Part Three

Spotlight on Science, Technology and Mathematics Education

Chapter 4

The Road from Oxford to Halifax: Snapshots of Science, Technology and Mathematics Education

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1 Introduction

The Oxford conference took place the same year the Sputnik was launched into space. This latter event caused a great deal of soul-searching about the role and importance of science education, in particular, and provided much of the impetus for curriculum change in science education in the 1960s. Shortly after this, in 1964, the then British Prime Minister, Harold Wilson, referred to the 'white heat of technological revolution', thus stressing the importance of technology as well as science.

The international context of Science Technology and Mathematics Education (STME) has changed and developed over the 40 and more years of Commonwealth education ministers' conferences but two very important themes recur throughout the period. The first of these may be described as 'continuity and change'. The records of the early CCEMs and key specialist conferences such as the 1963 conference on 'School Science Teaching' held at the University of Ceylon, show that key issues and topics identified then are still significant now. For example, the importance of teacher training and the significant role of resources for teaching, including both equipment and books, are still relevant. In the earlier stages, there was reference to the supply of teachers, often referring to the provision of expatriate specialist teachers; this is no longer a significant issue for some countries. However, in a number of Commonwealth countries there is an acute shortage of science and mathematics teachers, and expatriate teachers are still needed.

The second key issue is that of 'partnership and co-operation'. In the 40 years since the Oxford conference, an immensely wide range of activities has been undertaken in STME in the Commonwealth. None of this would have been possible

without partnerships at a variety of levels, starting from the personal and ranging through institutional to governmental co-operation. In addition, the growth and development of national and international professional associations and organisations has enabled a wide range of activities.

For example, national science associations such as the All India Science Teachers Association, the Association for Science Education (UK) and the Science Teachers Association of Nigeria, international organisations such as UNESCO, donor agencies such as the Canadian International Development Agency (CIDA), DfID and the German International Development Agency (GTZ), and foundations such as the Rockefeller Foundation have all contributed in various ways to Commonwealth STME.

Partnerships between countries and institutions in the earlier years were often predicated on the assumption that models developed in the industrialised countries of the Commonwealth could be translated (sometimes with little or no adaptation) to the less developed countries. Partnerships now are much more likely to have a more equal basis – an illustration of continuity and change

The two themes of 'continuity and change' and 'partnership and co-operation' will recur throughout this chapter. The first section provides a brief historical overview of the developments in STME in the Commonwealth over the 40-year period. This gives a basis for the following section, in which some examples of the important issues in Commonwealth STME are described in more detail. The final section is about the future, since the needs of Commonwealth countries are changing and it is important not only to learn from the past but also to be able to identify and respond to future needs.

2 Overview of Developments in STME in the Commonwealth

The Oxford conference identified some important priorities for Commonwealth co-operation in education, some of which are still important 40 years later. Among the key areas identified were the training and supply of teachers and technical education, the latter largely because there was a perceived link between technical education and economic growth. The focus in teacher training was largely on in-service programmes, which could be used to help overcome teacher shortages in specialised areas such as science and technical subjects.

The priorities in STME were largely those of the industrialised countries of the Commonwealth. For example, during the 1960s and early 1970s there were very powerful movements of curriculum reform, such as the Nuffield project for the sciences, the Science Education Project (India) and 'new' mathematics. These in turn were often used as the basis for curriculum reform in the less developed countries of the Commonwealth, often drawing upon expertise made available through bodies such as the Center for Research on Education Outcomes (CREDO, later CEDO) and the British Council. There was little sense at that time of the interrelatedness of science and mathematics, and technology was often seen as discrete

and different – for example as part of an approach to craft, design and technology.

The key issues identified at the second Commonwealth Education Conference, held in India in 1962 were very similar to those originally pinpointed at the Oxford conference, but perhaps had an increased focus on the problems of textbook development and supply. The need for the training of teachers in science and mathematics was also clearly identified, as was the training of technical teachers, this latter being seen as a key priority area. At the second CEC, there was recognition of the importance of training for technicians, which has remained an area in which there has been substantial Commonwealth co-operation (see the section on Training for Technicians).

