technology required by a national production unit, it is necessary to make an assessment of needs in terms of the curriculum requirements and the scientific concepts to be acquired by the pupils. These requirements will vary according to the educational standard of the people and the level of the institutions to be served. Further, a national incomes policy, if it exists, should be taken into consideration so that the most appropriate choice can be made between a labour intensive or a capital intensive approach. It may also be necessary to carry out a number of surveys and studies to find out, amongst other things: (a) the type and nature of existing units engaged in the production of science equipment for the target educational levels; (b) the expected volume of production and sales potential; (c) the machinery required and its costs; (d) the availability of raw materials; (e) foreign currency factors; (f) manpower threshold; and (g) those sectors of the economy other than science education which could benefit from the production facility or its products.

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 a 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 teachers' associations. Reference was made to the existence of such co-operation in Kenya and Nigeria. In Kenya, for example, the school equipment production unit has on its management board personnel drawn from the Ministry of Education, the Ministry of Finance and Planning, the Kenya Science Teachers College, the National Council for Science and Technology, and the Kenya Institute of Education. It was pointed out that the consultative group envisaged should be involved not only in initiating the production processes but also in evaluating the finished product.

It was noted that depending on the availability of human and physical resources a production unit could start operation at one of three levels: local bulk purchase of imported equipment, importation of critical components followed by local assembly and distribution, and full local manufacture and distribution.

The Manufacturer of Low-Cost Science Teaching Equipment

Considering the diversity and varied sophistication of the science teaching materials required, the seminar suggested that the efforts of all the institutions responsible for production at national and regional levels should be co-ordinated. Thus, governments might set up pilot plants to manufacture equipment, preferably on a commercial basis, when prototypes had been developed. Alternatively, commercial enterprises, including cottage industries, might undertake mass production. However, it was emphasized that complete governmental control should, where possible, be discouraged lest the organization be crippled by bureaucratic bottlenecks. Furthermore, it was pointed out that since most people live in rural areas, consideration should be given to siting production units in these areas in order to help improve employment prospects in those areas.

Design of equipment

Participants agreed that the curriculum should determine the type of equipment to be made by a production unit and not vice versa. Ideas for design of equipment must therefore originate from teachers and students in schools.

At the design stage, or even later when it becomes necessary to standardize the equipment, quality and durability must be reconciled. This is particularly important at the primary level where the process of learning often involves taking equipment to pieces and rebuilding afresh. This fact demands flexibility in design, a factor which may further allow for future changes in curricula. The modular approach to the construction of equipment may sometimes be found suitable, and participants at the seminar pointed out that when a kit has to be manufactured as a whole, the possibility of producing interchangeable and replaceable parts should be investigated. Such findings may lead to the development of a wide range of apparatus which can be used for different purposes at primary and secondary levels. Again, in designing, the use of local materials should be considered. For, when local material is used, the kit or pieces of equipment may become more realistic to the pupils.

Support Materials

In considering the production of support materials, the seminar emphasized that the production of curriculum objectives and guidebooks should precede production of equipment. This is especially important wherever teachers work without the benefit of high-level academic training. The production of support materials such as slides, film strips, and manuals should be associated with the available mechanisms for equipment production. The successful cases of Kenya and Nigeria give support to this contention.

The Choice between Kits and Apparatus

Several countries represented at the seminar expressed a preference for apparatus; others preferred the production of both apparatus and kits. Apparatus is advantageous for schools that wish to buy only what they do not have. A further advantage is that whereas apparatus is easily adopted and modifiable, a kit may contribute to wastage through inclusion of items which are not necessary for every school. Also, in some countries, schemes for producing apparatus already exist and it would be uneconomical to abandon them.

On the other hand, kits have some advantages too. For one thing their production enables financial savings to be made. In addition, kits can very easily be made compatible with a curriculum or syllabus; problems of storage can be reduced, and accompanying manuals can be made more precise than textbooks. But they also have disadvantages. They can lead to a fixed way of teaching for years, thus inhibiting innovativeness in teachers; they are inferior in operation because of the smaller size of individual pieces; and if one or two pieces get lost, teachers are apt to abandon the whole kit.

In two cases - Kenya, and Bendel State of Nigeria - kits have been employed successfully; up to the school certificate in Kenya, and at the primary-school level in Nigeria. These two cases show clearly that in the absence of apparatus (a common situation in lower-secondary and primary classes in Africa) kits are indispensable.

Taking into account the economics of kit production or of apparatus production, a choice can be made as in Tanzania in favour of individual pieces of apparatus. Where the decision to use kits is accepted, their greatest usefulness is likely to be seen to be in the lower-secondary and in primary classes. It may be worth while in this case to produce the core of a science kit which should be suitable for all the schools in the country. In any particular locality, this core could be complemented by those locally available materials that are especially relevant to the pupils' environment.

Regardless of whatever choice is made between kits and apparatus, it would be wise for any production unit to limit the range of items it intends to manufacture to those for which it has the expertise, the necessary machinery, a ready source of raw materials, and a ready market. Further, the unit should aim at producing cheap equipment while at the same time ensuring that the quality of its products compares to that of imported ones.

Distribution of equipment

It was generally agreed that in order to reduce expenses incurred in transportation, packaging and handling, it is desirable to convey items of equipment directly from factory to schools or if necessary to regional distribution centres. The internal administration and management of ordering and delivery to schools should be left to individual countries. It was noted however, that warehousing causes deterioration, especially in the tropics; consequently, careful stock keeping is required.

Production of chemicals

It was noted that in current efforts to make use of local materials in the production of equipment, little or no attention has to date been paid to the identification and processing of natural products for use as chemicals in the African environment. Participants cited, as examples, the following sources of chemicals that can be produced in Africa: ashes from plants such as bananas, palm trees, groundnuts and cocoa trees (which have very strong alkaline properties); rice grains and the lubi plant found in West Africa (which can be used as desiccants); and lime and orange juices (which have acidic properties).