PERSPECTIVES ON TEACHER EDUCATION

Teacher Education in Science, Mathematics and Technical/Vocational Subjects

Report of a Round Table on the Teacher Education convened by The Commonwealth of Learning in Vancouver, June 15-19, 1992

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THE COMMONWEALTH of LEARNING

The Commonwealth of Learning is an International Organisation established by Commonwealth Governments in September 1988, following the Heads of Government Meeting held in Vancouver in 1987. It is headquartered in Vancouver and is the only Commonwealth intergovernmental organisation located outside of Britain.

The purpose of The Commonwealth of Learning, as reflected in the Memorandum of Understanding, is to create and widen access to education and to improve its quality, utilising distance education techniques and associated communications technologies to meet the particular requirements of member countries. The agency's programmes and activities aim to strengthen member countries' capacities to develop the human resources required for their economic and social advancement and are carried out in collaboration with Governments, relevant agencies, universities, colleges and other educational and training establishments among whom it also seeks to promote cooperative endeavours.

The Chairman of the Board of Governors is the Rt. Hon. Lord Briggs of Lewes and COL's President and Chief Executive Officer is Professor James A. Maraj.

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Foreword

The quality of education depends to a large extent on the quality of the teachers involved in its development and delivery. Teacher training is a need for all countries of the world. Nowhere is the need felt more keenly than in the provision of teachers for science, mathematics and technical/vocational subjects.

The problem is exacerbated in developing countries, which must simultaneously deal with shortcomings in other areas. The Commonwealth of Learning (COL) recognises the problem and is committed to finding and applying new methods of teacher education and training to complement conventional systems and to help accelerate solutions.

This was the main focus of the Round Table meeting convened by COL in Vancouver, Canada, in June 1992, and attended by 22 experienced educators drawn from 13 countries of the Commonwealth. In order to share the participants’ ideas and experiences more widely, it was considered appropriate to publish the papers and proceedings of the meeting in this form.

The Commonwealth of Learning wishes to record its appreciation to all who have contributed to this publication which, we hope, will stimulate further discussion and action toward enhancing quality education through teacher training in science, mathematics and other specialised subjects.

Professor James A. Maraj
President
The Commonwealth of Learning
CHAPTER 1

INTRODUCTION

KEY THEMES

The Commonwealth of Learning (COL) undertakes, as one of its many functions, the task of improving teacher training in Commonwealth countries. This role is of vital importance, especially in the training of teachers for science, mathematics and technical/vocational subjects. With a view toward developing a set of viable policies and programmes for teacher education in these fields, COL convened a Round Table with the following objectives:

1. To identify the key issues and problems in the training of teachers for science and mathematics;
2. To discuss and recommend strategies to resolve these problems, with illustrations from specific examples and case studies;
3. To develop a programme of activities for COL in teacher education and training; and
4. To evolve approaches and strategies for effective cooperation among the various institutions, agencies and countries, and COL's role in these processes.

The meeting took place in Vancouver at The Commonwealth of Learning from June 15-19, 1992. It was attended by 22 participants representing 13 Commonwealth nations. The meeting was chaired by Dr. Alexander A. Kwapong, Director, African Programmes, Teacher Education, Research and Evaluation, who also delivered the keynote address. Dr. Peter E. Kinyanjui, Assistant Director, African Programmes, Teacher Education, Research and Evaluation,* serviced the meeting. Other COL staff members, including Mrs. Augusta Morton, Programme Assistant, attended various sessions.**

Most of the papers presented at the Round Table have been included in this report. Brief summaries of each are provided here. In his opening address, Dr. Alexander A. Kwapong notes that the Round Table has been convened "at a time of momentous changes." He points to the ever-widening "information or knowledge gap" that is surpassing the economic gap between rich and poor nations. The poor nations of the South must equip themselves to benefit from the scientific and technological revolution. Science and technology, he states, are "indispensable components of the development challenge, and mathematics is fundamental to both." Dr. Kwapong emphasises that "education and training of the human resources within these nations" are the only means of bringing them into the 21st Century. Attainment of this goal is

* At the time of the Round Table, Dr. Peter E. Kinyanjui was Senior Programme Officer.
** A full list of participants is included in the Appendix.
thwarted, however, by a number of factors, the most critical of which is a shortage of teachers. Lack of prestige and appropriate remuneration deter many individuals from entering the teaching profession. Instead, they pursue more rewarding careers in commerce and industry. The "creation and deployment of teachers in the right numbers and of appropriate quality" is a task for which traditional teaching methods are inadequate, especially in science and technology, which are constantly changing and require continuing in-service education.

Dr. Kwapong asserts that new approaches are required and suggests that distance mode is probably the only viable method of meeting this challenge. He observes, however, that many countries lack the necessary infrastructure to maximise the potential of distance learning. Dr. Kwapong concludes that Commonwealth countries need to focus on "cooperative programmes and efforts to share information, knowledge and skills." He views COL's role as one of coordinator in such endeavours and expresses the hope that the Round Table will serve "to develop a viable, distinctive and feasible programme of activities in teacher education and training...."

Peter Burpee focuses on the training of teachers in specialised subjects, including computer science. He explores the requirements of producing competent teachers in science, mathematics, technical/vocational subjects and educational computing. Various teacher training programmes in Canada are discussed in detail and their relative merits are assessed. Burpee emphasises the need for "availability of good distance education programmes" and offers an in-depth appraisal of the requirements for such programmes in each of the subject areas. He views COL's role as that of a coordinator and commends the formation of the ICDL database, in which existing distance education courses are recorded and updated.

Geoffrey Potter addresses the topic of international cooperation in science teacher education as a means to overcome the shortage of adequately trained science teachers. First, he points out the necessity of establishing exactly what type of international cooperation is required and what type of educational system such cooperation would be directed toward. Potter explores five key methods suitable for assessing the needs for science education and thus, for science teacher education. He then postulates nine components essential to the development of effective teacher education programmes and discusses the ways in which international cooperation could assist in bringing them about. The most important vehicle for achieving this goal is electronically stored information. Potter concedes, however, that some underdeveloped countries still lack the requisite infrastructures to access these information systems. Nevertheless, other approaches to sharing resources, such as exchange visits, can introduce available information and technologies to educators from such countries. The possibility of enlisting aid from local, national and multinational corporations is also suggested. Potter concludes that an external agency, such as COL, could provide "a major service to science teacher education if it can facilitate the placement of educators from less developed nations in institutions where they may gain a broader understanding in the areas of greatest difference; and if it can locate instructional designers and science educators from the more developed institutions in less developed nations...."