There was a useful British contribution to the provision of textbooks in the form of the ELBS (English Language Book Scheme) through which paperback versions of British texts for post-secondary education and training were made available at a reduced price.

An important recommendation endorsed by the second CEC (but proposed at the Oxford conference) was that for an expert conference, which resulted in the December 1963 conference on School Science Teaching, held at the University of Ceylon (now Sri Lanka). This was a good example of co-operation and partnership, since Commonwealth governments, UNESCO and the USA supported it. The conference was held under the auspices of the Commonwealth Education Liaison Committee.

The themes at the conference were instructive:

- Science for All (which has continuing resonance with the emphasis on Education for All at the 1990 Jomtien and 2000 Dakar UN conferences, and the continuing emphasis on primary science teaching and learning);
- Teaching Science (with emphasis on primary science, science for the more and less able, technical training, syllabus revision and practical work);
- Teacher-training and science teacher associations;
- Aids to teaching;
- Evaluation;
- Co-operative measures such as emergency training of teachers and research centres.

Each of these themes remains important, even though the emphasis may have changed.

The conference also focused on developments in science teaching in the UK, Europe and the USA – it is noticeable that there is relatively little mention of programmes and activities in the less developed countries of the Commonwealth. Co-operation at that stage tended to imply the absorption of ideas and models from the

industrialised countries by the less developed countries.

One example of such co-operation was the focus on curriculum development in the 1960s and early 1970s, during which there were a number of projects, often funded by donor agencies such as ODM (UK), CIDA, UNESCO and USAID, in which science, mathematics and technical curricula were developed in various parts of the Commonwealth. Such projects included the East African Secondary Science Project, the West Indies Integrated Science project, the development of 'new' mathematics curricula in many Commonwealth countries and industrial arts curricula. Substantial work was also done at primary level, for example the African Primary Science Programme (which became the Science Education Programme for Africa).

The work of the Ceylon meeting was commended by the third Commonwealth Education Conference in Ottawa, Canada.

The key importance accorded to curriculum development in the 1960s was reflected in the establishment and growth of curriculum development centres or units as part of ministries of education or autonomous organisations in many countries. However, it became clear that it is not possible to isolate the curriculum from other components of the education system, since curriculum changes have immediate and continuing implications for assessment and evaluation, teacher training, provision of texts, and the nature and scale of equipment required. Ironically, it is still possible to find examples of education systems in which the staff members of curriculum development units and teacher training institutions have little professional contact with each other.

The third Commonwealth Education Conference continued to stress the issues identified in previous conferences. Apart from the training and supply of teachers (including technical teachers), attention was drawn to the importance of equipment. There were at least two components to this concern. The first related to the need for equipment in order to be able to teach the sciences, and this led to an emphasis in the 1970s on the production of low-cost equipment, often at centralised production units such as that at the Kenya Science Teachers College (see below). The second related to the need for different types of equipment, taking account of the development of new curricula in the sciences, technical subjects and mathematics. There was also a focus on the role of science teachers' associations, a concern that predated the founding of the Commonwealth Association of Science Technology and Mathematics Educators in 1974.

Following a recommendation of 3CEC, a conference on the education and training of technicians was held in Huddersfield, UK, in 1966, and the report of the Conference was considered by a committee at 4CEC which took place in Lagos, Nigeria. The education and training of technicians continues to be an important issue (see below). Some of the most important topics considered at the Huddersfield conference were:

- The importance of an accurate assessment of needs;
- The role of technical education within general education;
- The need for a close working relationship with industry and commerce;
- The nature of planned technician education programmes;
- Assessment and evaluation in the training of technicians.
- The training of technical teachers;
- Gender issues in technician training.

