Low-Cost Science Teaching Equipment: 2

Report of a Commonwealth Regional Seminar-Workshop

Dar es Salaam, Tanzania,
20-30 September 1977

Commonwealth Secretariat

Low-Cost Science Teaching Equipment: 2

Report of a Commonwealth Regional Seminar-Workshop

Dar es Salaam, Tanzania,
20-30 September 1977

Commonwealth Secretariat, Marlborough House, London SW1

COMMONWEALTH SECRETARIAT

Marlborough House Pall Mall London SW1Y 5HX

ISBN 0 85092 147 3

Copies may also be purchased from the Publications Section of the Commonwealth Secretariat.

Printed and Published by the Commonwealth Secretariat

CONTENTS

INTRODUCTION

Until recently, science as a school subject has been unknown at the primary school level in most countries of the Third World. Even at the secondary school level where science has been taught for a number of years in Commonwealth African countries, the subject has still not made much impact at the classroom level partly because of the non-availability, inadequacy and ineffective utilization of teaching aids and equipment. Commonwealth governments have therefore requested the Commonwealth Secretariat to promote and encourage co-operative activities specifically aimed at alleviating the problem of school science equipment. This task is being undertaken by the Education Division of the Commonwealth Secretariat.

One aspect of the Division's work has been to begin the production of publications on science equipment and science centres as a contribution to the exchange of information. Another has been to embark on a series of regional science teaching seminar-workshops aimed at assisting member countries to make science teaching more effective and less costly by the use of locally-made equipment.

The current seminar-workshop is the second in the series of such meetings on the theme of low-cost science teaching equipment. Detailed discussions were held on the broad topics treated at the first seminar, paying special attention to the strategies for production and use of low-cost equipment in the African context. Again, the seminar included practical laboratory sessions at which participants actively familiarized themselves with workshop techniques for the construction of some basic items of equipment which are at present generally imported into the various countries. Participants showed great enthusiasm and produced some equipment themselves.

Ways of identifying regional and pan-Commonwealth co-operation was, as usual, another objective of the meeting, and some proposals were made in this connection. It is hoped that these proposals will result in practical programmes and projects that will assist countries in Commonwealth Africa in making their science education programmes more effective.

The Commonwealth Secretariat wishes to acknowledge its gratitude to the Government of the United Republic of Tanzania for its hospitality in hosting this seminar-workshop and for the facilities it kindly provided through the Institute of Education and the University of Dar-es-Salaam. Special thanks are undoubtedly due to the hardworking Chairman, Ndugu W. S. M. Migembe who very ably steered the sessions and, who, with his cheerful, friendly team of local support staff, made us feel at home in every possible way. Our thanks are due also to the consultant, the resource personnel, the delegates and the observers who all contributed effectively to the work of the seminar.

The seminar-workshop took place from 19-30 September 1977. It was funded by the Commonwealth Fund for Technical Co-operation.

SEMINAR/WORKSHOP RECOMMENDATIONS

STRATEGIES FOR PRODUCTION

Recommendations to Governments

Every Government in Commonwealth Africa should :

1. Identify and clearly spell out its objectives for science teaching within the context of its overall plans for national development.

2. Devise a curriculum that reflects its needs, and choose appropriate low-cost science teaching equipment and support materials which have been developed hand in hand with the curriculum in order to implement its objectives for science education.

3. Endeavour to set up a science equipment production unit wherever one does not exist, either as a self-contained national unit or as a component of a larger sub-regional or regional complex. One of the aims of such a unit should be to produce a set of basic science kits suitable for all schools and colleges in the country.

4. Consider an institutional framework for science equipment production units which ensures communication and collaboration across Government Ministries/Departments as well as across educational institutions and agencies including curriculum development units and teacher training institutions.

5. Pursue actively the identification and local processing of available natural products for use as chemicals.

6. Ensure through appropriate legislation that where importation is necessary, material required for the local production of science teaching equipment can be imported at the lowest possible cost and with minimum delay.

Recommendation to the Commonwealth Secretariat

7. The Commonwealth Secretariat is requested to hold in the near future a review seminar/workshop and to continue further follow-up action, including monitoring action through existing regional centres or programmes, which will enable member states to assess the progress made by each country in developing and mass producing school science teaching equipment.

Recommendations to Governments and International Bodies

8. Governments and International Bodies are requested to encourage:

   (a) The formation of Science Teachers' Associations in countries where these do not exist and to support the national and international roles of such associations where they exist, if necessary with the assistance of international agencies with special interest in science education in Africa.

(b) The formation by Science Teachers' Associations of effective science clubs in all schools and colleges.

9. Regional co-operation in its many forms should be given further support by Governments and International organizations as a vital means of exchange of information and personnel especially where bilateral contact is difficult or impossible.

10. African Governments should actively consider, as a long-term measure, the establishment of a regional centre to monitor development in the field of school science equipment in the African region.

STRATEGIES FOR USE

Recommendations to Governments

Every Government in Commonwealth Africa should :

1. Establish and actively pursue a science policy designed to ensure that science is taught practically and effectively in schools, and that such science is relevant to the development of its pupils and its society in the context of the modern world.

2. Provide laboratory assistants with sufficient professional training and career prospects to increase their efficiency, retain their services, and increase their productivity.

3. Provide adequate financial and career incentives to science teachers in order to increase their efficiency and productivity and retain their services.

4. Lay down careful specifications of pieces of equipment suitable for use according to local climatic and other conditions, and encourage standardization in order to reduce production and maintenance costs by the use of a set of basic equipment by all schools and teacher training institutions.

5. Encourage creative and innovative teaching by making special financial provision or grants to those schools which show originality in the development of science teaching equipment.

6. Assist institutions of teacher education in devising programmes of training and retraining which will produce teachers who are properly oriented for creativity and innovation.

Recommendation to Teachers and Examining Bodies

7. Teachers and examination boards should lay more emphasis on continuous assessment of both practical work and projects carried out during the course in arriving at the final evaluation of pupils' work.

8. It is strongly recommended that each country's science curriculum should contain a set of basic science experiments to be carried out by all schools, and that appropriate low-cost equipment, pupils' texts and teachers' guides should be provided for these experiments. Teachers and local authorities should then be responsible for supplementing this list with other experiments and materials reflecting local environmental needs.

SCIENCE EDUCATION IN COMMONWEALTH AFRICA

Some countries represented at the seminar provided papers on the progress they have made in science education and its present state of development. The main points emerging from these papers are summarized below.

Primary Cycle

Objectives

African countries in the Commonwealth share a science education approach attributable to historical factors. Prior to independence and for some years thereafter, the objectives of science education in the primary school were not stated explicitly. In terms of practice, however, they seem to have included identification of plants and animals, a knowledge of basic rules of hygiene, and an ability to recall facts. Science appeared in the primary school timetable under the labels of Nature Study and Hygiene.

In 1960, Commonwealth African countries participated at a conference in Lagos on "Science in the Advancement of Newly Independent African States". The meeting resolved that science should be taught in primary schools in Africa not merely to serve purely intellectual purposes. It should also aim to equip young persons with a functional and rational understanding of their world to a level that would create feelings of liberation and of mastery of the environment. Science education would thus adopt a generalized approach suitable for all children. Also, at the 1961 Addis Ababa Conference of African Ministers of Education it was noted that African primary education as a whole was at variance with the postulates of independence and with the demands of rapid technological advancement. But it was not until a similar conference in 1968 that African Ministers of Education spelled out the objectives of science education in the context of national development and stressed the development of attitudes in the learning of science.

Earlier in 1965, at a conference held in Kano, Nigeria, and attended almost entirely by African members of the Commonwealth, a definitive overall objective of primary science had been suggested: the focus would be the development of children - intellectually, physically, culturally and socially - to understand and make rational decisions about their total environment. Science would serve as a useful medium for that development. Science was deemed useful for this purpose because of its nature, methodology, and wide applicability. To nurture and refine this objective at the regional level, the Science Education Programme for Africa (SEPA) was formed.

Each African country in the Commonwealth has made some effort to develop the idea of using science as a vehicle for human growth in consonance with its total aspirations. The Arusha Declaration of 1967, for example, provided an appropriate framework for Tanzania; the New Primary Approach served in Kenya; while a 1970 White Paper, the recent National Policy Paper, and the 1970 Takoradi Conference enshrined the objective in Sierra Leone, Nigeria, and Ghana respectively.

Content and Methodology

In the days of Nature Study and Hygiene, subject content was limited to a few plants and animals and to a study of a few rules of personal hygiene. Children had to identify from drawings, and to remember names of specific plants and animals found in the local environment. The "chalk-and-talk" method of teaching was used. The teacher would make diagrams and write notes on the chalkboard for children to copy. Very often pupils copied diagrams from books, and occasionally the teacher would dictate notes. Very few or no visual aids were used. An important characteristic of the methodology was the memorization and recitation of facts by pupils.

During the last ten to 15 years, because of the shift in the major objective of primary science, the content has changed dramatically; it has been enriched by the development of primary science curricula in all Commonwealth African countries. The primary science syllabuses now being prepared in each country organize content in terms of different attributes to be developed - intellectual processes and concepts; inquisitiveness, interests, and attitudes; and physical and manipulatory skills. Nevertheless, the use of the inquiry-based practical approach at the classroom level remains largely a hope than a reality.

Pre-service Teacher Education

As in the primary schools, science as such was not, until recently, taught in institutions training teachers for the first cycle of education. The content of Nature Study and Hygiene was slightly broader than that of the primary school; the teaching methodology was the same.

Science was introduced in teacher training colleges following its appearance in the primary school curriculum. Consequently, the science background of teacher trainees was either non-existent or very poor. This often led to an academic orientation of content and to the exclusion of the methodology of science teaching since this was the responsibility of the methods tutor! Though content and methodology are now integrated, many teacher training colleges still devote the better part of their science education periods to the improvement of the students' background in science.

One of the fundamental problems of science education in the teacher training colleges was that science tutors themselves had an academic orientation to science, and their methodology was largely that of the transfer of scientific information to the students. Even as equipment and laboratories became available, science teaching remained theoretical. Country papers, notably from Nigeria, Zambia, Tanzania, Sierra Leone, and Botswana indicated that this situation is changing gradually.

Further, with the re-orientation of science in primary schools towards integrated environmental science approaches and with the stress on practical science, a practical problem-solving approach to science teaching is now emerging. This is evident for example in the regional tutor-training programme at the Njala campus of the University of Sierra Leone which receives Commonwealth Secretariat support (through the CFTC) by way of fellowships to students from Commonwealth Africa.

In-service Teacher Education

All the African members of the Commonwealth run refresher and re-orientation courses for serving teachers, many of whom have a poor knowledge of science and very little training in practical science and its use as a medium for education.

In-service training courses range from short briefing sessions to workshops lasting several weeks. Although briefing courses tend to be theoretical, in-service workshops adopt activity approaches so as to develop practical skills in making and selecting materials and equipment that will make science teaching practical and meaningful at the classroom level. It is noteworthy that some countries, such as Zambia, have special colleges for the extended retraining of serving teachers.

Facilities for teaching science

In the last decade, Commonwealth African countries have established science curriculum development centres to spearhead the improvement of science teaching in schools and teachers' colleges. Where such centres do not exist, Institutes of Education have served the purpose. Centres and Institutes have been engaged in the development of science curriculum and syllabus guides containing suggestions for content, built-in methodology, materials, and locally available simple equipment and tools. Science curriculum development centres and their sub-centres also serve as training points for teachers during formal courses and allow individual teachers to avail themselves of their facilities.