Denis Wall devotes his paper to issues in the organisation of distance teacher training in mathematics and the sciences. His primary interest, as a social scientist in Canada, is Aboriginal education. Wall views distance education as a "means of transforming the power relationships in an educational system and in remote communities." He believes the best approach to science education is to concentrate on its relevance to the social experiences and needs of everyday life. Enthusiasm for science is thereby fostered in both teachers and students. Wall presents an overview of the scholarly literature and examines various issues, including the concept of "autonomy" in education. He advances
arguments for the “consolidation of alternative science concepts” and the inclusion of Aboriginal views in response to the question: Whose knowledge is important? The necessity of developing a science curriculum in partnership with the community is also stressed. Wall concludes that science teacher training must “enable teachers to understand how political events can affect how they teach, what they teach, how long they teach, and how management and administration are performed.” He suggests that COL could assist in the planning, management and funding of national distance teacher education systems in science, mathematics and technology.

Jane Mogina’s paper concentrates on developments in science teacher education in Papua New Guinea. She commences with an overview of the educational system at primary, secondary and tertiary levels. Teacher training at the primary and secondary levels is also explored. Mogina notes that teachers experience the greatest difficulty with science teaching. They attribute their dislike of this subject to the “lack of material and equipment rather than lack of subject knowledge.” She asserts, however, that teachers often lack the capacity to improvise, using materials readily available in the environment. Also, they neglect to read local journals on science and science teaching, which could provide inspiration. The University of Papua New Guinea’s in-service education programme for teachers was revised between 1988 and 1990, yet enrolment is sparse as a result of inadequate sponsorship by the National Department of Education. She observes a trend away from “formalistic” teaching toward a more “reflective” style – an improvement that a recently created national body will help bring about through monitoring the academic status of training institutions. Mogina’s paper concludes with a call for “a collaborative effort of science educators to develop worthwhile in-service programmes and participate in them.” Information networks, including a newsletter for teachers, to disseminate ideas are also essential.

James Murray commences his paper with a discussion of the geography, demography and economy of the Bahamas. He then focuses on the obstacles hampering recruitment and training of teachers in science, mathematics and technical/vocational studies in his country. No programme to train technical teachers exists at the College of the Bahamas. Since the number of locally trained teachers is low, the Ministry of Education must recruit British, Canadian and American teachers. This proves difficult, as few incentives are provided to attract teachers in the subjects most urgently required. In the Bahamas, teaching as a profession is held in low esteem, and teachers’ salaries fall short of other professionals’ salaries in the private sector. Thus many individuals choose careers in tourism and finance rather than teaching. Murray notes that a current strategy designed to induce local graduates to enter teaching is the Teacher Corps, which has been formed at the upper levels of secondary schools. Its aim is “to identify interested and intellectually competent high school students, who might show a positive attitude toward teaching as a career.” Regarding educational curricula for teachers, Murray argues that these programmes tend to place too much emphasis on theoretical studies to the detriment of practical work. He suggests that The Commonwealth of Learning could provide guidelines to assist the College of the Bahamas in creating a four-year, teacher-training programme, focusing on specialised subject areas. Moreover, he calls for a feasibility study on the establishment of a Commonwealth College of Education, “similar to or an extension of the United World Colleges concept....” Such a college would concentrate on teacher training in mathematics, science and technical/vocational studies and ultimately, would provide a model for such training programmes in underdeveloped countries of the Commonwealth.

Kenrick Seepersad considers the experience of Trinidad and Tobago in providing in-service teacher education for mathematics, science and technical/vocational subjects. Since 1989, in-service training has been actively pursued, despite a critical shortage of the “trainers of trainees.” He notes that both human and material resources need to be
augmented. One priority should be the preparation of standardised training packets, including audio cassettes with slides and videotapes. Regarding laboratories and workshops, Seepersaud expresses concern about proper maintenance of these facilities and their equipment in order to prolong their life. He proposes that COL should organise regional meetings to produce teacher training packets and videotaped lessons, which would provide models for fledgling Materials Production Units. COL could also assist member countries in developing distance education techniques with a view to offering certificates and diploma courses in the relevant subject areas.

Leton Thomas is concerned with “educating and training teachers to meet the present and future demands of teaching, and helping student teachers move from educational concepts to professional action.” He notes that some Caribbean educationalists complain that objectives of training programmes are unclear and professional expertise is lacking in the classroom. Thomas believes the focus of expanding teacher education programmes in St. Lucia and other parts of the Caribbean should be on creating a “well-organised and closely integrated programme of clinical experiences.” Innovation is required not only in teacher education institutions, but also in the management, organisation and use of staff in schools. Recently, a number of valuable reports as well as a CARICOM Advisory Task Force have provided useful directives toward reform. Thomas argues that the “quick fix” approach will not succeed in the long run. More research and development studies are required before initiating improvements.

Regarding curriculum development, he emphasises the need for relevance and the production of “modules that can be applied at any level to the design of learning experiences by the teacher or teacher educator.” He advises pursuing the modular approach because it fosters integration of subjects and provides a “core around which learning and instruction at any level can best be systematised.” Thomas concludes with the suggestion that COL could assist in the development of such instructional units.

S. Muralidhar reviews the situation of teacher education in the islands of the South Pacific. The latest development has been the establishment this year of a College of Advanced Education, which provides both pre-service and in-service teacher training for the lower secondary level. Muralidhar’s research on science teaching in Fiji reveals a long list of issues and concerns that are common to all countries of the region. He advocates the adoption of strategies that centre on the professional development of teachers and “recognition of the role in-service education can play in improving teaching, curricula, examinations and learning.” The education ministries should design an on-going, in-service programme for science teachers, most of whom receive only pre-service training. Muralidhar also suggests that the focus in workshops ought to shift from “how to teach” to “how to learn” and that teachers could benefit from exposure to the science curricula of other countries. Distance education is currently used in the South Pacific for professional development. Programmes in Educational Evaluation, Educational Administration, and Guidance and Counselling are very much in demand.

K. Gopalan focuses on teacher education in India. He considers the many factors that influence teacher education programmes and the ever-changing role of the teacher. Gopalan stresses the need for institutionalised teacher education to keep pace with theoretical and practical developments in school education. He laments India’s failure to achieve its goal, provided for in the constitution of 1950, of universalisation of elementary education. The only way to rectify this situation is through the introduction of advanced communication technology to train sufficient teachers through distance education. “Teacher education curricula,” states Gopalan, “should reflect a concern for value development.” It must also reflect the teacher’s role as “information organiser.” Various initiatives required in teacher training are outlined and the need for complete reorganisation of teacher education programmes in science, mathematics and
technical/vocational subjects is recommended. Gopalan explains that “emphasis ought to shift toward developing rather than simply training the teacher.” Toward this end, India is currently creating infrastructures for the institutionalisation of in-service teacher education under its centrally sponsored Scheme of Teacher Education. Gopalan’s paper concludes with a call for international cooperation, especially with the development of distance education.