The main concerns of both the 1963 and 1966 expert conferences have remained important in science and technical education. They were followed by a similarly important expert conference on Mathematics in Commonwealth Schools, held in Trinidad in 1968. The key themes of the conference were:

- Fundamental ideas and objectives of mathematics education;
- The teaching of mathematics at primary level, including both methods and content;
- The teaching of mathematics at secondary level; (a) as a general 'core' subject; and (b) as a subject for those with specialist requirements;
- Assessment of children's progress and evaluation of programmes, purpose and method;
- Teachers: selection, initial and subsequent training;
- Resources for learning mathematics, including textbooks, films, radio and television;
- Programmed learning.

The fifth Commonwealth Education Conference, held in Australia in 1971, which proposed the expansion of the Commonwealth Secretariat's Education Division, included a specific reference to a Commonwealth Book Development Scheme. The focus of previous conferences was largely reiterated, with an increased emphasis on assessment and examinations; there had been some regional approaches to this issue, such as the West African Examinations Council and the East African Examinations Council (the Caribbean Examinations Council was founded in the 1970s).

The sixth CEC took place in Jamaica in 1974, the year of the formation of the Commonwealth Association of Science and Mathematics Education at a conference held in Jamaica in 1973. CASME incorporated Technology to become CASTME in the early 1980s. The formation of CASTME was reflection of the increasing importance placed on professional teacher associations. The section below on

CASTME provides an outline of some of the important activities of the association. The Jamaica CCEM reflected concerns about equipment in the form of kits.

Prior to 7CEC, held in Ghana in 1977, a seminar/workshop on technical education and industry was held in Hong Kong in 1976. The conference drew attention to the importance of science education (including issues of relevant equipment) and technical education, and provided the basis for the formation of the Commonwealth Association of Polytechnics in Africa, founded in 1979.

The work on low-cost equipment, which was carried out during the 1970s, was recognised at 8CEC, held in Sri Lanka in 1980. Work on mathematics education reported to the conference included the first Inter-African Seminar of the African Mathematical Union, held in 1979. A recommendation was made for a conference on STME.

STME was dwarfed by the issue of student mobility at the 1984 CCEM held in Cyprus; this is an issue that has continued to engage successive CCEMs, as explained in Chapter 1. The 1980s could be regarded as a decade of consolidation and possibly retrenchment, as resources became increasingly difficult to obtain. The single greatest achievement flowing from the 1987 CCEM (Nairobi) was the recommendation leading to the acceptance by the 1987 CHOGM in Vancouver of the establishment of the Commonwealth of Learning. This has provided the basis for a review of all the different methodologies for the delivery of education and training (see Chapters 1 and 6). However, the issue of the popularisation of science was also discussed (see below).

Science education has been one of the five key themes of the Commonwealth Education Programme. The resources available for the Education Programme during the 1980s were not large, and this was a continuing source of concern from the mid-1980s. Attention was drawn to this issue at the 1990 CCEM (Barbados) and even though resources have been made available through CFTC, the core funding available to the Education Programme has remained low. This has meant that the search for partnerships has been not just desirable but essential.

The emphasis in the 1990s has tended to reflect the emphasis on basic education of which the World Bank has been a strong proponent. The Bank holds the view that the allocation of scarce resources should contain a strong emphasis on primary education. This was reinforced by the two conferences on Education for All (Jomtien, 1990 and Dakar, 2000). The theme of the 1990 CCEM was 'The Quality of Basic Education' and this included an emphasis on science education at basic level. The professional development and support of teachers was the subject of work carried out jointly by the Commonwealth Secretariat and UNESCO. The issue of resources was again reflected at the conference – fewer resources were available for the core programme of the Education Division than at 10CCEM.

This historical overview has provided some of the context and background for the work carried out in key areas by the Commonwealth Secretariat in STME over the years since the Oxford Conference. The following sections contain brief

descriptions of the work done in these areas, in order to indicate the range and scope of this work, and to emphasise the importance of the key themes of 'continuity and change' and 'partnerships and co-operation'.