Science laboratories are a regular feature in teacher training colleges but not in primary schools. In most colleges the laboratories are equipped for tutor demonstration only, but in others the situation allows for student experimentation as well. Usually teacher training colleges also have wood and metal workshops where students get opportunities to design and construct science teaching aids. At the primary school level, an "outdoor" approach to science learning, and the use of technology artifacts found in the local community, are preferred. Notwithstanding, at some centres (e.g. at Abraka in Nigeria) pilot schemes are under way on the production of science teaching kits for primary schools. The paucity of reliable information relating to actual classroom practice in primary schools and teacher training colleges, and to the costs and effects of a practical science teaching approach on schools, suggests a deficiency in monitoring and feedback services which requires urgent attention.

Secondary Science Education

Historical Introduction

Concurrently with the drive for the expansion of education to meet the targets assigned by the Addis Ababa Conference of 1961, there has existed in Africa a trend towards the improvement of general scientific and technical education. One of the recommendations of the 1961 conference was directed towards the reform of the content of education in order to meet the demands of technological progress and economic development, especially industrialization in Africa. In August 1964, an international conference held in Lagos recommended a plan for scientific research and training with a view to "study conservation and utilization of natural resources in Africa". The Lagos plan envisaged the training of scientific personnel at three related levels: the highest level would be that of experienced scientists with full postgraduate training, the middle level would group together those scientists with a university degree, and the third level would deal with training given at the post-secondary school level. On the subject of science teaching, the conference recommended that new approaches be introduced "including the teaching of science at early stages in schools, making use of more realistic methods of practical and experimental work, and of producing new text-books suited to local conditions".

Development

In the past most Commonwealth countries in Africa taught science as Physics-with-Chemistry, Physics, Chemistry, Biology, General Science, and Health Science. The teaching was based on the Cambridge Examination syllabuses. In general the syllabuses were examination-oriented, not teaching syllabuses, and teachers tended to teach for the examination rather than educate the students. Rote learning was the order of the day; students learned and reproduced at examinations results of experiments they had not performed in class.

In the 1960s, new science curricula such as Integrated Science, Agricultural Science, and Home Economics were gradually introduced and were supported with materials in the form of teachers' guide-books, student manuals and science equipment. In many countries this school science project material was at first provided from other countries with very little or no modification. For instance, the Scottish Integrated Science Project, and the Malaysia Integrated Science Scheme, were introduced into Botswana and the Seychelles respectively.

The innovation in science curriculum was aimed principally at the junior secondary school, and in most countries only pilot schools were involved. It was soon evident that although the projects led to improvement in science teaching they left a number of problems unsolved, particularly the increasing cost of equipment which had to be imported from the sponsoring country.

Attempts to improve science syllabuses and to write student manuals and teachers' guides followed next. In some countries, the designing of syllabuses has been a function of institutes of education which are either outside the university systems (as in Tanzania, Kenya, Mauritius and Sierra Leone) or within the university set-up (as in Nigeria and Ghana). Apart from, or in addition to, these institutes, curriculum development centres have been established in countries such as The Gambia, Zambia, Seychelles, Malawi, Ghana, and Nigeria as separate units of the Ministry of Education, and their science panels are responsible for planning, revision, and reform of the curriculum.

Science Teachers' Associations have played and continue to play prominent roles in science curriculum reform especially in Zambia, Nigeria and Ghana. For instance, the Science Teachers' Association of Nigeria (STAN) pioneered the Integrated Science Education Project for Nigeria, and the Ghana Association of Science Teachers (GAST) has been responsible for the Project for Science Integration whose syllabuses, student manuals and teachers' guides are currently being used in the first two years of secondary school in Ghana. Both STAN and GAST are noted for their professional input to the syllabuses and examinations organized by the West African Examinations Council.

It must be mentioned that successful science curriculum development necessitates the collaboration of many educational institutions. Curriculum units on centres, teacher training institutes, and university education facilities must join forces with teachers in the field to produce material that was relevant both to national educational goals and to the teacher working in the classroom.

Although this has been the general trend, progress on the road of science education reform is slow. One of the main reasons for this is the large number of primary school leavers gaining admission to secondary schools. They put more strain on science teaching facilities than most secondary schools can cope with. The demand for places will increase with the trend towards universal primary education which is on the way to being fully implemented in such countries as Mauritius, Nigeria and Tanzania. To promote national development and productive employment, secondary school syllabuses are being diversified to include agricultural training, and technical and pre-vocational education. In countries like the Gambia and Tanzania for instance, attempts are being made to do this by setting up secondary technical schools which aim to provide technically oriented and vocationally oriented courses. It is hoped that these applied courses will enable graduates to be directly absorbed into the manpower pool of technicians.

Other factors mentioned as militating against the teaching and learning of science include shortage of qualified staff, non-availability, inadequacy and ineffective utilization of teaching aids and equipment.

All the countries represented suffer from a lack of qualified science teachers. Thus, for a long time to come, they may be forced to rely on expatriate teachers who are employed on contract basis for a duration of three years or so.

The qualifications normally required for teaching as a trained teacher is a university degree together with a certificate or diploma in education. Nearly all the countries now have national universities able to train students for science education degrees. But generally it is found that education diploma courses are not popular with science students. They prefer to be employed in industry. Many schemes have been put forward to attract to the teaching profession and keep them there. For example, the Federal Government of Nigeria offers, as an incentive to graduate science teachers entering teaching initially, additional salary increments above that of their Arts counterparts. Kenya, Tanzania, Sierra Leone and Ghana have similar schemes. Other steps taken to improve the conditions of service of qualified science teachers are easier University admission requirements, quality upgrading of serving teachers through in-service education, and the creation of more Colleges of Education which train science teachers only (Tanzania and Kenya).

School Science Laboratories and Equipment

No matter how much the curriculum is improved or how imaginative and well trained the teachers are, every school needs a minimum of science equipment and laboratory space to make science teaching effective. However, except in a few cases, most science laboratories are ill-equipped, ill-maintained, poorly staffed and not spacious enough. Surveys of secondary schools in some countries have shown not only that equipment is lacking in most secondary schools but that damaged equipment is often left unattended and unrepaired.

It is very rare to have laboratory technicians in schools. Most laboratory attendants or assistants have at the most a junior secondary certificate, and normally they are trained on the job by class teachers who are themselves lacking in technical skills. There is therefore a great lack of expertise in the techniques of maintenance and repair of science equipment in schools.

Wherever a sound programme of science teacher education exists, experience in improvisation of science equipment also exists. It is usually expected that science teachers should learn how to construct some science apparatus during the course of their training. Although this activity should be encouraged as one effective mechanism for the renewal of ideas and the introduction of new designs in science equipment, efforts to supply equipment have to go beyond improvisation. There should be local production which implies a sophistication over and above improvisation, and which results in supplying apparatus for the needs of the whole school system rather than for the needs of an individual school.

Almost all the countries report activities aimed at producing equipment for science teaching particularly for primary and lower secondary schools. Detailed descriptions submitted by participants will be used in updating the Secretariat's publication, The Production of School Science Equipment. For this reason only a few examples are given briefly here. The most advanced efforts have so far been made in Kenya where the School Equipment Production Unit (SEPU), set up in 1969, has produced students' kits for Physics, Chemistry and Biology. The set of three kits cost only about US $150. Most of the items in the kits have been developed locally. SEPU's programme of activities includes pre-service and in-service training for teachers. The Science Curriculum Development Centre in Njala University College in Sierra Leone, has constructed simple items principally for primary teaching. The Scientific Instrumentation Centre in Accra, recently set up as a joint project by UNDP and the Government of Ghana, has started production in glassware equipment. The Centre for School Science Equipment in Yaba, Nigeria, is currently focusing its attention on the repair and maintenance of equipment in schools through the operation of Mobile Service Units, though there are plans for production of equipment in the near future. JETS (Junior Engineers, Technicians and Scientists) - the official organization responsible for school science clubs in Zambia - organizes activities at which various items of equipment are produced. In Botswana, a Teaching Aid Production Unit has been set up in Francistown. In Lesotho, plans are underway to staff and equip the production unit at the Science/Maths Centre. The Tanzania Elimu Supplies, a para-statal organization is concerned mainly with distribution of equipment, but under the Small Industries Development Organization there are plans for some small industries to produce science teaching equipment. And, in Swaziland the Science Centre at William Pitcher Teachers' College produces a limited range of equipment.

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).

LOW-COST SCIENCE TEACHING EQUIPMENT : STRATEGIES FOR USE

All too often there is an unfortunate presumption that once the problems of production are solved, the objective of teaching and learning science using enquiry-based practical approaches will be achieved automatically. Evidence refutes that assumption; witness a reliable study that revealed a 43% non-use of available science teaching kits in one Commonwealth country over a six-month period. Recognizing this fact, participants at the seminar considered ways of ensuring that once equipment was produced it would reach the classroom and be used appropriately, imaginatively and effectively.

Why Practical Work in Science?

In the study of science, theory and practice should be seen as inseparable since science is rooted in experiment. Practical work not only helps to develop a functional understanding of scientific concepts and of scientific equipment, it also plays a role in the inculcation of scientific attitudes and practical skills. Because it can provide an immediate sense of satisfaction, self-confidence, ingenuity and dexterity, it is an invaluable source of motivation. It can contribute to a cultivation of desirable social attributes such as co-operation with others and learning from one another. It can also lead to an appreciation of the value of knowing things at the "doing" level, and cater for varied individual interests and creative imagination.

Selecting Science Equipment

Even though an understanding and appreciation of the place of practical work in school science would contribute immensely to the use of science teaching equipment, the value of practical work would be diminished if it was not preceded by a wise selection of equipment, both at the national level and at the classroom level.

At the national level, selection will relate to the policy for science and the policy for science education. Generally the former will be concerned with human resource utilization for scientific, technological, industrial, and economic development; the latter with the country's desire not only to develop scientists, technologists and technicians but also the creation of a practical scientific awareness in the population at large.

It is essential for the national policy to be embodied unambiguously in science curricula and syllabuses as well as in examinations and assessment schemes. Decisions relating to the selection of equipment to be produced or ordered, and to the style and extent of equipment usage, should be made in that context. Of course selection should also take into account the educational levels for which the equipment is destined, in particular the development of specified psychomotor capabilities and the acquisition of scientific concepts in a meaningful and directly applicable practical fashion.

It is meaningless to select equipment which is so costly that schools cannot afford it. Low-cost equipment should, therefore, be preferred and all possible sources of such equipment should be explored. For example, local technologies which for generations have been the mainstay in societies of Commonwealth African countries should not be overlooked in the search for producers of science teaching equipment.

An important component of the wise selection of science teaching equipment is the provision of adequate specifications. In a number of cases, non-use of equipment can be attributed to lack of essential information about the equipment. Another aspect of specification is the provision of a basis on which to decide the size of an order. Yet another is an indication of which material is suitable for which parts of the country.

At the classroom level, selection must take into account the factors already mentioned above. But more specifically, the objectives of particular lessons to a given class play a paramount role. These objectives concern choices between precision of measurement (which may require expensive equipment) and an understanding of principles, which can often be achieved with low-cost apparatus. Considerations for the development of original ideas in the use of equipment should also receive attention. It is imperative that selected equipment should correspond to the physical and conceptual attributes of the learner if profitable learner participation is to be enhanced.

The Needs of Teachers

Strategies for use of science teaching equipment must take into account the many existing problems, including the shortage of suitably trained science teachers and science teaching supporting staff. Ineptitude in the use of science equipment, as well as poor pedagogical practice on the teacher's part, discourage student experimentation and engender feelings of insecurity. Combined with the pressures of time and syllabus requirements, these problems can lead to the elimination of practical classes.