S.J. Rajput is concerned with teacher training in the context of science education at the elementary level. He declares that the quality of learning institutions “is directly linked to the commitment, willingness and professional preparedness of the teachers.” The author evaluates the results of India’s Scheme of Restructuring and Strengthening Teacher Education, which was launched in 1987-88. Specific responsibilities of a high-calibre training institution are elucidated in this paper, as are the numerous factors that must be considered when designing programmes for professional upgrading of teacher educators. One challenge India’s teachers face at the elementary stage is the variable linguistic abilities of the students. Dialects and differences between the spoken and written language create many difficulties. Rajput argues that “mobilisation of community resources is a must.” Mutual accountability between the learning system and the community is also essential. “Teacher education programmes,” he argues, “must accept the universal role and place of science in the life of every learner.” Moreover, they must include education in “humanistic, ethical, moral and cultural values.”

P.K.D.P. Kudaligama provides a comprehensive analysis of the current state of scientific and technical education in Sri Lanka. She emphasises the need for her country “to keep pace with rapid developments in the global economy, as well as with scientific and technological advances.” Recognising the role that science, mathematics and technical/vocational education plays in the domestic economy, the Sri Lankan government has taken steps to expand its educational system. Kudaligama points out that the need for teacher training has reached critical proportions. She asserts that the only cost-effective means of providing teacher education programmes is through the distance mode, yet administration of these programmes is thwarted by inadequate personnel and resources. The Open University and the National Institute of Education are, for example, operating with only half of the necessary academic staff for their scientific and technical programmes. There is also a dearth of required support staff. Addressing the Sri Lankan teacher education curricula, Kudaligama states that it is outdated and should ideally be reassessed at regular intervals. She advocates “the application of student-centred teaching methodology” and recommends that a national plan to link all teacher education facilities be formulated. Kudaligama suggests that Commonwealth countries could organise “a panel of experts to advise on curriculum development, teaching strategies and evaluation of teacher training.” Cooperation in the production of equipment and materials, staff exchange programmes and the creation of a research journal for distribution in member countries are also proposed.

Qudsia Rifat focuses on teacher education programmes at different levels in Pakistan. These are organised by a number of formal sector institutions as well as by Allama Iqbal Open University through its distance education system. Rifat discusses at length the pre-service training of primary, middle school and high school teachers. He then addresses the in-service training programmes for teachers. As far as science and technical/vocational studies are concerned, however, the facilities and output of teachers are insufficient for the country’s requirements. Teachers face problems of severe overcrowding and ill-equipped classrooms. Little opportunity for career advancement exists. Rifat concludes that the conventional face-to-face system of education simply
cannot prepare enough teachers. Only the Open University can meet this demand. He looks to COL for assistance in developing and evaluating distance education programmes for pre-service and in-service training of teachers.

Peter E. Kinyanjui examines the training of science and mathematics teachers in a number of African countries. He points out that the difficulties associated with teaching and learning these subjects are common to most developing countries; in fact, they are interconnected and tend to reinforce one another. Kinyanjui reviews several innovative African projects designed to overcome some of the problems that encumber the teaching of science and mathematics. The Kenya Science Teachers’ College, established in 1965, provides a two-year diploma course in science subjects and mathematics, which prepares teachers for the secondary education system. Facilities of the School Equipment Production Unit (SEPU) are utilised for the Workshop Practical Course. SEPU was established as an independent company with all shares owned by the Ministry of Education. Its purpose is to aid schools in upgrading the teaching of science and education in general. SEPU is also involved in distance education. The Correspondence and Open Studies Institute at the University of Lagos in Nigeria also uses distance mode, supplemented by printed course texts and face-to-face tutoring, to teach the sciences and mathematics. It plans to construct laboratories with a capacity of 250 students each. Mention must also be made of the Zimbabwe Science Programme, which has successfully pioneered the use of practical experiment kits for the teaching of science in the classroom. Kinyanjui closes with an appraisal of what remains to be done and extols the merits of distance education as the means to achieving Africa’s educational goals.

Grace A. Williams examines the obstacles that prevent adequate training of sufficient numbers of teachers for science, mathematics and technical/vocational subjects in Nigeria. Still affected by their colonial heritage, many Nigerians continue to believe that an education in the humanities will provide them with greater social status and power than a technical or vocational education would. Williams identifies seven problematic issues that combine to result in a severe shortage of teachers in the sciences. She also offers specific strategies for remediation of these challenges. Central to most of the problems is the question of funding. Williams points to the necessity of re-examining educational policies and practices with a view to “bringing together educational institutions and industry.” Regarding the cost of equipment and facilities, she advocates dual usage for teaching and commercial activities. Obtaining obsolete equipment from developed countries and “compiling types of indigenous technology in various parts of the country” are also proposed. Williams calls for the government to increase production of teachers by offering financial incentives, such as scholarships and training allowances. The quality of teachers must also be addressed. Entry requirements to Colleges of Education should be raised in line with those of the universities and polytechnics. Teacher education programmes need to be expanded to allow sufficient time for practical work and comprehension of the theoretical aspects. Williams concludes with the recommendation that universities should have schools of Vocational Teacher Education with their own departments headed by Provosts, rather than being grouped with other occupational fields in one department.

Andrew J. Salisbury’s paper identifies the myriad issues that must be confronted by teacher educators in teacher education institutions. Perhaps the most important of these issues is the need to clarify the goals of education. Professional development of teachers, instilling the confidence to teach, and conveying information about the “legal, contractual and administrative responsibilities of teachers” are also vitally important. “Education,” Salisbury points out, “must be made relevant to life outside the classroom.” This goal necessitates development of a socio-economic concept of science, mathematics and technical/vocational subjects with emphasis on “enterprising and
entrepreneurial approaches to living in the 21st Century.” A cross-curricular method in teaching these subjects as well as enlisting the aid of parents would go a long way toward achieving this aim. Children who have special needs, including the “very able child,” must be accommodated by the educational system. Salisbury closes with the observation that the concerns of schools often conflict with those of teacher education institutions. He calls for both to share their responsibilities and expertise in human and material resources, communications, in-service and non-formal education.

S.T. Bajah addresses the problem of insufficient “trained and retained” teachers for science, mathematics, technical and vocational subjects. He argues that although many of the obstacles are similar in member countries, the strategies adopted to overcome them must be tailored to each country’s unique situation. A fundamental issue identified is whether teachers, especially in primary schools, should be generalists or specialists. Bajah views the difficulties associated with teacher training as revolving around six core issues: time, quality of initial training, the dynamic curriculum, cost, the socio-economic environment and the quality of available teachers. Of these issues, cost of training is a significant factor to be dealt with. The author proposes “(i)nvolvement of industries in training of science teachers and giving a percentage of profit to training institutions involved with science, mathematics and technical/vocational teachers.” Bajah also suggests providing awards, bursaries and special science teachers’ allowances.