3 Key Areas of Commonwealth Co-operation in STME

There has been an amazing diversity of Commonwealth activities in STME over the last 40 years or so and it is not possible to provide a full description of all of these. However, by focusing on a number of key areas in which activity took place either over the entire period (such as the training of teachers) or for a good part of it (such as resources for science teaching including equipment), it is possible to provide a framework which can be used as the basis for discussion of the future. The areas selected illustrate the issues identified by Commonwealth governments over time, and reflect their approaches to the implementation of policy on STME. For example, the focus on the training of teachers has remained a recurrent concern for many governments. The popularisation of science and technology with the objective of achieving scientific and technological literacy has been seen increasingly as a key factor in devising an indigenous STME culture, as well as providing a sound basis for the increased inclusion of girls in STME. The policy of individual governments has often reflected the concerns articulated not only at Commonwealth conferences, but also in expert group meetings.

a. The Relevance of STME

Much of the work undertaken in STME could be broadly described as being about its relevance, since there has been a continuing debate about the role of science and technology in development and the contribution that STME makes to science and technology in any given country. There would appear to be general agreement that science and technology are crucial for economic development, but there is no consensus about the specific ways in which the education system can provide the necessary skills and experiences in these fields. In the Commonwealth context, these and related issues have recurred at a variety of levels. For example, in the late 1970s there was particular concern about the need for science, mathematics and technology to be inter-related. This concern was translated into a recommendation for a specialist conference, which never took place. However, a number of papers were commissioned, seven of which were published in 1985, drawing upon expertise from various parts of the Commonwealth. The importance of the training of teachers was stressed, as was the need for appropriate local equipment. An important paper looked at the need for inter-related teaching of the subjects as preparation for the world of work. Much of the curriculum development work of the 1960s and 1970s focused on 'pure' science and mathematics, with little apparent attention to the need to relate school curricula to the world outside in appropriate ways. It was proposed in another paper that there were two ways to bring about interrelatedness:

a) By identifying related topics in the existing curricula, and then interrelating the existing curricula;
b) By signing teaching modules covering topics commonly found in all science and technology subjects.

There was an important CASTME activity in 1986 (see below), at which the issue of making STME relevant was discussed. The importance of teacher preparation was strongly advocated in one of the lead papers. In the overview paper, some of the assumptions underlying the approach to making STME relevant were reviewed. For example, it is not necessarily true that some form of STME training will enhance an person's employment prospects.

All this work was undertaken against an international background in which the relevance of much STME was being questioned, with a strong movement towards the recognition of the impact of science and technology on society manifested, for example, in 'Science, Technology and Society' courses and programmes. The continuing need to review and reflect upon the nature of STME curricula is illustrated by the increasing importance ascribed to environmental education, largely as a result of the major international conference held in Rio de Janeiro in 1992. Despite moves towards integrated science curricula at secondary level in many countries, much remains to be done in making creative and effective use of the interrelatedness of STME.

b. Teacher Education for Science, Technology and Mathematics

Teacher education has been a lead area for Commonwealth co-operation in STME, since the quality of education is critically dependent on teachers. The emphasis on Basic Education and Education for All since the 1980s has indicated not only the increasing importance of initial training, but also of continuous professional development not only of teachers but also of teacher trainers at the primary level. In addition, there has been an emphasis on the development of resources and materials for use in in-service training. This has come about in part, at least, because of concerns about the quality and quantity of science (and technology) education at the primary level, and the need to develop scientific and technological literacy for all. In-service education and training (INSET) can be a useful tool for continuous professional development of teachers and for overcoming present deficiencies, while pre service-training should provide a sound basis for an educational system in the future.

The Commonwealth Secretariat had two main partners in this area in the 1980s – the International Council for Science Committee on the Teaching of Science (ICSU-CTS) and UNESCO. Immediately after a major conference sponsored by ICSU CTS in Bangalore in 1985 a Pan-Commonwealth workshop took place on primary science. This was the precursor to a joint Commonwealth Secretariat/ UNESCO project which focused on the development of materials for use in the in-service training of teachers. The trainees would begin to develop an awareness of