It was observed that efficient and effective use of science teaching equipment depends on the teacher's attributes and capabilities. Teacher training should therefore be seen as a vital component in all processes aimed at introducing any new range of low-cost science teaching equipment. Desirable teacher characteristics in the use of science teaching equipment should be developed at the pre-service stage so that at the in-service stage teacher education can concentrate on the renewal of skills and on training in the use of newly designed equipment. Also, teacher training institutions must assist their trainees to get the most from the apparatus they are likely to find in schools. Where the majority of trainees are to be posted to rural schools with limited laboratory facilities (a common situation in developing countries) both in-service and pre-service training should reflect this consideration.

Given the current situation dominated by untrained teachers in Commonwealth Africa, massive in-service teacher education is mandatory. Training techniques, to be effective, should incorporate a thorough understanding of concepts as well as proficiency in the use of science teaching equipment. Experiences in the design and construction of simple prototypes would improve the quality of training; so would opportunities to learn to exploit the school environment and resources available in the community.

Laboratory Facilities

Poorly designed laboratories and storage rooms, as well as inadequate space and safety provisions, discourage the use of science equipment.

Vaguely written manuals and lack of clarity in instructions for the use of apparatus also create problems.

Another difficulty associated with the use of science equipment arises from insufficient maintenance and repair services. The situation arises from both non-availability of spare parts and the lack of trained support staff.

Science Teachers' Associations

Science teachers' associations, when properly run, may provide a very effective professional machinery alongside the official government services. They are capable of co-ordinating national efforts towards the implementation of a sound and meaningful science education programme in harmony with national scientific and technological goals. They can play a crucial role in the promotion of further education for teachers in the use of updated equipment. By emphasizing and rewarding imaginative locally oriented projects, they can go a long way towards the re-orientation of science teaching. They can, for example support science clubs and other ways of popularizing the use of science teaching equipment. These science clubs should endeavour to do more than demonstrate the use of equipment or the illustration of scientific principles: they should also aim at solving problems that arise out of the environment and relate to the life of the community.

Using the Media

The improvement of the quality of science education must go hand in hand with its expansion. The use of mass media for promoting effective use of low-cost science equipment is an attractive proposition because of the extent of the coverage achieved. However, the radio does not lend itself readily to promoting the use of science equipment. Television, where it exists, can certainly make valuable contributions in that field. It was suggested that both TV and radio could be very appropriate in tackling science teachers' problems in the use of equipment by broadening their information field and providing a forum for answering their questions.

A similar service can be rendered by newsletters, magazines and newspaper supplements. These can provide a medium for the professional exchange of experience in the field of design and use of appropriate science equipment. Many countries are well advanced in the practice, and useful newsletters and magazines are produced by science clubs and associations. This is an area where action by science teachers' associations can be decisive and effective.

COMMONWEALTH CO-OPERATION IN THE PRODUCTION AND USE OF SCIENCE TEACHING EQUIPMENT

One of the functions of the Commonwealth Secretariat is to encourage and promote co-operation among member countries in the field of education. At the seminar it was noted that four main ways in which this is done are: organizing conferences, seminars and workshops; carrying out research; collecting and disseminating information; and organizing and supporting training courses.

It was also pointed out that in performing its tasks the Commonwealth Secretariat works closely with international agencies such as UNESCO and the World Confederation of Organizations of the Teaching Profession (WCOTP), regional organizations such as the Science Education Programme for Africa (SEPA), and national organizations such as the British Council, thus avoiding duplication of effort. In addition, the Commonwealth Secretariat tries to keep in touch with teachers' associations, particularly in their task of fostering educational development not only on a national basis but also among Commonwealth countries.

Attention was drawn to the varied nature of the meetings which the Education Division organizes on behalf of the Commonwealth Secretariat. It was explained that Commonwealth Conferences, the seventh of which was held in Accra in March 1977, take place once every three years. Their recommendations give guidance and authority to what the Education Division does. The present seminar/workshop is an example of a meeting which has a training component, an element which governments find particularly useful. A third type of meeting is the Specialist Conference, one of which is normally held in the period between triennial ministerial conferences. These are organized to focus attention on a specialist subject of concern to governments. Participants at the seminar welcomed the news that science and mathematics education and technical education might form the topic for the next Commonwealth Specialist Conference.

It was noted that the Commonwealth Secretariat has recently launched a programme of regional training courses. Two regional courses have been held this year, one in Africa on educational administration and supervision, and one in the Caribbean on book production. These courses are examples of what the Commonwealth Secretariat hopes will be further regional courses if the demand for them continues.

The need to strengthen understanding in Commonwealth countries about what the Commonwealth Secretariat is, what it does, and what it can offer to member countries was emphasized, and note taken of the strong support which Commonwealth Heads of Government, at their recent meeting in London, gave to the Secretariat in its plans to stimulate, in every possible way, the knowledge and understanding necessary for effective co-operation between member countries.

The problems associated with communication between the Commonwealth member countries received much attention. Participants complained that the

Secretariat's publications seldom reached them. They requested that the Secretariat's system of disseminating information should be reviewed to ensure that the information was sent to all institutions, organizations, and individuals in need of it. They suggested further that if it were feasible, the Commonwealth Secretariat should establish an Africa Regional Office to handle matters relating to the Secretariat's educational projects in the region.

Regarding the need for Commonwealth regional co-operation in science education, it was observed that regional co-operation already existed to a certain extent among many African States through SEPA and through national science teachers' associations in some of the countries represented at the seminar/workshop. Participants expressed appreciation for the role the Commonwealth Secretariat was playing both through its publishing efforts and in its regional activities. They broadly endorsed, in the context of the needs of the Africa region, the recommendations of the Bahamas 1976 seminar on the same theme. In particular they requested the Secretariat to hold, in the near future, a review seminar/workshop. This would enable and encourage member states to assess their progress in the development and mass production of school science teaching equipment.

PRACTICAL LABORATORY SESSIONS

Objective

To provide workshop experience in designing and producing materials locally for teaching science at low cost.

Programme

There were 11 laboratory sessions. The following four-fold approach was adopted:

(a) Four sessions were devoted to a study of the Kenya School Equipment Production Unit (SEPU).

Participants were briefed on the history of SEPU and on its present organization, pointing out SEPU's links with the Ministry of Education, the Kenya Institute of Education, and Kenya's teacher training colleges. The manufacturing facilities of SEPU were described, and the three basic kits for physics, chemistry, and biclogy were demonstrated. During the fourth session, participants carried out a circus of experiments using the SEPU kits.

(b) During the next five sessions, attention was focused on designing and developing equipment, and on drafting manuals.

Participants were divided into four groups. The functioning of each group was to simulate an educational system in which a science equipment production unit might be expected to operate.

Each group appointed two of its members to select a discrete area of the school science syllabus (syllabus organizers/curriculum developers). Another sub-group of two members (science teachers as experiment designers) was asked to outline student experiments and/or teacher demonstrations to illustrate topics within the area of a specified syllabus. The remaining members of each group surveyed the facilities (materials, tools, printed safety instructions etc.) of the work place.

Each of the original four groups reassembled to discuss plans for the production of an item or items of equipment to enable them to teach different specific topics. Construction of equipment and production of related manuals were subsequently carried out.

(c) The next laboratory session was devoted to the presentation of the equipment and related manuals produced by participants. Presentation was done by representatives of each group in turn. The equipment produced included two versions of an electric motor, apparatus concerned with the application of forces for lifting purposes (inclined plane, levers, pulleys, hydraulic press), solar-powered water pump, linear expansion demonstration apparatus, electro-magnetic attraction apparatus, model periscope, steam turbine, and solenoid (for plotting magnetic field).

(d) The last laboratory session was devoted to evaluating prototype equipment and related manuals, together with brief accounts of equipment centres in Ghana and Nigeria, and discussing their products and services.

Evaluation of Laboratory Sessions

Questionnaires were answered relating to the general layout of the laboratory programme, and the following information was obtained:

(a) 70% of the answers revealed that sessions dealing with SEPU were interesting or very interesting to participants. The allocation of the available time was acceptable.

(b) 40% of the answers showed that participants found the work of designing and manufacturing science equipment interesting or very interesting. They would have preferred to have had more time allocated to it.

(c) 55% of the answers indicated that the work of drafting manuals to accompany equipment was less popular, and that more time should have been devoted to this activity.

(d) The most popular of the 11 sessions was that which was concerned with the presentation of the finished equipment; 95% of the answers showed this to have been interesting or very interesting.

One of the invaluable suggestions put forward for improvement was that in future participants should be divided into smaller groups for practical work.

LEAD PAPERS

LOW-COST SCIENCE EQUIPMENT: STRATEGIES FOR PRODUCTION

Awele Maduemezia
Professor and Head of Department of Physics,
University of Ibadan, Ibadan, Nigeria.

Introduction

The subject of low-cost science equipment has occupied the minds of a large number of teachers and administrators alike ever since science education found its way into the African school system. The matter has been researched and discussed in conferences, symposia, and books. Interest in this problem derives in the first instance from the fact that money is generally in short supply. But, even where nature's resources allowed for an abundance of convertible wealth, other issues have rated higher than science education in the list of national priorities.

People who are interested in finding a solution to this problem generally start by analysing the reasons why the present state of affairs in most developing countries is unsatisfactory. They then proceed to study ways and means of redeeming the situation. With some luck one may find a text in which one of such ways and means is actually prescribed as a "cure". More often than not, the discussion is inconclusive.

In preparing this paper, I have had the benefit of ideas contained in numerous published texts. I should like to mention in particular, the booklet by Warren and Lowe, The Production of School Science Equipment, and the Report of the Commonwealth Regional Seminar/Workshop on Low-Cost Science Teaching Equipment held in Nassau, Bahamas in 1976. These two Commonwealth Secretariat publications taken together contain what I believe is the correct strategy for the successful production of inexpensive science equipment. However, if one takes the African context into account, I believe the ideas in these books will fail to yield the desired results for the simple reason that the proper motivation for producing low-cost scientific equipment has not yet been correctly stated. In these studies, there is a tacit assumption that the science which Europe is pursuing now is the science which Africa should also be doing but "unfortunately" cannot yet do because it is underdeveloped. I think this is wrong. This is the kind of thinking that produces the negative psychological stresses so inimical to progress. Every nation must work on issues relevant to its state of development and strive to improve the quality of its people's life.

What I propose to do in this lead paper is to discuss as part and parcel of the strategy for the production of science equipment, the philosophy which must guide the production of such equipment for efficient teaching in schools. Equipment so produced is low-cost, but this is only a happy coincidence. I shall illustrate my discussion with a brief reference to an actual case, namely the effort at present being made by the Department of Physics, University of Ibadan, Nigeria. I shall suggest that the strategy for the successful production of school science equipment entails two considerations, the first long-term, and the second short-term. The long-term consideration involves a psychological reorientation of the basis for science education in Africa. The short-term consideration concerns the need to maintain an effective scientific and technological interface with the rest of the world.

Developed Versus Developing Countries

I have always wondered why the world is divided into the developed and the developing. The main problem we in the so-called developing world face is the psychological one that derives from this division. The history of human "cultural evolution" - I shall not use the word "civilization" - shows that no sooner has man solved one pressing problem than another one rears its head. There is no human society that can claim to have solved more than an insignificant fraction of what it considers its problems. The only difference between one culture and another is in the definition of what constitutes their respective problems.

When I was at school, we first did addition and subtraction by counting with objects called counters. We did not handle large numbers in this way, but it did not matter at all since we had no immediate use for such numbers. Then we graduated to higher forms and began to use logarithm tables. And we were quite happy with these. Many of us did not know of the existence of slide rules. But that did not matter. At the level at which we were operating, the existence of more powerful tools was irrelevant. We did not feel inferior to anyone. We were simply at our own level of development. Then later in life, we discovered mini-computers, and larger-than-life IBM and CDC machines, and we used these with as much glee as we used counters at school. Some day there will be more powerful ways of doing arithmetic. This, however, does not interfere with our satisfaction with what we now have. And that is as it should be.