John D. Turner addresses the difficulties associated with training science teachers specifically. He points out that there is, in fact, a world-wide shortage of properly qualified teachers of science. Factors resulting in this shortage include: weak science teaching in schools that provides an inadequate foundation for advanced studies; the exclusion of female students from science programmes; a perception of science as “difficult and unattractive”; and the increasing demand for scientists in commerce and industry. Another challenge is the ever-increasing knowledge base of science, which necessitates ongoing in-service education to keep science teachers current. Turner asserts that traditional teaching methods cannot fulfil the demands for training and retraining of science teachers. He proposes distance learning as the only feasible approach, although there is also a shortage of specialists in this field. New media, such as CD ROM, computer-assisted learning and interactive video programmes may, however, help to overcome this deficiency. Turner discusses the various purposes for distance learning and declares that “students provide the most reliable evaluation of programmes.” He explores the relative merits and drawbacks of learning science through distance mode, advocating a methodical, “minimalist” approach. The paper ends with a summary of COL’s role in terms of advice, training, evaluation and research, cataloguing and coordination.

Emmanuel Apea offers a broad overview of several challenges in the training of teachers for science. He asserts that teachers are, in fact, the most important element in determining the quality of education. Emphasising the training and support required by science teachers, especially in underdeveloped countries of the Commonwealth, he advocates more in-service training through workshops, regional meetings and conferences. These programmes are needed not only by teachers, but by teacher trainers as well. Apea maintains that the key component of effective teaching is teacher confidence and he discusses five “aspects of knowledge,” elucidated by Wynne Harlen and others, as essential in promoting such teacher confidence. The issue of gender in science is also addressed and “process-based science teaching and learning” is proposed as one means to enhance participation of female students in science. Apea recommends that COL become involved in developing materials that would be free of sexist stereotyping. He also points out that “COL needs to form links not only with formal
educational institutions, but also with non-governmental organisations ... to influence educators and other persons concerned with training teachers at all levels of the educational system."

MAIN ISSUES IN TEACHER EDUCATION FOR SCIENCE, MATHEMATICS AND TECHNICAL/VOCA TIONAL SUBJECTS

A shortage of resources – both human and material – hampers progress in teacher education for science, mathematics and technical/vocational subjects. The demand for competent teachers and teacher trainers far exceeds the available supply. Inadequate facilities and teaching materials negatively impact the quality of teaching, especially in these subject areas. Lack of government commitment in terms of clearly defined educational goals and appropriate allocation of funds makes improvement difficult, if not impossible. Even the issue of gender may be cited as a factor in the shortage of resources. Due to the social, cultural and economic circumstances in some countries, female students are underrepresented in science and mathematics classes. Consequently, female teachers and trainers of these subjects are also few.

THE CASE FOR DISTANCE EDUCATION

The chief disadvantage of the conventional approach to teaching is that it cannot meet the demand for training large numbers of teachers. The high costs of required facilities and equipment also make traditional teaching methods impractical. The advantage of distance education is that it can meet the demand for mass education. Although it requires a certain minimum infrastructure, distance education does not create a need for more facilities and equipment. Moreover, it is the only feasible means of professional development for teachers in remote areas. The following aspects are crucial to the success of distance education programmes:

- course design and development
- preparation and delivery of course materials
- student support systems (tutorials, practical work, etc.)
- feedback and assessment mechanisms
- periodic revision and updating of courses.

COL can play a role in stimulating the availability of and improvements in the delivery of distance education in science, mathematics and technical/vocational subjects. For example, COL has produced directories of courses that are available and could provide sources of costing for the minimum level of infrastructure necessary for distance education programmes, as well as the implementation of new distance education projects until they become self-sustaining.

COL should also expand its cooperation with other agencies having similar interests, such as the Commonwealth Secretariat, UNESCO, the International Council for Scientific Union, the International Council for Distance Education, and the Commonwealth Association for Science, Technology and Mathematics Education.
COL'S ROLE AS A CATALYST
FOR INTERNATIONAL COOPERATION

The Commonwealth of Learning could play various roles in the dissemination and coordination of information required by member countries for the planning and development of curricula for teacher education in science, mathematics and technical/vocational subjects. Its functions in this capacity may be broadly organised under the following three categories:

1. **Information and Publicity.** COL would ensure that educational institutions in the Commonwealth are fully informed about its functions and activities. It could, for example, include teacher education news in the COL newsletter. This would cover descriptions of projects and other Commonwealth initiatives in teacher training. A fourth module might be added to the COL database, which would list information about major curriculum and course development distance education projects in Commonwealth countries. Positioned to act as a clearing house for information, COL could also commission papers as a means to promote the exchange of ideas.

2. **Production, Exchange and Use of Materials.** COL could commission or produce materials for the education or training of science and mathematics teachers at a distance where such materials are lacking. Groups of countries with common interests and needs could be organised by COL to co-produce and fund some materials. COL may also assist member-country institutions in negotiating copyright and licensing agreements to permit materials developed at one institution to be used at another.

3. **Training and Consultancy.** COL could facilitate enrolment in courses on distance education that are available through distance mode. Attendance at practical courses on distance education could be supported and arrangements made for consultants to provide on-the-job training and short courses through institutions in member countries. It would be possible to assign responsibility for teacher education in science, mathematics and technical/vocational subjects to a COL staff member whose mandate would be to collect, analyse and collate information while supporting initiatives undertaken in Commonwealth countries. Regional group conferences could be organised to stimulate initiatives in the relevant subject areas.

In these and other ways, COL could address national problems by mobilising and sharing international resources and expertise.
CHAPTER 2

KEYNOTE ADDRESS

ROUND TABLE ON TEACHER EDUCATION FOR SCIENCE, MATHEMATICS AND TECHNICAL/VOCATIONAL SUBJECTS

Alexander A. Kwapon

AN OVERVIEW

This Round Table takes place at a time of momentous changes as we stand at the threshold of the 21st Century. The World Conference on the Environment and Development has just been concluded in Rio de Janeiro, and the emerging global development agenda for the 21st Century has just been affirmed. This stresses, above all, the key issues of global interdependence and the importance of cooperation in resolving the twin challenges of environmental degradation and global poverty through a programme of sustainable development. Central to sustainable development is a fair and equitable human development. The important changes that we have witnessed on the geo-political landscape, with the transformation of Eastern Europe, the end of the Cold War, the emergence of the various economic and regional blocs, all have heightened our awareness of our global interdependence.

As a microcosm of the global community, the Commonwealth nations will have to devise appropriate programmes and strategies to meet these global development challenges.

The great global divide in the coming decades is being rapidly transformed from an income gap between the rich and poor nations into an information or knowledge gap between the “haves” and the “have-nots” of knowledge. Closing this information or knowledge gap is at the top of the global agenda. This is the greatest challenge before the poor nations of the South. It is only by equipping themselves to benefit from the scientific and technological revolution fuelled by advances in information and biology that they can hope to bridge this gap. Science and technology are, therefore, indispensable components of the development challenge, and mathematics is fundamental to both.