the role and value of science process skills both in their learning and teaching. This was intended to enable teachers to move away from both a 'nature study' approach to teaching science, and from the approach in which the emphasis was almost entirely on memorisation by rote. A planning workshop in 1986 was followed by a 1987 international seminar in Barbados on primary science teacher training. At the seminar, draft materials were used and reviewed. The participants identified both gender issues and those associated with technology as prime areas for future consideration. Workshop participants agreed to develop country-specific materials. After successful development of country-specific material in India a group of Commonwealth specialists, together with the Commonwealth Secretariat's Director of Project and Chief Programme Officer, visited India to review the material. One eventual useful by-product of this project was the UNESCO source book for science in the primary school. Further collaboration between the Secretariat and UNESCO resulted in the publication of a workshop module on professional development, 'Assessment in Primary School Science'. This material was based on intensive piloting and consultation with those who tried out the materials.

In order to sustain quality teacher training it is essential that trainers themselves are adequately trained. In recognition of this, training of trainers in science and technology education was the subject of a significant initiative in the Commonwealth Secretariat in the 1990s, with the publication of four regional editions of a handbook, *Training of Teachers in Science and Technology*. Each edition contains six monographs, with topics ranging from 'training needs in science and technology teacher education' to 'participating in science and technology education research'. Mathematics was not forgotten, with the publication of a joint Commonwealth Secretariat/National Council for Teacher Education (India) handbook in 1999 containing modules in mathematics for elementary teacher educators. These modules were later reviewed and revised at an Asian Regional workshop held in New Delhi in June 2000. The work on mathematics education was also carried out in the context of gender (see below).

The need for an emphasis on gender issues and the importance of drawing on local culture was emphasised in a meeting in Malawi in 2000 that focused on the development of resource materials for teachers in science and mathematics at upper primary and junior secondary level. This work focuses on providing useful teaching resource materials for teachers, which integrate content and pedagogy, including gender issues and the popularisation of science and technology. Thus the Commonwealth Secretariat continues to make a sustained effort in the area of teacher education and the training of teacher and this will continue to be an important part of its work.

c. Resources for Science Teaching

It is often assumed that the teaching of science requires adequate laboratory space, complemented by a wide array of equipment that will enable the learners to behave

as if they were scientists. There is some doubt about this assumption, since many of the exercises undertaken by students are more like cookery, with precise instructions to be followed and a prescribed format for writing about these experiences. However, there is little doubt about the need for a wide range of experiences for effective science teaching and learning, drawing, for example, on resources available in the environment. The essential need for equipment and other aids for teaching was recognised in the 1963 conference on school science teaching, and that concern has been reiterated in various ways up to the present. One of the major problems facing less industrialised countries where there has been a massive expansion in educational provision has been that of allocating sufficient resources to enable effective science (and technology) teaching. It was therefore important to examine different and hopefully more cost-effective ways of providing equipment. One way of confronting this problem has been to examine a variety of approaches to 'low-cost' equipment. Commonwealth activities in this area were undertaken in the 1970s and 80s in particular, starting in 1975 with a general review of the various approaches to the production of science equipment. (This review was revised and updated in 1983.) This included useful information on equipment design, relevant books and the various kits that were available.

This was followed by three regional seminar/workshops which took place in 1976, 1977 and 1979 on low-cost science teaching equipment. The overall emphasis in these activities was on training for both production and use of low-cost equipment. Yet again, the need for adequate teacher preparation and training had been highlighted. The seminar/workshops drew upon an impressive range of expertise, including from the National Centre for Research and Technology (India), the Regional Centre for Education in Science and Mathematics (Malaysia), the Science Education Policy Unit (Kenya) and Professor S. T. Bajah of the University of Ibadan, who later worked at the Commonwealth Secretariat, underlining the importance of effective co-operation and partnership. The role of vibrant and effective science teacher associations was also stressed.