Now you may ask: what has all this got to do with the production of low-cost science equipment? The answer is everything! For in Africa there appears to be the idea that because Europe has learnt a few scientific tricks before us, we must all do what we can to catch up with them. We see ourselves not as people living normally evolving lives like the rest of humanity, but as people lagging behind some others, and perpetually faced with the problem of catching up. This is a negative attitude which ought to be halted. It is true that because of the demands of international trade, no nation can afford to be isolated. Even so, every nation has to discover its level of development and operate happily at that level with the full realization that it will steadily advance in the fullness of time. The reason why low-cost science equipment is imperative in an African environment is that it is nearest to the level of the people's development. It can be fashioned by the people themselves, and so has in the long run a superior pedagogical value to sophisticated equipment. And one is not here saying that "the grapes are sour". Far from it! One is saying that the proper way to learn to do arithmetic is to use counters before one uses logarithm tables. If this philosophy is accepted, the manufacturer of counters will be assured of a decent living even if logarithm tables were to flood the market. Developing countries must see themselves as being at a different stage of development, and approach school science at the level nearest to their state, without feeling that they must make levelling contact with the contemporary state of other cultures. Our experience with the reasonably effective operation of local automobile mechanics with no science education, shows that such levelling-up is not dictated by the necessities of foreign trade involving technological hardware.

The Strategy

It was mentioned earlier that the strategy may be divided into two parts: one long-term, and the other short-term. But both are related. The long-term strategy is to alter the philosophy behind science education in Africa in a direction that will enable the average scientist to operate happily at his nation's current level of development without feeling bad about not yet being able to do what scientists in other countries are doing. This then means that the process of production of science equipment is part of the development of science in the country. In practice, this means that a few of the country's more developed institutions of higher learning will undertake, as part of their normal pedagogical functions, the production of such equipment as may be used in primary and secondary schools. The production of equipment by a section of the people themselves has the same effect on the rest of the people as a spectacular American space feat normally has on the average American, however modest his own personal intellectual endowments may be. I believe children will learn faster, and with greater confidence, if they can identify with the sources of the tools they use. The strategy here is to have the apparatus production firmly rooted as a matter of principle in an existing institution. This is confirmed by the rich experiences described by Warren and Lowe.

The short-term strategy has to do with the kind of apparatus that should be produced. I think this will be determined by the workshop facilities actually available in the institution. For instance, a number of universities in Commonwealth Africa are institutions that have very good workshop facilities manned entirely by local people, from the Professor and Head of Department to the youngest technician. The limit to what can be fashioned is set only by skilled manpower available and by human imagination. As a short-term strategy, what we have done at the University of Ibadan for instance, is to concentrate on producing standard equipment used in routine text-book type experiments: accurately machined brass balance weights, metre bridges and potentiometers, optical benches, resistance boxes, switches, ray boxes, and so on. We have in the process gained considerable experience and confidence. We have been selling such equipment to schools and to some of the country's new universities. As a result, we must now pay some attention to quality control. This is because our customers are reacting critically. At the same time, we are encouraged to move into innovative sectors, and look at equipment with some electrical and electronic content, and with design possibilities dependent only on our own imagination and stamina. The investment is quite modest since ours is a teaching workshop, and technicians are learning from the process of production.

When the short-term objective of gaining confidence has been achieved, and people realize that it is best to make equipment locally, we can then gradually reshape school curricula through novel experimental packages developed with specific objectives in mind. All this will take a long time. It is therefore essential that at each stage, we see ourselves as living perfectly normal scientific lives at our own level, and not locked in a desperate struggle to catch up with someone else on another continent. This then leads one to conclude that no teacher from a foreign culture, however good his intentions may be, can make any meaningful impact on the situation. The reason is that an expert from a foreign culture tends to live at his own level and would want to pull other people up to this level in the short space of time he generally has at his disposal. This can be a frustrating exercise. His success can only be superficial. Indeed African universities are bristling with the results of such effort - a growing community of academics carefully tutored to do measurement-oriented research in the best traditions of the West and East, but totally unable to produce even the most basic components of the equipment they use.

I seem to have deviated from the issue of low-cost. This is because I believe this issue is fortuitously in consonance with the view that science equipment for successful teaching in schools should be locally produced by a section of the people themselves. It happens also to be cheaper this way!

Conclusion

Rather than suggest a wide range of ways and means for producing such equipment therefore, I think it is far more beneficial to confine oneself to one method which has been tested here in Ibadan, Nigeria, and seems to be working. To iterate, I would suggest that:

(a) Every African country, however poor, should accept its state of development realistically.

(b) Each country should establish at least one good workshop in an existing institution of higher learning, and as a first step use it to produce standard scientific equipment for schools. The technicians would learn in the process.

(c) When sufficient confidence has been achieved, the workshops should venture into the innovative sector, and try things that can change school science curricula in a predetermined direction.

(d) There should be no need for workshops to use only local material, unless these materials are found to be better than imported ones.

Where the government is unable to provide the funds necessary for this modest activity, foreign foundations should chip in what they can. They should, however, scrupulously avoid sending their own men to do the work. I believe that any country that needs such sustained external input of man-power in order to develop its science is a lost cause, and should be left alone.

LOW-COST SCIENCE TEACHING EQUIPMENT: STRATEGIES FOR USE

W.J.E. Indge
Formerly Education Consultant, School Equipment Production Unit, Nairobi, Kenya

The discussion of lead papers presented at the first of this series of Commonwealth Regional Seminars on Low-Cost Science teaching equipment held in the Caribbean in November 1976 revealed that there was considerable confusion over the term "low-cost". In an attempt to avoid a similar problem arising here, it might be worth-while to try to define this term at the outset. "Low-Cost" 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 improvization 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.

Presumably for the sake of convenience, the lead papers of this seminar have been devised to focus separately on production and use. This approach, however, reflects a distinction which has led much too frequently to two serious shortcomings; the technician loses sight of educational objectives and the curriculum specialist demands a particular item of apparatus without giving adequate thought to its production. The Caribbean seminar/workshop already referred to, provided an excellent example of this. As might be expected with a group of experienced educators, good ideas abounded; failures resulted mainly from a lack of understanding of the properties and limitations of basic materials. It follows then, that while this paper specifically deals with the use of low-cost equipment, a central theme must be the underlying co-operation of the educator and the technician.

Traditionally, textbook production has been seen as central to all aspects of progress in science education. The design and production of the accompanying apparatus though, is regarded as having a commercial bias. As such, it tends to be a long way down the list of government priorities, and meets with little academic support. Under such circumstances, it is scarcely surprising that many projects in equipment development and production are struggling on very limited budgets. They are staffed by a dedicated few who have little contact with key personnel in schools. Any strategy for the use of low-cost science teaching equipment must begin by determining the exact needs of the particular system, its teachers and its students.

The Needs of the System

The variety of cultural and political backgrounds at this Meeting is such that it is difficult to generalize. I shall therefore draw extensively on experience gained while working with the School Equipment Production Unit (SEPU) in Nairobi in the hope that specific points will emerge which bear some resemblance with the situation in other countries.

The principal objective of SEPU has been to produce a basic but adequate range of apparatus to enable students to carry out experimental work up to the level of the East African Certificate of Education. In order to achieve this, it has been necessary to look much further than the guidelines provided by the examination syllabus. Some of the points considered were:

Educational Problems. The use of a practical, inquiry-based approach is seen by almost all science curriculum specialists as desirable and consequently it has a prominent place in modern science syllabuses. However, we must recognize that the task of interpreting the curriculum belongs to the teacher. Teachers are aware that techniques that involve student practical work are recognized as good practice and, not unnaturally, they are reluctant to admit to failure to use such methods. Although much pre-service training is centred on these techniques, teachers are reluctant to depart from patterns they were familiar with as students. Often, once teaching practice is over, there is a rapid reversion to what is referred to as traditional teaching (i.e. a series of lectures relieved by occasional demonstration exercises).

Thus merely providing schools with the necessary apparatus is no guarantee that it will be used. This fact was confirmed in a survey recently conducted by a leading equipment production centre. Results revealed that 43% of the kits had been in the school for six months and had not even been unpacked! Surely, it cannot be overemphasized that production units should not expect teachers to use new and different apparatus without considerable guidance, a corollary being that such centres need to have an effective feed-back system to guide them.

Financial Constraints. It is pointless in a paper of this sort to discuss current economic problems and attempt to relate them to education; it is quite sufficient to state that the situation in most schools in Africa leaves much to be desired. Clearly, financial issues should feature prominently at the planning stage of any project involving the production of school science apparatus. No apology is needed to repeat what was discussed in the opening paragraphs; the prime economic consideration should not be the savings that can be made over commercially available items but rather whether the new materials relevant to the local situation will fall within the budget of schools. Frequently this calls for radical thinking by curriculum planners.

An example for SEPU is relevant here. In the original biology kit it was proposed to include an inexpensive student microscope. By purchasing in bulk direct from the suppliers the costs could be cut down enormously. However, it was quickly recognized that the item would still fall well outside the science vote of many schools. Thus after a careful consideration of biological and educational aims and objectives, a substitute was devised; a stand-mounted slide viewer and a set of photographic slides. Not a microscope certainly, but a very good substitute and, more to the point, teachers could afford to purchase a class set at less than the cost of a single imported microscope.

It must also be borne in mind that the same financial constraints will not apply to all schools in a given system. Primary schools in general have so little money that were SEPU, for example, to embark on producing materials for them it would be disastrous to think in terms of the present kits, successful though they may have been at the secondary level. It was pointed out at a workshop held in Botswana in 1975 that "Primary school science is not secondary school science made easier". Its objectives are different. It might be regarded as more of a way of teaching the methods of science, by training children to observe, collect evidence by simple investigation, and communicate their results to each other. As the exact nature of the factual material is of less importance, it is possible to make a fuller use of the child's immediate environment. This is the approach of the Science Education Programme for Africa (SEPA) and as a result the course has almost become no-cost, let alone low-cost in terms of apparatus.

Multi-Level, Multi-Purpose: The Kit Approach. Whatever size a production unit for low-cost materials may be, two basic strategies are open to it: bulk purchase of either locally made or imported material, and local production. The particular emphasis is determined by such economic factors as cost of raw materials and of labour. These same factors will also determine to a large extent the minimum cost of the individual items that can be produced by the Unit. In order to make further significant savings, it is necessary to look towards the strategy for use. It may be relevant to consider two questions in this context.

1. In theory, it should be possible to design a range of apparatus which can be used for different purposes at primary, lower secondary and upper secondary levels. How realistic is an approach of this sort? Although such a move might be expected to improve cost effectiveness, it is frequently unacceptable in practice. Teachers are reluctant to entrust heavy-handed junior students with apparatus reserved for older students. Frequently, difficulties exist in free movement of apparatus and materials between departments and between educational levels within one institution. The chance of apparatus exchange between schools is almost non-existent.

An extension of this idea is a loan system operating from a central pool. A basic range of frequently used items of apparatus stored in the particular school can be supplemented by additional items when the need arises. Though this idea has proved successful in the teaching of the integrated science course run in the junior secondary schools in the Seychelles, in almost all other countries within the region represented here the cost of organizing and running a central pool for equipment would be prohibitive.

2. Science kits contain a very limited range of items, but each item may be used in a considerable number of teaching situations. Are there any drawbacks to this type of multipurpose design?

The answer depends very much on the production unit concerned. The weakest link in the kit approach is the replacement of lost or damaged items. There are a number of possible solutions. SEPU for example prefers replacement to repair, since the cost of individual items is low.

On the other hand, Turkey's School Materials Manufacturing Centre, considering the emphasis it places on mobile workshops and the in-service training for teachers which includes instruction in repair, appears to favour repairs. What matters is that provided some form of satisfactory service for the replacement of standardized parts can be maintained, the kit system can represent an enormous saving.