Science and technology are important components of the wall dividing poverty and prosperity, and their use in overcoming poverty and ensuring equitable development is now generally acknowledged by all nations of the Third World. It is also accepted that education and training of the human resources within these nations constitutes the most
effective means of overcoming their underdevelopment. This provides the framework for the educational challenge before the nations of the world in general and within our present context, for the Commonwealth community.

Seen in this light, the Round Table that we have now convened here is timely. It has both a general and specific significance, since teachers of science, mathematics and technical/vocational subjects have an overarching role in the educational process so essential for development.

Education is recognised as the key to effective human development. No meaningful development can take place without education; yet education is a necessary, but not sufficient, condition for development. Political, economic and social policies, the cultural and traditional environments, management and technical skills all play key roles in promoting development. Good governance and open democratic processes, the rule of law and the exercise of human rights by the population are now accepted as essential factors in building the capacity of a people. But central to all of these factors in promoting human development is the human resource – the human capital – and the efficiency with which this capital is invested, developed and utilised. The quality, appropriateness and accessibility of basic education is a central part of this investment, and teachers are the determinants of such effective human development. The creation and deployment of teachers in the right numbers and of appropriate quality is the crux of the educational challenge.

The magnitude of this educational challenge has been underscored by many recent studies and declarations, the most dramatic being the Jomtien World Declaration on Education for All in 1990, which highlighted these daunting statistics: more than 100 million children, including at least 60 million girls, have no access to primary schooling; more than 960 million adults, two-thirds of them women, are illiterate; more than one-third of the world’s adults have no access to printed knowledge, new skills and technologies that could improve the quality of their lives; and more than 100 million children and countless adults fail to complete a basic education programme.

If access to basic education is a human right, as is accepted by most nations, then it is also true that the resources to provide such basic education are constrained and woefully insufficient. The challenge, therefore, is to meet this burgeoning demand for education with limited resources by making the most effective use of the most important resource of which there is an abundance – the human resource. It is the teacher who can meet this challenge.

The first and most important issue is the shortage of trained teachers of all kinds. Many developing nations have adopted various strategies to increase the number of trained teachers, the shortage of which is most acute at the primary and secondary levels, but also serious at the tertiary level. Hard choices and cost-effective measures must be implemented to meet this challenge. Many nations are making good progress. But the shortage of trained science teachers is particularly severe, which has been emphasised in the various papers you have submitted. This shortage is a worldwide phenomenon due to well-known causes that have been analysed in your papers, and I need not detail them here.

I wish to mention only one important issue. The overall shortage of scientists is exacerbated by the increasing demands from commerce and industry in most countries. The best students who will make the best teachers, who will train more scientists and mathematicians, tend to be creamed off by commerce, industry and the science-based professions, which are more prestigious and better remunerated, thereby reducing the numbers available for training as teachers. The teaching profession, as several of you
have noted, does not enjoy the prestige or remuneration of other professions in many countries. Not only is it more expensive to train science teachers, who require laboratories and equipment at all levels of training, but since science and technology are constantly changing, the need for in-service courses to upgrade knowledge and skills becomes more urgent. Traditional methods have proven clearly inadequate, so the question is, How can this enormous problem be resolved? It is obvious that new approaches have to be adopted in the teaching of science and the other specialised subject areas.

Distance learning has been proposed as the only feasible methodology to overcome this conundrum of quantity and quality. How valid is this proposition? The essential question before us is to determine whether and in what ways distance education can really meet the need of providing this new, up-to-date and more effective training for large numbers, given the insufficient financial and material resources. As the papers have stressed, our knowledge of the techniques of distance learning in the teaching of science, mathematics and the technical/vocational subjects is inadequate for our needs. It will be very valuable to probe this issue.

For most of the potential users of distance education in the poor countries, the lack of basic infrastructure, such as digital telephones, good postal and radio broadcasting systems, not to mention television and, above all, computers, precludes the adoption of the advanced technologies being employed in distance learning programmes in the advanced countries. The example of India, which is succeeding in providing itself with the necessary infrastructure to meet this need, may be mentioned. Before even the low-cost techniques can be utilised, there is need for a minimal level of technical infrastructure. This is a question of national policy and priority, and on this, technical assessment and advice could be provided by an agency like COL. This is a major problem for the developing countries, and they must learn from the success stories of other developing countries that are managing to introduce innovative, low-cost techniques and audio, printed and other materials to upgrade the training of their teachers and the enhancement of their educational systems as a whole. This calls for cooperative programmes and efforts to share information, knowledge and skills.

But a critical problem still remains that this Round Table must seriously address: What is the specific role that the trained teacher must play in the introduction of these innovative methods of distance learning in science, mathematics and technology? And specifically, how suited are these methods to the teaching of science at a distance in countries without the technical equipment and resources or the scientific and technological culture of the more advanced nations? How far, and to what extent, can the traditional methods of face-to-face instruction be complemented or transformed by the distance-learning mode? The issue is of fundamental importance, especially in providing a new orientation at the secondary and tertiary sectors of the educational systems. It would be worthwhile for the Round Table to probe the efficacy and applicability of the two modes in promoting the training of teachers in science, mathematics and technical/vocational subjects. The dual mode of providing instruction at the secondary and tertiary levels is clearly going to be a major preoccupation of our various nations. COL is organising a meeting next month in Delhi with heads of Commonwealth University Grants Committees. It will be useful for the Round Table to spend some time on this matter.

The area of materials acquisition and adaptation is manifestly one of the central issues for the subject of this Round Table. The ability to design, select and adapt materials suited to the needs of the specific countries is an important benefit, which proper cooperation between the different countries can enhance. The use of centrally produced science and mathematics teaching materials and courses shared by countries with the
same cultural and social environments could ensure that science teachers would attain
the same standards and achieve comparable quality and competence. South-South
cooperation clearly has an important contribution to make in addition to the more
established North-South twinning relationships and partnerships, which must assume
increasingly major importance.

The case studies of innovative programmes in the various parts of the Commonwealth
discussed in the papers contributed all reinforce the importance of effective coordination
and dissemination of information among the member countries. COL's initial
programmes have begun to make some contribution in this direction, but clearly a lot
more needs to be done. One of the tasks for this Round Table will be to examine in
detail the five functions summarised by Professor John Turner in his paper in relation to
teacher education in science, mathematics and technical/vocational subjects, and to
which several of your papers devote attention: advice, training, evaluation and research,
cataloguing and coordination.

Of these, it is absolutely clear that and I quote: "COL must maintain a collection of
evaluations of different distance education projects in the Commonwealth and
elsewhere," to be available to member states for comparative studies. A most urgent
function is to have a fully developed database of all available distance education
learning materials that are available from public sources in the Commonwealth,
containing detailed descriptions of the material, module by module, the purposes for
which it was devised and the history of its usage, which can be easily accessed. The role
of coordinator will obviously be an increasingly vital function, which COL will have to
exercise in collaboration with its partner organisations and agencies. I hope the Round
Table will provide valuable guidance on this important function.