An issue which was almost ignored for a long time, and has only been recently addressed, has to do with the maintenance of science equipment. Another is the need to consider how to provide effective teacher preparation to enable teachers to make use of their environment to improvise equipment.

d. The Training of Technicians

The key importance of technician support for professional/technological activities has been recognised for many years. However, it has often proved difficult to translate this recognition into a convincing career structure for technicians, particularly in the public sector. This may in part reflect the superiority ascribed to 'pure' science, as against technology, in many Commonwealth countries. Good laboratory (or workshop) technicians can make the difference between an imaginative and creative programme of practical work and one in which routine procedures are the

order of the day. The presence of a trained laboratory technician can mean that science teachers have more time to support students, as well as increasing the life of equipment through care and maintenance. Laboratory technicians can also ensure a safe working laboratory. The importance of identifying training needs and providing appropriate training opportunities was stressed in a survey conducted in the 1970s on technician training in Commonwealth Asian countries. It also drew attention to the need for appropriate and relevant training – there is little point in providing training on equipment and machinery which is no longer in use in the outside world.

Since the 1980s there has been an emphasis on the development and delivery of training programmes for technicians, the first of which was a joint CASTME/ University of the West Indies project on the distance training of technicians, using the UWIDITE system. This was a good example of one of the advantages of distance learning, in which the trainees did not have to leave their home countries or jobs – an interesting omen for the future. Two key players involved in this project, as in so many other facets of Commonwealth STME, were Dr M. Goldsmith (founding President of CASTME) and Mr E. Apea of the Human Resource Development Group, the Commonwealth Secretariat and latterly of UNESCO).

During the 1990s, a substantial body of work was undertaken on the training of laboratory technicians involving the Secretariat, COL and CAPA. COL obtained the rights to the use of technician training materials developed by Scitech Diol, a UK-based company. These have been the basis for the development of relevant and appropriate distance learning materials for technicians in India (through the Indira Gandhi Open University) and Sri Lanka (through the Open University of Sri Lanka), the South Pacific (through the University of the South Pacific) and in Kenya, Tanzania, Uganda and Zambia (through CAPA). Unlike Asia and the South Pacific, where universities had experience of distance learning, in Africa the Commonwealth Secretariat and COL developed the capacity of participating institutions through training courses in writing resource material for learners and in assessment and delivery mechanisms, including management of distance learning courses. Kenya and Uganda have already started offering these courses through distance methods. Work has also been undertaken on the training of technicians at university level in Africa under the auspices of the Commonwealth Higher Education Support Scheme.

The continuing need for the training of technicians draws attention to the need for a 'culture of maintenance'. When scarce resources are invested in equipment it is crucial that the equipment is properly maintained.

Provision of a distance training programme for technicians highlights the importance of institutional support, since a range of practical experiences are needed that can be properly assessed at the institutions, with some form of external moderation. Given the ongoing developments in ICT, there is little doubt that distance training of technicians will continue to be an important field of activity.

e. Popularisation of Science and Technology

Even if there is no clear relationship between science and technology education and economic development, there has been an increasing emphasis on the need for countries to provide education for all their potentially school-going population. If this is to be achieved, there is an important role for the development of scientific and technological literacy, however defined. This has been recognised by many organisations and institutions, including UNESCO, which was responsible for Project 2000 + on Scientific and Technological Literacy for All. The Commonwealth Secretariat was a partner in this project. Effective efforts to popularise science and technology could provide a basis for scientific and technological literacy for all.

The popularisation of science was the subject of a regional seminar held in Zambia in 1985. Some of the issues identified then remain relevant now, including the need for mathematics and science to be linked (see above), the role of both formal and non-formal education, the need to make effective use of the media, and the role of science fairs and science teacher associations.