Individual Students Experimentation/Teacher Demonstration. Practical work in schools is often divided more or less rigidly into two categories, individual experiments and teacher demonstration. Current curriculum development favours work on an individual basis, and much effort is being made to persuade teachers to move away from the traditional demonstration. We must not forget that in many developing countries we are considering a group of very inexperienced teachers, a high proportion of whom may be untrained and may, for want of confidence and security, prefer the comparatively more controlled and predictable demonstration exercise.

Quite apart from 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. Because of this large market, the National Council of Educational Research and Training (NCERT), which is responsible for the necessary development work, has no problems as far as size of target population is concerned. In fact, the target population is so large that NCERT is able to afford to offer two categories of kit, one for teacher demonstration and the other for individual student experimentation. In the case of a country like Kenya, however, there are only about 1250 secondary schools, and there are many items of equipment that SEPU cannot manufacture because the production run is not sufficiently large. This applies obviously to the development of a demonstration kit. SEPU is therefore concerned mainly with the production of individually based science kits. This fits in well with educational objectives, for one of the practical aims of the SEPU kits has been to encourage an investigatory approach which will improve both the general standard of science teaching and the interest displayed by students.

We are nevertheless presented with a dilemma: on the one hand it is educationally desirable to move towards student experimentation; on the other there are constraints imposed by meagre school budgets and a lack of adequate numbers of qualified and experienced science teachers.

This dilemma is of fundamental concern when one is considering strategies for the production and use of teaching equipment. Perhaps the best solution is to produce teachers' manuals to accompany the use of apparatus which provide adequate instructions both for work in small groups and for teacher demonstration exercises. Some of the factors one must bear in mind in designing these manuals are the academic qualifications, professional training, experience, and motivation of the teachers.

The Circus Approach. Although frequently advocated as a strategy for more economical use of limited science equipment, the "station" or "circus" approach has severe limitations. The inexperienced teacher is reluctant to make full use of practical work. In the little that he attempts, he requires experimentation to be rigidly controlled. Indeed, a situation in which small groups are working on different investigations is much more difficult to handle successfully and effectively. There might be a saving on cost, but the time and effort needed to arrange a single lesson of this sort are considerable. Additionally, a circus technique will come into conflict with the science kit approach; multi-purpose use of individual items will obviously limit the number of experiments that can be conducted at the same time.

The Needs of the Teacher

The report of the 1975 Commonwealth Conference on "Materials for Learning and Teaching" 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." This statement confirms the sentiments of many production units. The need to see teacher training as a necessary component in the process of introducing any new range of low-cost apparatus cannot be overemphasized. A review of the work of a number of successful units would provide a catalogue of examples, but here we will consider two only:

In South East Asia, The Regional Centre of Education in Science and Mathematics (RECSAM), organizes courses relating specifically to equipment. In its own words, RECSAM describes these courses:

> "To assist each member country build up a core of equipment, key personnel who could develop prototype equipment and produce design plans for dissemination as well as organize in-service training of teachers and laboratory personnel in equipment production, RECSAM has successfully implemented the course, "Development of Primary Science Apparatus". This intensive course of about ten week's duration is specially designed for SEAMEO key personnel who are actively involved in equipment design, development and manufacture in their respective countries."

Here the emphasis is on the training of a selected few at a production level. What of provision of in-service training at the local level for teachers? This is exemplified by our second example, SEPU.

Of the approximately 1250 secondary schools in Kenya, some 850 are either private or are built on a self-help basis to serve a local community. 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 of Education) level. In the non-government sector, the teacher shortage can be described as acute. Vacancies tend to be filled, therefore, on a temporary basis by secondary school leavers. Every opportunity must be taken to raise the academic standards of these teachers without, at the same time, damaging the little confidence that they possess.

There is the problem which arises from 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. Inexperience frequently results in lack of confidence.

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 so that adequate plans can be made to overcome it.

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

The basic plan was to provide a series of one-day courses throughout the provinces, each involving as much teacher activity as possible. The courses were designed on a unit plan, combining a local adaptation of some of the material developed in the UK Science Teacher Education Project with opportunities to use the SEPU science kits. In outline the most successful combination of units was:

(a) Introductory session - aims and methods in science teaching. A group discussion led to the establishment of a set of aims for the teaching of science. These were used as a basis for comparing specially prepared slide-tape sequences of two methods of teaching - a lecture and an inquiry-based lesson. Discussion of this confirmed the view that limited apparatus made the preferred inquiry approach difficult to implement. This paved the way for introduction of the science kits themselves.

(b) Examination of the kit material - A circus of experiments and corresponding worksheets was set up and teachers carried them out. It was argued that only by putting themselves in the place of students could they appreciate the difficulties that were likely to be encountered, and judge the suitability of the material for the classroom.

(c) Closing session - Discussion centred on the problems of being a student. A purposefully light-hearted approach was made here and a circus of gimmicks and games was laid out to highlight some of the problems likely to arise in a practical class.

It is, of course, ridiculous to pretend that such a course would be ideal in all circumstances. What matters is that it worked in the Kenyan situation. Nevertheless, there are two general points that are worth stressing if the most effective use is to be made of the time available for a one-day course:

(a) A unit plan has considerable advantages in that it produces variety for the participants and can be altered easily if the need arises.

(b) One of the most difficult problems associated with the one-day course is establishing a relationship with the participants. The dominant part of teacher involvement makes this much easier and allows for better communication between all participants.

The diagram (page 35) illustrates the training available to an individual teacher. He can 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 provide him with practice in other teaching skills. Finally, if he is still interested, he may have the opportunity to continue to gain experience and help through half-day practical sessions which are organized locally.

Part of SEPU's 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. 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 centred on existing local organization, and help has been received from the Ministry of Education's local 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, as far as I know, not the policy in most Commonwealth African countries), it is impossible to reach every teacher in this way. Alternative strategies are necessary. Most important of these is an adequate teacher's guide. The SEPU biology guide for instance, sets out 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 struck between providing full information and keeping the guide brief enough to appeal to readers.

Any programme of in-service training is expensive. A brief examination of the SEPU programme in terms of cost-effectiveness may be of interest here. The largest single item on the budget is the transport and accommodation of teachers, particularly where co-ordination between schools is not possible. This was kept to a minimum by repeating courses on a provincial basis. The cost of each teacher's transport and subsistence was met by his school from the appropriate vote; SEPU paid for staff accommodation and transport. A full list of participants was made and from this the total of orders which could be directly attributed to these courses calculated. These figures are shown below:

Total number of courses - 6

Total number of participants - 170

Expenses of course tutor (transport and subsistence) K. Shs 2650

Sales for March 1976 directly attributable to courses - K. Shs 41,899

Pre-Service Training

There is little to add here to the ideas presented in the preceding section. Any institution involved in teacher training has a responsibility to its students to assist them to gain the most from such apparatus as is likely to be found in its target schools. If the majority of students are to be posted to rural schools with limited facilities, this must be reflected in the training. SEPU has produced a pre-service scheme along the same lines as the successful in-service teacher training programme. These units are at present used as an integral part of the appropriate teaching methods courses at the Kenya Science Teachers College. Possibilities exist as well for follow-up during students, final teaching practice but, at present, a shortage of personnel precludes this.

The Needs of the Student

A student's needs must also be considered in designing satisfactory low-cost equipment. Identifying these needs is not easy. Thus, teachers report problems (e.g. of slowness, language, and vocabulary) that do not feature frequently in students' comments. Part of a survey of science kits in Kenya involved inviting a sample of over 200 form one students to write a sentence in answer to the question, "What do you find hardest about science lessons?" This is not the place for a detailed analysis of the results but the following remarks are relevant to our discussion of strategies for use of low-cost teaching equipment:

(a) Over half the test population listed difficulties with the mathematical part of science, particularly physics. One's heart goes out to the student who wrote, "Physics is a hard and unmemorable subject to myself. If the calculations in physics were not there, I could be one among those brilliant physics pupils".

(b) A large number of students experienced difficulty with the setting up and handling of apparatus. Problems listed here range from "When I am holding a beaker I do tremble very much and fear", to more general difficulties in assembly. It was disturbing to watch a group of form one girls in a rural secondary school attempting to assemble a nut and screw.

(c) Failure to understand rather than difficulties in drawing accounted for most of the responses associated with diagrams. To many students, diagrams represent an entirely novel means of communication.

(d) Also frequently listed was the failure to understand why a particular experiment was being carried out. Students need to know this.

A paper such as this obviously cannot present a universal panacea. Solutions for the effective use of low-cost materials must be individually tailored to meet the needs of the system, its teachers and its students. To determine these needs, incorporate them into each stage of design and production, and provide for the successful introduction of the resulting material into school, needs the full co-operation of teacher, educator and technician alike. A strategy for production must go hand in hand with a strategy for use.

REFERENCES

1. Commonwealth Secretariat, Low-Cost Science Teaching Equipment: Report of a Commonwealth Regional Seminar/Workshop, Bahamas, 1976.

2. Commonwealth Secretariat, Materials for Learning and Teaching: Report of the Commonwealth Conference, New Zealand, 1975.

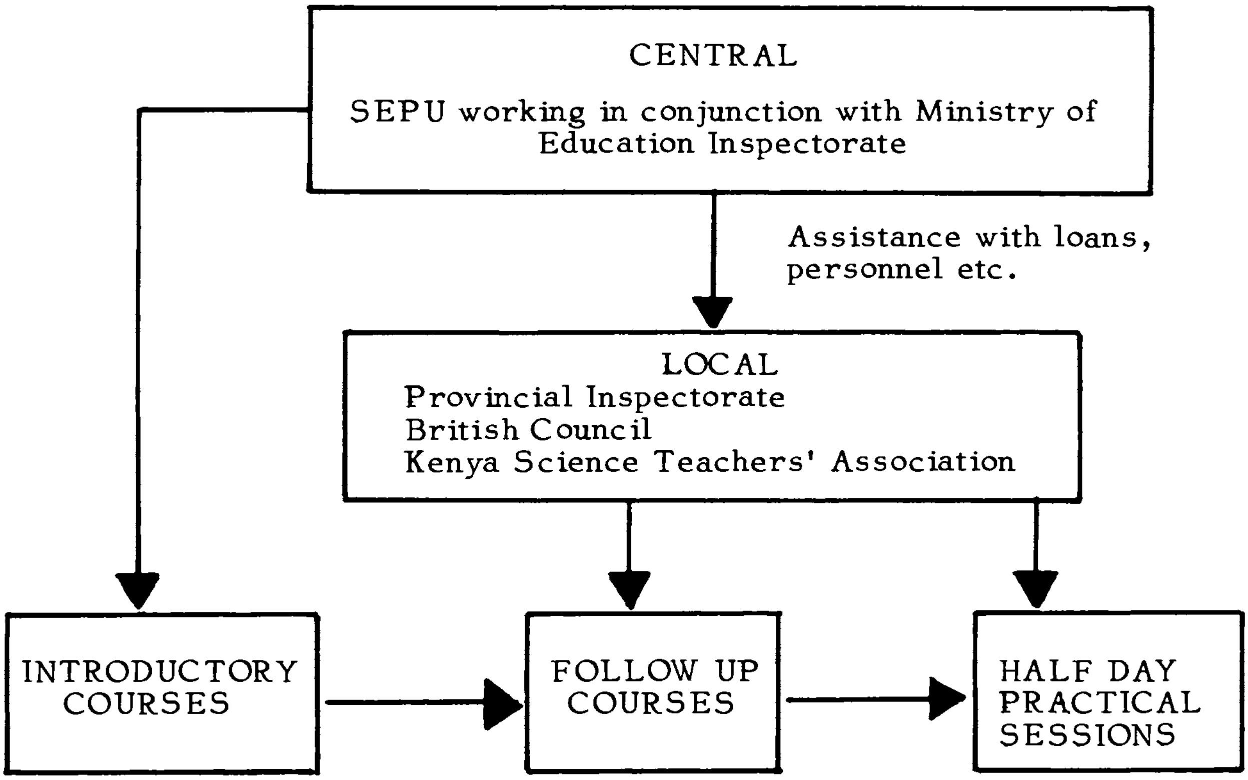
3. Commonwealth Secretariat, The Production of School Science Equipment, 1975.