In looking at the area of teacher education for science, mathematics and
technical/vocational subjects to which so much lip-service has been given, the Round
Table will perform a signal service if it brings very clear light to bear on the substance
of the challenge, that is, if it clearly demonstrates that for this critical area of teacher
education, distance education, as a methodology, really does have a seminal role to play
in transforming education as a whole. Especially for science, mathematics and
technical/vocational subjects, distance education provides the way for the future.

The Commonwealth of Learning will be greatly indebted to this Round Table if your
deliberations enable it to develop a viable, distinctive and feasible programme of
activities in teacher education and training, and to evolve the strategies for effective
cooperation between COL and the various institutions, agencies and organisations
involved in this common enterprise. If the Round Table is able to accomplish these
tasks, it will have made a fundamental contribution to the advancement of human
resource development.
CHAPTER 3

TRAINING TEACHERS IN SPECIALISED SUBJECTS: WITH A PERSPECTIVE ON EDUCATIONAL COMPUTING

*Peter Burpee*

RATIONALE

The need for specialised subjects increases during the secondary years of schooling. It is during these years that young people acquire higher-order intellectual abilities, which help them understand and appreciate the study of disciplines in the curriculum. For this reason, the school curriculum generally shifts from integrated or general subjects in primary and lower-secondary years to specialised subjects in the upper secondary years. Vocational subjects also call for specialisation, since they are primarily experience-based and require a strong background in modern trade, industrial and commercial practices. School subjects can be divided into disciplines and fields of study. Subjects such as physics and mathematics are regarded as disciplines; in contrast, a school subject such as geography is sometimes described as a field of study, since some would maintain that it embraces and integrates many disciplines.

Training teachers in specialised subjects presupposes three goals:
1. for science, thorough academic training in specific scientific disciplines; for technical/vocational areas, a strong background based upon theory, practise and experience;
2. an ability to apply theoretical knowledge to the local situations and conditions;
3. pedagogic training appropriate for teaching specialised subjects.

What do science teachers require to be competent in their responsibilities?
- academic depth in one or more sciences
- first-hand knowledge of scientific method
- experience in the problem-solving/discovery approach to learning
- a practical as well as theoretical introduction to teaching, and especially
- a thorough understanding of pedagogic approaches to science.

What do mathematics teachers require to be competent in their responsibilities?
- academic depth in mathematics
- a practical as well as theoretical introduction to teaching
- a thorough understanding of pedagogic approaches to mathematics.
What do technical/vocational teachers require to be competent in their responsibilities?
- extensive first-hand knowledge, experience and formal training in a specific technical/vocational field
- a practical as well as theoretical introduction to teaching
- a thorough understanding of pedagogic approaches in their field.

What do teachers require to be competent in educational computing?
- a practical knowledge of computer operating systems and of managing computer networks and resources
- a basic knowledge of school-based applications software or of business-oriented applications software
- a practical knowledge of communications software
- an introduction to a programming language such as Logo, Pascal or HyperCard.

ISSUES AND PROBLEMS

Teacher-Training Programmes

1. Training science and mathematics teachers by means of an undergraduate degree.
A general university pattern in teacher training for the secondary school is a two-level approach. At the first level, the teacher trainee may learn through a three-year B. Ed. programme, which integrates at least two academic disciplines with education and elective courses. It is the integration of academic subjects and the accompanying pedagogy over the three years that is attractive in this approach, especially in institutions that meld the two together. The practice of including Education Studies in each year of the programme provides the trainee with a longer time to acquire the pedagogic skills pertinent to given subject areas. On the other hand, a three-year programme may also reduce opportunity for studying a discipline in depth. In the North American context, this could amount to as little as three one-term courses in each of the two academic disciplines. For a subject such as physics or mathematics, this would permit an introductory course and two intermediate-level courses. Lacking courses at a higher level, the student would have made but a bare beginning in the field. If the subject area were broader, for example, General Science, this pattern might allow three introductory courses in each of physics, chemistry and biology, but nothing further to provide depth as well as breadth in the subject area. Thus, in our experience, the superficial nature of training through the three-year B. Ed. model has serious weaknesses and is perhaps best suited only for preparing teachers for the primary school and lower secondary years.

The second approach to teacher training requires an initial three-year undergraduate degree such as a B.A. or B.Sc. with specialisation in one or two school subjects, followed by one year of teacher training. This approach creates greater strength in the academic fields, since the one additional year of study is critical for the upper end of university education and allows significantly greater depth in specialised subjects at the secondary school level. This first degree becomes an entrance requirement for Education Studies. By definition, teacher trainees are older, more mature, more demanding and more critical. With this combination of four years of solid academic study and pedagogic preparation, secondary schools have reason to expect more of young teacher trainees. It is from their ranks that a core of knowledgeable teachers and future department heads can be expected to emerge.

Primary school teachers who normally teach most or all classroom subjects require a general academic background in many school subjects. In a three-year programme,
emphasis will be given primarily to the development of language skills, and training is then spread out across as many as five or six school subjects. This profile means that most primary teachers lack any courses in science and many lack mathematics as well in their academic studies. Primary school teachers in Canada are consequently ill-equipped to teach these subjects. In their hands, science often becomes reduced to an unexciting book subject, taught with little reference to the real world around them. Lacking explanations for the common phenomena in the local environment, they typically lack confidence in their ability to teach science or mathematics.

2. Training technical/vocational teachers. The initial entrance requirement for technical/vocational teacher training in Canada is usually based on experience in a given technical/vocational field. Because vocational programmes are part of secondary school education, B.Ed. (Vocational Education) at, for example, McGill University, offers candidates the opportunity to take courses leading to teaching certification in two secondary subject areas. The first of these must be either business or technical, and the other can be any other recognised secondary school subject area. While the B.Ed. (voc) programme components are similar to other two-subject option B.Ed. programmes in the Faculty of Education, one major difference is that some of the courses specific to the vocational subject may be taken in conjunction with business and industry courses.

Note that with the exception of two computer courses in business education, the university does not offer courses in the technical/vocational programme through distance education.

3. Provision of computing skills. I will differentiate between skills needed by teachers of school subjects such as English as a Second Language, skills needed by business education teachers and those required for administrative purposes. Essentially, this is a matter of software selection, learning how to integrate computers, programming and software applications into school syllabi, and of providing experience with basic computer and printing operations. Ideally, most new teachers in any field should receive an introduction to computers and a common application, such as word processing, as part of their initial teacher training. This is about as much as the normal profile constraints in initial teacher training permit. Further learning in educational computing then becomes relegated to in-service or distance education.

Providing an introduction to computers may not be possible in places where computers are almost unknown in schools, and training is, therefore, impractical or purely theoretical.