A substantial body of work was undertaken in the 1990s, with three expert group meetings (Singapore, 1997; Malawi, 1998; and Trinidad, 1998) on popularising scientific and technological culture. The importance of both formal and non-formal education was stressed, as was the role of both teachers and parents. The need to demystify science and improve communication between scientists, media personnel and curriculum developers resonated in all expert group meetings. It was also stressed that information about good practice must be exchanged. As a follow-up, the Commonwealth Secretariat, in collaboration with the Asian Media Information and Communication Centre, Singapore, published *Asian Case Studies* on the popularisation of science and technology. A similar book is under preparation for Africa in collaboration with the African Forum for Children's Literacy in Science and Technology (AFCLIST). Another innovative work on the popularisation of science and technology has been the production by the Commonwealth Secretariat of *Using Science Centres and Museums to Popularise Science and Technology*, a book for museum curators and science teachers. An interesting approach of the book has been the use of all kinds of museums, not just science museums, in popularising science and technology. The Secretariat stresses the need to take careful account of the local context. In order to achieve useful results, it is important to identify relevant sources of information and also the target groups for particular activities. As in the 1980s, the role of national and regional science fairs has been stressed. CASTME (see below) has also played an important role by establishing the CASTME annual awards, which have been in existence since the mid-1970s. These encourage creative and imaginative approaches to the teaching of science, technology and mathematics and therefore contribute to the popularisation of these subjects.

If scientific and technological literacy for all is to be achieved then there will be

a continuing and expanding need for the popularisation of science and technology, drawing upon a wide range of media and both formal and non-formal education. This should also also facilitate increasing participation by girls and women.

f. Technical Education and Technical Teacher Training

The 1966 Huddersfield conference drew attention to the importance of technical education and technical teacher training. Even though curriculum content has changed markedly since then, particularly with the impact of the development of ICT, this remains important. There have been a number of different approaches to technical education, one of which involved the provision of separate schools (such as technical high schools), while another drew inspiration from a Canadian model of industrial arts. There appears to be little general agreement about the ways in which technical education should be provided at the secondary and immediately post-secondary levels. This is an important issue for the less industrialised countries, since technical education is expensive and there is considerable doubt about its cost-effectiveness if it is included in general secondary education programmes. There is also a continuing debate about the relationships between technical education and the world of work, and the need to take account of developments in approaches to small business and entrepreneurship. This will be discussed in Chapter 5.

Polytechnics became an important vehicle for the delivery of technical education in the 1960s and 1970s, and this was reflected in the foundation in 1978 of the Commonwealth Association of Polytechnics in Africa (see Chapter 5). CAPA has remained a valuable source of support, experience and knowledge, even though it is very short of resources.

Technical teacher training was the subject of a seminar held in Kenya in 1980 at which the importance of identifying training needs and of staff development in training institutions was reiterated. Canada played a key role in advising on technical teacher training and in providing funding for infrastructure in support of it.

The assessment of technical education is an important issue, with the City and Guilds of London Institute (CGLI) playing a vital role in the early years, and national and regional bodies taking on increasing responsibilities in the 1980s and 1990s. The importance of ensuring a suitable role for local industry in setting standards, for example, has to be recognised.

g. Gender Issues in STME

Participation by girls in STME and their poor performance in these subjects has been a subject of concern to all Commonwealth governments. This concern has been made more manifest since the setting up in the 1980s of a mechanism for reporting on Women's Affairs. The Forward Looking Strategies for the Advancement of Women (Nairobi, 1985) provided part of the background for the Commonwealth Plan of Action, which was adopted in 1987. The 1994 Beijing

Conference provided an important platform for the discussion of women's concerns.

The subject of women in science and technology has been extensively discussed in Chapter 3, so will not be further discussed here. This is not to detract from the importance accorded to this issue in the Commonwealth over the years.

h. The Role of the Commonwealth Association of Science, Technology and Mathematics Educators

Teachers are at the heart of education in STM, and it is important to draw on and utilise a range of strategies for their continuing professional development. One such strategy is the fostering and development of professional teacher associations, first at the national and then the regional and international levels. Such an association can provide a forum, through meetings, conferences and publications, for continuing professional development. One successful national example is the Association for Science Education (UK) which now embraces technicians and primary science teachers; another is the Science Teachers Association of Nigeria. The International Council for Associations of Science Education (ICASE) provides an umbrella for national and regional associations.