4. Ferreyra R.E., Low-Cost Equipment for Integrated Science Teaching, Latin American Seminar on Integrated Science Teaching, Uruguay, 1975.

5. Report of the Primary School Science Workshop, Lobatse Teacher Training College, Botswana, 1975.

6. Government of Kenya. Ministry of Education Annual Report, 1973.

SUMMARY OF SEPU IN-SERVICE TRAINING SCHEME



COMMONWEALTH CO-OPERATION IN THE PRODUCTION AND USE OF SCHOOL SCIENCE TEACHING EQUIPMENT

Presented by the Commonwealth Secretariat

This paper seeks to indicate areas in which the Commonwealth Secretariat can assist in promoting Commonwealth co-operation in education in Africa.

The educational programme of the Commonwealth Secretariat can be described under three main heads: the organization of conferences, seminars and workshops; the collection and dissemination of information; and the organization and support of training courses.

Information

One of the main functions of the Commonwealth Secretariat is to act as a clearing house for information about educational developments in the Commonwealth.

(a) The collection of information is done in various ways, for example through visits to Commonwealth countries, through correspondence, and through the large number of journals and periodicals that the Division receives. When necessary, the Secretariat may commission specialists to obtain infomration in various fields. For instance, it was as a result of a commissioned study that we were able to publish The Production of School Science Equipment. The Secretariat also organizes surveys in order to provide information required by Commonwealth countries.

(b) The dissemination of information is effected through a number of publications. The Secretariat publishes reports of its seminars, workshops and other conferences, as well as results of surveys. There is in addition the Education in the Commonwealth series of publications dealing with special areas of education, and a number of special publications such as Educating and Training Technicians, Mathematics Teaching in Schools, and The Production of School Science Equipment.

Conferences, Seminars and Workshops

Commonwealth Secretariat meetings dealing with Education are handled by the Education Division. The meetings vary from ministerial conferences to specialist conferences and smaller meetings like workshops, seminars and symposia on various aspects of education. Of late the Secretariat's emphasis has shifted more to the seminar/workshop type of meeting which, in addition to discussing problems in general terms, aims at providing an element of training for participants. The present seminar/workshop is a case in point.

Training

Training in the field of education is provided and supported by the Commonwealth Secretariat in various ways, some of which are:

(a) Bursaries. The Secretariat encourages Commonwealth countries to send personnel to train at courses which are already in existence. So far emphasis in training has been mainly on the training of middle-level personnel, and awards have been made for a wide variety of courses in technical and professional institutions.

(b) Provision of Consultants. The Secretariat has often procured consultants to assist national training programmes. For example, the Commonwealth Secretariat was involved in a review of educational policy and programmes in Sierra Leone, and in 1975 a team of consultants was invited to advise the Government of the Bahamas on the organization and administration of their educational system.

(c) Regional Training. Where regional training courses already exist, the Secretariat is prepared to consider requests to support personnel sent there for training.

In response to a recommendation of the Sixth Commonwealth Education Conference, the Commonwealth Secretariat has launched a programme of its own regional courses. The first, which took place in Kenya from January to April 1977, provided training in educational administration and supervision for school administrators and supervisors drawn from Commonwealth Africa. Similarly, a six-week Commonwealth Caribbean course which provided training for those engaged in book production was held in Guyana in July-September 1977. These are the first of what we hope will be a number of regional courses if the demand for them continues.

(d) Educational Visits. The Secretariat has in the past provided a number of travel grants to enable personnel from developing countries to travel to other developing countries to examine special educational areas of interest. These visits have proved very useful.

Bilateral Co-operation

It is encouraging to note that the widening of the range of Commonwealth co-operation through the Secretariat has not lessened the importance of bilateral co-operation. The following could be considered as areas suitable for increased bilateral assistance:

(a) Visits of personnel through travel funds to the donor country or a third country to see educational projects.

(b) Training by means of awards given in the donor country or in other countries in selected fields.

(c) Support for trainees at regional training centres.

(d) The supply of personnel to support national training programmes.

(e) The exchange of materials for the teaching of science.

Commonwealth Associations

There is room for Commonwealth associations as well as other organizations to assist with the training of personnel. Commonwealth Secretariat support may be requested by any professional education association in the Commonwealth, including Science Teachers' Associations and Teachers' Unions wishing to assist with training personnel for the manufacture, supply or use of low-cost science equipment.

National Science Teachers' Associations can be particularly useful by arranging in-service training courses and encouraging teachers to participate in them. In addition, the contact and exchange of information and personnel between such national associations is proving beneficial to science teaching through the transfer of experience arising from them.

Teaching about the Commonwealth

There is a great deal of ignorance in Commonwealth countries about what the Commonwealth is, what it does, and what it has to offer to member countries. At their meeting in London in June this year, Commonwealth Heads of Government gave strong support to the Secretariat's plans to stimulate the knowledge and understanding necessary for effective co-operation between member countries. In Britain, kits of information about the Commonwealth designed for school use are produced by the Commonwealth Institute in London. Other countries may wish to produce materials of their own, in which case the Commonwealth Secretariat will provide whatever assistance it can. Discussions are already going on between the Education Division and the African Social Studies Programme on the production of new materials for teaching about the Commonwealth in schools and colleges of the Africa Region.

Commonwealth Regional Co-operation in Science Education in Africa

Regional co-operation in science education already exists to a certain extent among African States (e.g. Botswana, Lesotho, and Swaziland), through the Science Education Programme for Africa and through national science teachers' associations. Regional co-operation is also desirable in the production of science teaching equipment. Such co-operation would enable the cost of designing apparatus to be shared and thereby reduced. It would increase the degree of utilization of the production facilities. In addition, it might be able to overcome problems arising over the importation of essential raw materials. A case in point is a test-tube making machine which has been lying idle in Ghana possibly because of foreign exchange difficulties which prevent the procurement of glass. If a regional mechanism were to be in existence whereby other countries could provide the glass on some mutually beneficial terms, Ghana could produce test tubes to meet the needs of West Africa, thus reducing costs and possibly delays that occur between a school wanting the apparatus and actually getting it.

Regional groupings can themselves be used to by-pass difficulties arising from strains in bilateral relations. Several instances have occurred where regional and international organizations have opened communication avenues for specialists who would otherwise have been unable to interact due to breakdown of communication at the bilateral level.

It is well known that regional and international co-operation can contribute directly to national educational development in a variety of ways. Some of those by which the Commonwealth Secretariat already provides assistance have already been described. In addition there is an emphasis on "third country" exchanges. The personal contacts thus created are important in strengthening professional linkages and in revealing mutually useful information which cannot always be conveyed through correspondence. The Secretariat intends to continue to build up its clearing house of information so as to be able to assist member states more effectively, and it is hoped that Commonwealth Governments will continue their co-operation with us in this regard.

The foregoing suggestions and ideas have been put forward on the premise that meaningful trade and economic relations, and a general atmosphere of co-operation, exist or can be promoted between member countries of Commonwealth Africa. It is suggested that such co-operation should be extended in the promotion of educational development and especially in the production of low-cost science teaching equipment. Clearly, any arrangements reached on a bilateral, regional or international basis would need to include provision for individual countries to have equipment produced to meet their national requirements. These arrangements could be devised so as to develop science equipment from locally produced prototypes which had been trial tested. They could thereby foster the encouragement of local initiative and educational experience in science and achieve a reduction in costs.

ADDRESSES

ADDRESS AT THE OPENING CEREMONY BY THE HONOURABLE NDUGU NICHOLAS KUHANGA MINISTER FOR NATIONAL EDUCATION

Read by Mr J F Gwagilo, Principal Secretary, Ministry of National Education

It gives me great pleasure to welcome you all at this seminar/workshop on Low-Cost Science Teaching Equipment, the first of its kind to be held in the country. We are told that the Commonwealth Secretariat organized a similar seminar in the Bahamas last year and that this is the second one. Indeed we feel greatly honoured to host this very important seminar/ workshop. It has a special significance, firstly, because it includes all the Commonwealth countries in Africa, and secondly because it is on a topic that has recently begun to receive much emphasis in international educational development.

Science education has been the focus of current innovations and experimentation, particularly among Third World countries. We are increasingly becoming aware of the fact that our economic development depends on technological advancement, which further depends on sound scientific and technical education. It is in this light that we in Tanzania lay particular emphasis on science and technical education in our schools, colleges and higher educational institutions. We hope that, through your discussions on the Tanzanian experience and your scheduled educational visits, you will be able to evaluate our situation. It is only through critical observation and sincere contribution in the discussions that we shall be able to improve our science and technical education.

Although the science taught in our schools should not deny our children such sophisticated innovations as landing a man on the moon, or even going to Jupiter, we wish particularly to relate science to rural life. While others aspire to go to the moon we aspire to go to the villages. We believe in the liberation of our people from the shackles of poverty, hunger, and disease. Therefore, our science education should enable our children to find out ways of bettering their living standards and those of their parents.

We all know that educational objectives, however clearly stated, are of little value unless they are assimilated. The quality of teachers, and their ability to select or make, use and manage instructional materials and equipment, are unavoidable factors in success. The actual situation one finds in most developing countries is that the equipment that teachers are trained to use is usually foreign. Many young teachers complain to the inspectors and education authorities about lack of equipment. But the equipment these teachers want is usually expensive, and in many cases is unsuitable to the local situation in which the teacher is placed. This expensive equipment, is imported from developed countries, drains meagre resources, thus raising the education budgets of developing countries to levels beyond resource capabilities.

Now we can appreciate why this seminar is very important; it has come to us at a most opportune time, and its contribution to our educational philosophy of Education for Self-Reliance should not in the least be underestimated.

Your seminar focuses on ways of making each participant realize his hidden potential for designing, making and using low-cost science teaching equipment. This is one of your objectives. In addition, you will be looking into the ways in which the experiences gained by the participants in this seminar/workshop can be transferred to classroom science teachers so as to enable them to design, make and use low-cost science teaching equipment (both software and hardware) using local material and appropriate technology. I am glad to see that you will also be considering the relationship of the local community and the school in the development of effective low-cost teaching equipment. By this I mean the collaboration between the classroom teacher and the local technician in the design and manufacture of low-cost science teaching equipment. Experience shows that involvement of the classroom teacher, the community and the pupils in the construction of classroom equipment builds up the spirit of ownership of the equipment and a sense of responsibility over the maintenance, care and use of it.

As my last remark, may I once again say that this seminar comes at an appropriate time. It is taking place only a few days after the end of a successful Commonwealth Agricultural Seminar held at Arusha in Northern Tanzania where the exchange of experience through exhibits of handy and multi-purpose agricultural equipment stole the show and fascinated not only the participants but also the general public. With the same African countries represented at this seminar there is no reason why similar, if not better, results cannot be expected.

In the past, the African has been criticized for uncritically copying technology and culture from outside the continent. However, I do not believe that an African should feel guilty about copying from fellow Africans because African environments are similar. So let us without shame share our experiences and learn from one another.

On behalf of my Minister, I now declare the seminar/workshop open and wish you success in your deliberations. You are all warmly welcome to Tanzania and particularly to Dar-es-Salaam.