I have placed computer science last. Those who intend to train in this field for education will find a wide range of existing courses in computer science and in business computing through distance education. Learning about computers and their applications by distance education is no different from learning about any other theoretical or practical subject.

Additional Comments on Teacher Training Through Universities

Most Canadian universities and teachers' colleges draw upon conventional methods of teacher training. One might envision other models based on a longer term collaboration between schools and teacher training institutions. As one example, young teachers might receive a modest initial academic and pedagogic training before entering the teaching profession, then return regularly for further education as a training requirement spread over several years. This is possible only in large urban centres where universities or teachers' colleges are readily accessible, and through summer institutes or short residential courses during the year.
A university education is an expensive investment for a national economy, and graduates are in general demand in many parts of the economy as well as overseas. In many areas of the world, teachers are underpaid and undervalued in the social and political system. Teachers with an undergraduate degree are often lured to better paying occupations. Notwithstanding, developed and developing countries alike rely upon a core of well-trained, experienced teachers with strong academic backgrounds to write textbooks and examinations, revise subject syllabi, become department heads and in many other ways provide leadership. Working conditions must, therefore, be such that well-trained teachers can be attracted to, and retained by the national school system.

**Training Teachers Through Short Programmes**

One-year and two-year programmes are considered emergency measures to provide teachers for primary schools in places where serious shortages of teaching staff exist. Given the time constraints, short programmes usually emphasise a basic training in pedagogy, but can provide little learning in academic subjects. Once on the job, training and schooling can continue through a structured programme of distance education courses. This is one way for developing countries to plan teacher training in specialised subjects.

**SOLUTIONS AND STRATEGIES**

1. **On-the-job teacher training in science through distance education.** Science comprises a field of knowledge of encyclopaedic proportions. Despite this vastness, the basic generalisations, concepts and skills of science can be taught simply or substantively to almost any age group. The degree of complexity depends on age, ability, maturity, and prior experience and knowledge. One approach is the spiral curriculum, which introduces increasingly complex ideas and generalisations. Some would argue that the ideas of science are more important than learning factual information. The rationale is that scientific knowledge is constantly changing and growing, while scientific generalisations, concepts and skills are more enduring. It follows that the scientific knowledge and generalisations understood by secondary school teachers require frequent periodic updating, and that teachers need opportunities to learn about new methods of teaching science.

Primary school teachers, who often lack a study of science in their pre-service education, have a more urgent need for regular workshops, formal on-the-job training and courses in background science. Even in Canada, 75% of all primary teachers have never taken a university-level course in science, and only half have taken a university course in mathematics. Individual workshops and short courses have their place, but the benefits do not always endure much longer than the workshop itself. The lack of continuing education and the limitations of what can be accomplished in a short time through workshops alone are serious shortcomings.

The roles of distance education and special short courses for the provision of in-service upgrading and renewal for science education take on special significance, given the proportions and importance of the tasks. Upgrading and renewal are especially essential where teachers in their initial training are only introduced to science as an academic subject and to the teaching of science as a school subject.

In-service training requires careful planning in order to have a close relationship with national or regional school syllabi. Where a syllabus is adopted from other sources, experience shows that most science teachers require help and supervised practice to
integrate the science syllabus with the conditions of the local environment and the potential opportunities that the milieu offers for experimental work and discovery activities by pupils.

2. *Practical activities in science.* Learning science implies activities that encourage the ability to:
   - plan, hypothesise and predict
   - design and carry out investigations
   - interpret results and findings
   - draw inferences
   - communicate about exploratory tasks and experiments (DES, 1989)

Although traditional school science accustoms us to think in terms of “lab experiments,” much progress in recent years has been made in activities based on the local milieu. For example, if the objective is learning how to classify categories of objects, then activities can be designed for pupils to collect disparate and similar objects such as rocks and stones found around the school premises, and then use these materials for an extended enquiry and classification exercise. Schools have found that expensive equipment can often be replaced with common materials and still provide the same type of opportunity for the kinds of activities essential to learning science. For this reason, science workshops for teachers nowadays often begin with “cardboard boxes” containing the basic materials needed for investigations, with the rest being found in the local area. The *UNESCO Source Book for Science Teachers* advocated this approach many years ago. Some equipment such as thermometers, magnets, simple chemicals and sharp knives may still be needed, but not on the same scale as previously thought necessary for learning science up to the middle years of secondary school. Imagination, creativity and an ability to recognise science in the local environment in many cases will satisfy the need for materials necessary for scientific investigations.

Instruction and demonstration through videotapes are important for suggesting the role models and methods of teaching science. It is advisable to produce videotapes with local exemplars and materials in order to improve the effectiveness of the medium.

3. *Learning about mathematics through distance education.* Since my university does not yet have distance education mathematics courses for teachers, I am going out on a limb with my ideas. Like many others, I have struggled with mathematics during my own university education and can fairly easily envision the problems that others would have without the direct support of a teacher. Yet, there are answers that the tools of distance education can provide:
   - audiotape commentaries together with printed worksheets, which help steer the learner through model problems and provide support for the solution of more difficult self-correcting problems
   - audiographic instruction for small groups can provide a progressive, visible development of theory and principles in mathematics, as well as the solution to problems
   - videotapes, though passive, can provide much the same advantages as audiographic instruction.

Perhaps more than in many other subjects, a rapid response is required from tutors who correct assignments. The establishment of self-help, peer-learning groups is a valuable form of support for all subjects, especially mathematics.
There is also room for teaching materials that raise some of the topics and issues actively debated in school mathematics. What is the purpose of problem solving in mathematics? Should students use calculators in problem solving? Should mathematics concentrate on theoretical concepts or should it teach basic life skills?

4. Technical/vocational partners with business and industry. Depending on the circumstances, field experience partnerships with business and industry provide on-the-job training during the programme for students:
   - whose work experience has become outdated
   - who require “broadening,” having entered with knowledge of a very specialised part of an occupation or industry
   - who have little prior experience in a particular field.

Field experience, generally a requirement for technical/vocational teacher training, is only made possible through cooperative partnerships with business and industry. These essential linkages enhance motivation and support the trainee by integrating critical skills and work experience with pedagogic theory. A distance education programme for training technical/vocational teachers should adapt this model of operation as basic.

5. Learning about computers through distance education. The basic assumption for distance education courses is that school authorities will permit, and even encourage, teachers to use the computers and printers available in their schools. Where schools or regional educational authorities have standardised their choices of software, distance education institutions are saved the worry and expense of providing software, or even of deciding what software is needed around which to develop their courses. Otherwise, software suitable for school applications must be selected and provided through loan or purchase arrangements.

Tutor support is perhaps more critical for this type of course than others, especially for novices. Perhaps the ideal arrangement would be a combination of an introductory, on-site course followed by distance education courses.