CASME (it should be noted that technology was not part of the original remit) was inaugurated in 1974, with Dr M. Goldsmith as its Founding President, at a conference in London on Conceptual Development in Science and Mathematics. The precursor to this conference was a meeting in Jamaica in 1973 on Social Significance in Science and Mathematics Teaching. CASME developed into CASTME in 1982, and the latter was recognised as a Commonwealth professional organisation in the early 1980s. The focus of CASTME's work has been on the promotion of the social, human and economic aspects of science and technology through low-cost quality materials.

The work of CASTME has been very varied, focusing on issues of importance to science educators and teachers. Mention has already been made of the role of CASTME in the development of a programme for the training of technicians in the Caribbean. One of CASTME's important contributions has been to promote classroom innovations in the teaching of science, technology and mathematics in the Commonwealth through its prestigious CASTME Annual Awards Scheme for Innovations in Science Technology and Mathematics. The scheme, which started in 1974, has kept going without interruption, in spite of having few resources. A large number of teachers and teacher educators have participated and received CASTME Awards. In many countries, CASTME award winners are being used by governments to support and train other teachers. The quarterly *CASTME Journal* provides a means for STM educators to reflect on developments in various parts of the Commonwealth and to share their experiences. CASTME regional conferences enable educators in a region to pool ideas and consider issues of future relevance – in July 1998, after 13CCEM in Botswana, CASTME organised a conference on educational technology for science and mathematics education in the

Caribbean and its social and cultural relevance in the twenty-first century. This is a good example of how a professional association can make bridges between CCEM and classrooms. Another important regional conference in Asia was organised by CASTME in collaboration with UNESCO and the Government of India in Goa, India in February 2001, on the theme 'Science Technology and Mathematics Education for Human Development'. Its task was to lay down priorities and strategies in the next decade in STME for human development.

To extend its reach to a larger number of teachers and teacher educators, CASTME is establishing regional branches. A Caribbean branch started in 1998 during the Caribbean regional conference, a West Africa branch is in the process of establishment and the Asian branch was established during the Goa conference. There will be a continuing role for CASTME in the twenty-first century as STM teachers around the Commonwealth endeavour to draw upon the experiences of others in different parts of the world, with the help of developments in ICT.

4 A View to the Future

The previous sections have provided a snapshot of contributions to STME carried out by and through the Commonwealth Secretariat over the past 40 years. They illustrate the importance of two overarching themes – continuity and change, and partnerships and co-operation. Concerns voiced in the 1960s as important to STME have been shown to be important still; yet it is also important to take account of change, not only at national but also at regional and international levels. For example, the training of teachers has been continuously identified as one of the key issues for STME in the Commonwealth. This remains true, but the content of and approach to teacher training has to be reviewed on a regular basis to ensure that advantage is taken of the most up-to-date research findings. Similarly, the production of quality learning resource materials and developing the capability of teachers to produce contextual materials continue to be important in improving the quality of science teaching in schools.

Another important area, which needs development in the Commonwealth, is technology education. There is a lack of clarity on what technology education includes. Different countries interpret it in different ways. Much thought has gone into developing this area in some countries, for example South Africa. There is a need to share experiences and help countries to develop their policies on technology education.

In addition, the modalities for the delivery of training need to be considered in light of developments in ICT, which have an impact on all nations. It is now potentially possible to deliver education and training to individuals where they are, rather than taking them away from their jobs and insisting that they enter dedicated training institutions. There are many issues to be considered here, including the ability of less industrialised states to afford the hardware and software costs associated with such modern developments. Nevertheless, the training of teachers and of

technicians will continue to be crucial for the development of STME, and the combined resources of the Commonwealth Secretariat and COL can be important in these areas. This was reflected at 13CCEM in Botswana, where the training and motivation of teachers was identified as one area in which ICT could be applied.

Given the level of resources available to the Commonwealth Secretariat's education team, it will be imperative to develop and expand the search for meaningful partnerships, since otherwise there will be little possibility of significant work in STME. There have been many instances of co-operation in the field of education between the Secretariat and national, regional and international institutions and organisations in the past 40 years and these provide a sound basis for future development. However, it will be crucial to ensure that the work undertaken meets the real needs of Commonwealth countries.