ADDRESS BY MR REX E O AKPOFURE
DIRECTOR, EDUCATION DIVISION, COMMONWEALTH SECRETARIAT

It is a special pleasure and privilege for me to bring you this morning sincere greetings and good wishes from the Commonwealth Secretariat in London. On behalf of the Secretary-General, His Excellency Mr Shridath Ramphal, I wish to welcome all of you who have found time to come to this opening ceremony. I welcome also our participants and observers, including those who are due to arrive later today. Thirty-nine participants representing 14 countries of Commonwealth Africa are expected at this seminar/workshop which has had the distinction of being "over subscribed", by which I mean that participants have exceeded the numbers originally envisaged. This clearly indicates that the subject is one to which member states attach high priority. Indeed, the calibre of participants nominated to attend is such that we expect a very high quality seminar.

The theme, as you have already heard, is "The Production and Use of Low-Cost Science Teaching Equipment". Specifically, the objectives we shall be trying to achieve are the following: to consider methods by which school science equipment may be most effectively developed through greater involvement with curriculum innovators and school teachers in order to fulfil curriculum objectives; to examine the role of teachers, instructors, technicians and the community in the development and production of low-cost science equipment; to consider the implications for teacher education, if teachers are to participate meaningfully and effectively in innovative teaching strategies using low-cost science teaching equipment; to provide workshop experience in designing, developing, and evaluating locally constructed low-cost science teaching equipment; and to consider ways of improving Commonwealth co-operation in the interchange of ideas and experience in the development and production of school science equipment.

Since the first Commonwealth Education Conference was held in Oxford in 1959, Commonwealth Ministers of Education, now representing 36 countries, have met every three years in one of the member states to review the state of education and, among other things, to identify areas of priority for action. The latest of these conferences took place in Accra last March. That conference endorsed as a priority the emphasis already laid by its predecessor on the need to implement ideas concerning the provision of low-cost science equipment for schools so that science can be meaningfully taught and the development of technology can take tangible strides forward. As a result of recommendations arising from these conferences, the Commonwealth Secretariat has planned a series of training workshops. The first of these was held at Nassau in the Bahamas in November 1976. The workshop being opened today is the second in the series. It covers the Africa region of the Commonwealth. The third is planned for the Asia or Pacific region sometime next year. So far, experience has indicated that the workshop approach is a valuable strategy.

Let me now briefly underscore the scope of this seminar/workshop. It deals not merely with science equipment but also with the curriculum content on which it is based, the methods by which the curriculum should be taught, the methodology by which teachers are to be educated for their task, and the roles which various agents in the community may be expected to play. It will communicate laboratory practical skills and experience; indeed, it will be a workshop in a full sense. Drawing on our experience from the Caribbean region, we will try to determine how to reduce bookish learning and science teaching by the talk-chalk method and increase the practical component in science education. We hope to persuade participants and teachers to subordinate their fear of students breaking expensive apparatus to the need for them to learn by experimentation. We hope also to stress that the physical forces that children read about can be observed, measured and recorded in their own environment with equipment made - or largely made - locally (even by themselves) without first going to Europe, or Asia or the Caribbean. We shall exhibit prototype examples of equipment from some Commonwealth African countries, and display examples of apparatus manufactured in one of the developing countries represented here at this seminar.

Our fathers and forefathers - hunters, fishermen, wood-cutters - had eyes which read and interpreted the spoors of animals in the forest, and the meaning of the flow of the tides. They understood the peculiar calls of birds at times denoting the presence of predators or other signs of danger - even a broken forest leaf. Today most of us, and most school children, walk through woods and forests with eyes and senses dulled to signs and signals all around; the skill of keen observation seems no longer to be with us. Likewise the many objects used for the arts and crafts of traditional industries, many of which showed exquisite skill, no longer capture children's interest. We appear to have educated children away from the use of their hands and their eyes into seeking the shortest cuts and the easiest ways out - for example, by copying what someone else has designed or produced.

Science is an active process and its study does not lie only on the pages of books which are but the record of the findings of others. In this workshop, therefore, our targets are to reduce costs and the problems of foreign exchange, and to show how science can be taught widely to all pupils through a curriculum that is relevant to every-day life. We hope to examine how various national agencies such as Ministries or Departments of Industry, Trade and Agriculture might be involved, and how the experience gained in other Commonwealth regions may be shared, not only between member states but also with international and regional agencies like UNESCO, UNICEF and Science Education Programme for Africa, to name only a few. For each participant at this workshop, there will be the obligation on returning home to initiate action at the national level or develop further action to establish or strengthen the design and production of science teaching equipment with an eye on low costs.

The work of the Commonwealth Secretariat does not consist of science workshops alone. Its work includes Commonwealth consultation and co-operation in a number of fields: International Affairs, Trade, Finance, Economic Affairs, Law, Youth, Information, Health, Science, and Food Production and Rural Development. In each of these areas of activity, Ministers from Commonwealth countries meet regularly for consultation and the exchange of information and experience. Programmes such as the Commonwealth Scholarship and Fellowship Plan and the Commonwealth Fund for Technical Co-operation (CFTC) to which voluntary pledges last June for example, exceeded envisaged targets, are all ways in which practical expression is given to the idea of Commonwealth co-operation. Indeed, this seminar, like its predecessor in Nassau, has largely been made possible by funds provided through the CFTC. Thus the Commonwealth association of 36 sovereign States (voluntarily bringing together some 900 million peoples across the continents through its Secretariat in London) does attempt by means of its various programmes to assist member states in ways which proceed much more quietly than the fan-fares of its political gatherings would seem to indicate.

Because of the size of the Education Division (9 professional staff) our strategy in seminars and workshops is to initiate schemes of action in areas which have been identified by member states and to depend for follow-up action on the members who attend them. Our methods also include the commissioning of educational publications, studies and research through experienced and outstanding specialists. In this way, especially through the dissemination of the information thus gathered, the benefit of individual experience - whether in research, in fellowships or in training opportunities - is spread to relevant members where the need is felt. From this particular workshop we hope such a result will follow.

I cannot end without expressing thanks, on behalf of the Commonwealth Secretary-General, to all those who have made this gathering possible. First, gratitude to our host Government, the United Republic of Tanzania, for its hospitality in hosting this workshop and for the facilities it is providing through the Institute of Education. Although the Honourable Minister of Education is unable to be present in person, his able representative Mr. Gwangilo has more than guaranteed us his interest and support. Later today we are to enjoy further hospitality given by our hosts. In addition, I thank the staff of the Institute of Education, with its Director Mr. Migembe in the vanguard, and the University, for providing the magnificent setting and facilities not only for this ceremony, but for the workshop. Next, we must thank our consultant, Mr. E. Bengtsson, and our resource persons Dr. Dyasi, Mr. Nalletamby and Mr. Morgan. All are experienced in this field. Our observer organizations have so regularly attended our seminars that we are sometimes tempted to take them for granted; to them too, I must add a special welcome.

One last point and I am done. Many of us have heard a great deal of, and some have previously enjoyed, the warm hospitality of this great city. All of us look forward to receiving, if not a golden key, a key of some other metal to open the gates to the city, so that after work there may be play at the end of the day. In that confident anticipation, I thank you all on behalf of all the participants for your kind attention, and in closing would add "Asante Sana".

ORGANIZATION OF SEMINAR/WORKSHOP

AGENDA

Theme

The Production and Use of Low-Cost Science Teaching Equipment.

Objectives

(a) To consider methods by which school science equipment is most effectively developed through greater involvement with curriculum innovators and school teachers, in order to fulfil curriculum objectives;

(b) to examine the role of teachers, instructors, technicians and the community in the development and production of low-cost science equipment;

(c) to consider the implications for teacher education if teachers are to participate meaningfully and effectively in innovative strategies of teaching using low-cost science teaching equipment;

(d) to provide workshop experience in designing, developing and evaluating locally constructed low-cost science teaching equipment;

(e) to determine ways of improving Commonwealth co-operation in the interchange of ideas and experience in the development and production of school science equipment.

Agenda Item 1 : Strategies for Local Production of Low-Cost Science Teaching Equipment

(a) Organization of production units.

(b) Design of equipment.

(c) Teacher involvement in production.

(d) Production units and its links with teacher training and other institutions.

(e) Kits and/or apparatus.

(f) Support materials.

Agenda Item 2 : Strategies for Use of Low-Cost Science Teaching Equipment

(a) Why practical work in science ?

(b) Selection of equipment for science teaching at the national level and for specific classroom situation.

(c) Problems associated with the use of equipment.

(d) Training techniques on the use of equipment.

(e) Mechanisms for encouraging the effective and efficient use of equipment.

Agenda Item 3 : Commonwealth Co-operation in the Production and Use of School Science Teaching Equipment

(a) Activities of the Commonwealth Secretariat and the Commonwealth Fund for Technical Co-operation.

(b) Commonwealth Associations.

(c) Areas for Commonwealth Regional Co-operation in science education in Africa.

Agenda Item 4 : Practical Laboratory Sessions

(a) Development of equipment for science teaching and related learning materials.

(b) Evaluating equipment for science teaching and related learning materials.

TIMETABLE

Monday 19 September

9.00 - 6.00	REGISTRATION

Tuesday 20 September

9.00 - 12.30	OPENING
7.00 - 10.00	RECEPTION : Government of Tanzania

Wednesday 21 September

9.00 - 10.30	COUNTRY PAPERS
11.00 - 12.30	COUNTRY PAPERS
2.00 - 3.30	LABORATORY : Session I
4.00 - 5.30	LABORATORY : Session II

Thursday 22 September

8.30 - 12.30	EDUCATIONAL VISITS
2.00 - 3.30	STRATEGIES FOR PRODUCTION
4.00 - 5.30	GROUPS : Session I

Friday 25 September

9.00 - 10.30	GROUPS : Session II
11.00 - 12.30	LABORATORY : Sessions I & II (a repeat for late arrivals)
2.00 - 3.30	LABORATORY : Session III
4.00 - 5.30	GROUPS : Session III
7.00 - 10.00	RECEPTION : The British Council (Tanzania)

Saturday 26 September

8.00 - 10.30	STRATEGIES FOR PRODUCTION : Report by Groups
11.00 - 12.30	STRATEGIES FOR PRODUCTION : Report by Groups
2.00 - 5.30	FREE
7.00 - 9.00	FILM SHOW

Sunday 25 September

8.00 - 10.00 pm	EXCURSION (Mikumi National Park)

Monday 26 September

7.30 - 9.15	EDUCATIONAL VISITS
9.30 - 11.00	STRATEGIES FOR USE
11.30 - 1.00	GROUPS : Session IV
2.30 - 4.00	GROUPS : Session V
4.30 - 6.00	LABORATORY : Session IV
7.30 - 9.30	GROUPS : Session VI

Tuesday 27 September

9.00 - 10.30	GROUPS : Session VII
11.00 - 12.30	LABORATORY : Session V
2.30 - 3.30	LABORATORY : Session VI
4.00 - 5.30	STRATEGIES FOR USE : Report by Groups
7.30 - 9.30	CULTURAL EVENING : Government of Tanzania

Wednesday 28 September

9.00 - 10.30	COMMONWEALTH CO-OPERATION
11.00 - 12.30	DRAFTING OF RECOMMENDATIONS : Sub-Group meeting
2.30 - 3.30	LABORATORY : Session VII
4.00 - 5.30	LABORATORY : Session VIII

Thursday 29 September

9.00 - 12.30	FREE
2.00 - 3.30	LABORATORY : Session IX
4.00 - 5.30	LABORATORY : Session X

Friday 30 September

9.00 - 12.30	FREE
2.00 - 3.30	FREE
4.00 - 5.30	DRAFT REPORT
7.00 - 9.00	RECEPTION : Commonwealth Secretariat

WORKING GROUPS

Seminar Discussions : Agenda Item 1

Group A:

Mr A Mbogho (Kenya) (Chairman)
Dr Magnus Cole (Sierra Leone)
Mr R O Botchway (Ghana)
Mr J T Matthias (Botswana)
Mr I K Medi (Malawi)
Mr Irenee Joseph (Seychelles)
Mr George Nobala (Lesotho)
Mr L K Kolapo (Nigeria)
Mr M S Lyembela (Tanzania)
Mr B Nyambe (Zambia)
Mr Phillip Nalletamby (UNESCO)
(Resource Person)

Group B:

Dr B C E Nwosu (Nigeria) (Chairman)
Mrs N S Ralise (Lesotho)
Mr W M Chileshe (Zambia)
Mr Edward Cege (Kenya)
Mr M G Mitengo (Malawi)
Mr C H Sin Yan Too (Mauritius)
Mr Matthew Luhanga (Tanzania)
Mr J T Seggalye (Uganda)
Mr David Morgan (UNESCO)
(Resource Person)
Dr Hubert Dyasi (SEPA)
(Resource Person)

Group C:

Mr D Mmari (Tanzania) (Chairman)
Mr P G Pillay (Seychelles)
Mr I M L Drammeh (The Gambia)
Mr I Odoi (Ghana)
Mr Thomas Ngugi (Kenya)
Dr I Isa (Nigeria)
Mr V M Bukozo (Tanzania)
Mr S L Abeti (Uganda)
Mr B T Chadwick (The British Council)
Mr E Bengtsson (SEPU) (Consultant)

Seminar Discussions : Agenda Item 2

Consultant: Mr E Bengtsson

Group A:

Dr Magnus Cole (Sierra Leone)
(Chairman)
Mr R O Botchway (Ghana)
Mr J T Matthias (Botswana)
Mr I K Medi (Malawi)
Mr Irenee Joseph (Seychelles)
Mr George Nobala (Lesotho)
Mr L K Kolapo (Nigeria)
Mr B Nyambe (Zambia)
Mr M S Lyembela (Tanzania)
Dr B C Nwosu (Nigeria)
Mr Phillip Nalletamby (UNESCO)
(Resource Person)

Group B:

Mrs N S Ralise (Lesotho) (Chairman)
Mr H M Phadi (Botswana)
Mr W M Chileshe (Zambia)
Mr Edward Cege (Kenya)
Mr M G Mitengo (Malawi)
Mr C H Sin Yan Too (Mauritius)
Mr S T Amarh (Ghana)
Mr D Mmari (Tanzania)
Mr J T Jusu (Sierra Leone)
Mr J T Seggalye (Uganda)
Mr A Mbogho (Kenya)
Mr B T Chadwick (The British Council)
Dr Hubert Dyasi (SEPA)
(Resource Person)

Group C:

Mr S Sooltan (Mauritius) (Chairman)
Mr Matthew Luhanga (Tanzania)
Mr P G Pillay (Seychelles)
Mr I M L Drammeh (The Gambia)
Mr I Odoi (Ghana)
Mr Thomas Ngugi (Kenya)
Dr I Isa (Nigeria)
Mr V M Bukozo (Tanzania)
Mr S L Abeti (Uganda)
Mr S P Mashala (NVTD)
Dr Elizabeth Bouey-Yates (WCOTP)
Mr David Morgan (UNESCO) (Resource Person)

Practical Laboratory Sessions

Group A:

Mr L K Kolapo (Nigeria)
Mr George Nobala (Lesotho)
Mr Irenee Joseph (Seychelles)
Mr J T Matthias (Botswana)
Mr R O Botchway (Ghana)
Dr Magnus Cole (Sierra Leone)
Mr Phillip Nalletamby (Resource Person)

Group B:

Mr W M Chileshe (Zambia)
Mr S T Armah (Ghana)
Mr Sin Yan Too (Mauritius)
Mr Mitengo (Malawi)
Mr Edward Cege (Kenya)
Mr H M Phadi (Botswana)
Mrs N S Ralise (Lesotho)
Mr D Mmari (Tanzania)
Mr David Morgan (Resource Person)

Group C:

Mr I M L Drammeh (The Gambia)
Dr I Isa (Nigeria)
Mr Thomas Ngugi (Kenya)
Mr I Odoi (Ghana)
Mr P G Pillay (Seychelles)
Mr Matthew Luhanga (Tanzania)
Mr S Sooltan (Mauritius)
Mr Emil Bengtsson (Consultant)

Group D:

Mr S L Abeti (Uganda)
Mr V M Bukozo (Tanzania)
Mr J T Jusu (Sierra Leone)
Mr J T Seggalye (Uganda)
Mr A Mbogho (Kenya)
Mr M S Lyembela (Tanzania)
Mr B Nyambe (Zambia)
Dr B C Nwosu (Nigeria)
Dr H Dyasi (Resource Person)

DIRECTORY OF PARTICIPANTS

Chairman of Seminar/Workshop : Mr W S M Migembe

DELEGATES

BOTSWANA

Mr Joseph Toitoi Ntui Matthias
Instructor
Teaching Aid Production Unit
PO Box 696
Francistown

Mr Herbert M Phadi
Lecturer
c/o Ministry of Education
PO Box 96
TTC
Lobatse

THE GAMBIA

Mr Ibrahim M L Drammeh
Regional Education Officer
c/o Ministry of Education
Youth and Social Welfare
Beford Place Building
Banjul

GHANA

Mr Robert O Botchway
Superintendent
Science Unit
Ghana Education Service
PO Box M188
Accra

Mr Laryea I Odoi
Technician/Technical Teacher
Science Unit
Ghana Education Service
PO Box M188
Accra

Mr S T Armah
Superintendent
Secondary School
PO Box 66
Nungua - Accra

KENYA

Mr A Mbogho
Principal
Kenya Science Teachers' College
PO Box 30596
Nairobi

Mr Edward Cege
Head of Physics Department
Kenya Science Teachers' College
PO Box 30596
Nairobi

Mr Thomas Ngugi
Senior Education Officer
Head of Kenya School Equipment
Scheme
Nairobi

LESOTHO

Mrs Ntsiuoa S Ralise
Education Officer
Maths/Science Centre
Box Ms 689
Maseru

Mr George N Nobala
Vice-Principal
Holy Family High School
PO Box SM97
St Monica

MALAWI

Mr I K Medi
Inspector of Schools
Ministry of Education
Private Bag 328
Lilongwe 3

Mr M G Mitengo
Science Curriculum Developer
Science Centre
PO Box 50
Domasi

MAURITIUS

Mr Shaukatally Sooltan
Education Officer
Ministry of Education & Cultural Affairs
Government House
2 Barbeau Street
Port Louis

Mr Chin Hin Sin Yan Too
Lecturer in Science Education
Institute of Education
Le Reduit

NIGERIA

Dr B C E Nwosu
Chief Education Officer (Science)
Federal Ministry of Education
Senate Building
Lagos

Dr I Isa
Senior Lecturer
School of Technology
Kwara State College of Technology
Ilorin

Mr L K Kolapo
Director
Science Equipment Centre
Federal Ministry of Education
1A Birrel Avenue
Yaba - Lagos

THE SEYCHELLES

Mr Irenee Joseph
Head Laboratory Technician
Ministry of Education & Culture
La Bastille
Mahe

Mr Patrick G Pillay
Science Education Adviser
Ministry of Education & Culture
La Bastille
Mahe

SIERRA LEONE

Dr Magnus J A Cole
Director
Science Curriculum Development Centre
Njala University College
Private Mail Bag
Freetown

Mr John T Jusu
Vice Principal
Wesley Secondary School
PO Box 9
Segbwema

TANZANIA

Mr D Mmari
Chief Technician
Faculty of Science
University of Dar es Salaam
Box 36065
Dar es Salaam

Mr M S Lyembela
Chief Technician
Faculty of Engineering
University of Dar es Salaam
PO Box 35131
Dar es Salaam

Mr Mathew Luhanga
Head, Production Department
Dar es Salaam Technical College
Private Bag 2958
Dar es Salaam

Mr Valentine M Bukozo
Science Teacher
Mazengo Secondary School
PO Box 47
Dodoma

UGANDA

Mr R Seggalye
Inspector of Schools
Inspectorate Division
Ministry of Education & Culture
PO Box 3568
Kampala

Mr S L Abeti
Inspector of Schools
Inspectorate Division
Ministry of Education & Culture
PO Box 3568
Kampala

ZAMBIA

Mr W M A Chileshe
Curriculum Development Specialist
Curriculum Development Centre
PO Box RW92
Ridgeway
Lusaka

Mr B Nyambe
Lecturer
National In-Service Teachers
Chalimbana
Private Bag E1
Lusaka

OBSERVERS

SEPA

Mr Hubert Dyasi
Programme Director
PO Box 9169
Accra

WCOTP

Dr Elizabeth Bouey - Yates
3-5 Chemin du Moulin
1110 Morges
Switzerland

UNESCO

Mr Philippe Nalletamby
UNESCO Regional Adviser in Science Education
BP 3311
Dakar

Mr David J Morgan
UNESCO Chief Technical Adviser
Science Equipment Centre
1A Birrel Avenue
Yaba - Lagos

OBSERVERS

THE BRITISH COUNCIL

Mr B T Chadwick
Head
Science and Mathematics
Education Unit
The British Council
10 Spring Gardens
LONDON SW1A 2BN

CONSULTANT

Mr Emil Bengtsson
Manager
School Equipment Production Unit
PO Box 30596
Nairobi

RESOURCE PERSONNEL

Mr Hubert M Dyasi
Programme Director
Science Education Programme
for Africa
PO Box 9169
Airport
Accra

Mr Phillipe Nalletamby
UNESCO Regional Adviser
in Science Education
BP 3311
Dakar

Mr David J Morgan
UNESCO Chief Technical Adviser
Science Equipment Centre
1A Birrel Avenue
Yaba - Lagos

SEMINAR/WORKSHOP SECRETARIAT

DIRECTOR

Mr Rex E O Akpofure
Director
Education Division
Commonwealth Secretariat
Marlborough House
Pall Mall
London SW1Y 5HX

CHAIRMAN

Mr W S M Migembe
Director
Institute of Education
S L P 35094
Dar es Salaam
Tanzania

SECRETARIES

Mr E Apea
Chief Project Officer (Education)
Education Division
Commonwealth Secretariat
Marlborough House
Pall Mall
London SW1Y 5HX

Mr C M B Gunze
Institute of Education
S L P 35094
Dar es Salaam
Tanzania

LIAISON OFFICER

Mr C L Abayo
Institute of Education
S L P 35094
Dar es Salaam
Tanzania

SUPPORT STAFF

CHIEF RAPPORTEUR

Mr S Katende

DOCUMENTATION OFFICER

Mr C Nyange

RAPPORTEURS

Mr C Kalugula
Mr M Laswai
Mr J Saka

PRESS LIAISON OFFICER

Mr G Mizambwa

AUDIO-VISUAL AIDS OFFICER

Mr L Mbawala
Mr J Mayoya

TYPISTS

Mr J Kingazi
Mr E Kidanga
Mrs S Rwehumbiza

SOCIAL AND AMENITIES OFFICERS

Mr S Mahai
Mrs T Mapunda

REGISTRAR

Mr H Mkondya

TRANSPORTATION

Mrs T Orio
Mr R Zahabu

REPROGRAPHIC MACHINE OPERATOR

Mr M Paul
Mr R Maringo

LABORATORY TECHNICIAN

Mr P Mabiki

WORKSHOP

Mr S Nkwabi

MESSENGER

Mr F Ngwiriri

Printed and published by
The Commonwealth Secretariat

May be purchased from
Commonwealth Secretariat Publications
Marlborough House
London SW1Y 5HX

ISBN 978-1-84859-269-8