RECOMMENDATIONS AND SUGGESTIONS

A distance education programme for training science teachers should:
   - result in an excellent knowledge of one or more sciences taught in school
   - have a practical component that links theory with practice in the context of school science
   - show by example how to design, produce and develop low-cost or no-cost student learning activities for the local milieu using available materials
   - provide in-service training for upgrading science teaching qualifications.

A distance education programme for training teachers in mathematics should:
   - result in an excellent broad knowledge of mathematics
   - employ a variety of imaginative instructional techniques to help and support learners
   - actively involve teachers in the creation of demonstration teaching materials for their own classes
   - provide in-service training for upgrading mathematics teaching qualifications.
A distance education programme for training technical/vocational teachers should:
- admit candidates with prior working experience in a technical/vocational field, or those who can obtain this experience while training through a partnership programme with business or industry
- provide practical in-service training for long-term education through placements with local business and industry.

A distance education programme for training teachers in educational computing should:
- provide an introduction to the educational applications of the computer
- provide training in how to manage computer resources
- introduce practical skills, such as word processing, as an effective tool for teaching writing skills, and other applications that have proven value for national/regional syllabi.

Training teachers for specialised subjects is a problem for educational authorities everywhere in the Commonwealth countries. In the case of science, mathematics and educational computing, it is especially clear that teacher training institutions often cannot meet the need. Where programmes do exist, the institutions may produce undertrained teachers who must then be encouraged to continue their training through in-service courses in their respective fields. Since many of these teachers do not have ready access to in-service education, they must rely on the availability of good distance education programmes.

At what stage are the developing countries in respect to distance education courses for specialised subjects? Apparently, not as far as they might be. The ICDL database lists no courses in educational computing outside the United Kingdom, Australia and Canada. There are some, but not many, science education courses. Even Canada has relatively little to offer in this regard. The picture for academic science courses is more promising.

The role of COL as a coordinating body is critical. Change is possible through design or by accident. An important step has been taken with the creation of the ICDL database. This identifies distance education courses now in existence and naturally, it is regularly updated. Secondly, by linking universities that have courses in specialised subjects with others that need them, COL intervention may stimulate the design of specialised courses and the production of instructional materials, including science kits in countries where they are especially needed. This assumes that funds from world and Commonwealth agencies can be found for the purpose, again through the intervention and support of COL.

One way to plan work of this kind is to cluster development projects by countries with similar environments, cultures and needs. The computer should be a part of the process, so that basic course materials may be readily adapted to meet the specific conditions of different countries. The production of demonstration and instructional videotapes should be a priority, especially those which can be recorded in two languages for greater flexibility.

Reference

CHAPTER 4

INTERNATIONAL COOPERATION IN SCIENCE TEACHER EDUCATION

Geoffrey Potter

One of the major educational problems facing many countries in this decade is the lack of adequately educated science teachers, particularly in developing countries. This paper examines in general terms some of the issues surrounding this problem and proposes that international cooperation in teacher education may be an essential component in addressing the inadequacy. Problems concerning international cooperation are also addressed, and strategies for facilitating cooperation between teacher education institutions are examined.

It has been estimated that over 700 million people in the world are involved in one way or another with education. In a few industrially well-developed parts of the world, the process is well funded and organised in such a manner that identifiable goals are reached. In most parts of the world, however, this is far from the case. In Pakistan, hundreds of thousands of children, particularly females, are denied access to any schooling, while millions more are "taught" under conditions that make any meaningful learning unlikely, namely, by teachers with little or no formal training and virtually no resources. Mohd. Sharma (1990), Senior Education Specialist of the Asian Development Bank has observed:

The four major problems currently facing South Asian education systems are illiteracy, quality, relevance and efficiency. Ignorance is the singular greatest enemy...70% of the 1.3 billion people of South Asian countries live in rural villages. 60 of these people live below the poverty line.... Education for all depends on encouraging educators to break down traditional attitudes towards formal education and to encourage more flexibility on the use of space, time and modern technologies.

In parts of India, adequately trained teachers and reasonable learning conditions (i.e., classrooms) are often reserved for senior-level students, while elementary pupils sit outside. Thailand appears to have sufficient numbers of teachers, but as many as 80% need upgrading.

It has long been assumed that the solution to these problems lies in the provision by individual countries of sufficient numbers of schools and adequately trained teachers. Two occurrences during the latter part of the 20th Century have altered that thinking: the population explosion and technology-based globalisation (Hardison, 1989). Developing countries anxious to be active partners within the global economy find
themselves without the educational infrastructure needed to produce a marketable workforce, and each year the gap between what some countries have and what others need grows wider. Gains made during, for example, the “green revolutions” in some countries, have been eaten up by expanded populations. Consequently, plans drawn up two decades ago for the building of schools and the training of sufficient numbers of teachers are now unattainable. Such conditions necessitate the search for both alternative educational forms and increased quality in the teaching of “core” subjects such as science.

The emerging educational crisis in developing countries in the 1990s has several interconnected components:

- large numbers of children who never attend school and may be, as uneducated adults, an enormous drain on their local and national economies
- inadequate provision of primary education, which could provide children with the learning skills that would carry them through the rest of their schooling
- inadequate numbers of elementary schools
- few elementary teachers trained sufficiently in contemporary relevant subject areas, particularly in the sciences
- few properly equipped secondary schools
- virtually no educational back-up systems for those who drop out or are pushed out of school
- few easily accessed tertiary-level training colleges (like Ramkamhaeng University in Bangkok) for young adults seeking training.

THE NATURE OF SCIENCE EDUCATION

Dominating this crisis is the question of science education. What is science education? The Oxford Dictionary defines science as “the pursuit or principles of systematic and formulated knowledge.” Science in this sense comprises three categories commonly referred to in education:

1. applied science (that which is studied for practical purposes)
2. natural science (that which deals with natural or material phenomena)
3. pure science (that which is studied without consideration of practical applications)

Science education attempts to impart awareness of these categories and processes, frequently directing such knowledge toward options for practical application. The scientific method is, therefore, a way of organising the relationship between theory and practice; it is a way of looking at the world. While not all educators espouse the scientific method, many equate the acquisition of the skills of systematic analysis and formulation with efficient social, economic, and cultural organisation and productivity. It is thought that there may be a strong link between a society’s economic and productive competitiveness and the quality of its science programmes. Associated with the achievement of such lofty goals, the education of science teachers is a complex process. It is generally believed that a lot of the world’s science teachers, especially those working in developing countries, have not been adequately prepared for the task expected of them. There is an international need to improve science teacher education, a process that is difficult and costly, particularly for those who need it the most and can least afford it. The following questions arise:

- To what extent may an expanded programme of science education within developing countries be essential to future economic stability?
Could a future generation possessing the basic skills of scientific investigation, numbering among themselves specialists in population control, food technologies, medicine and environmental science, both stabilise their own societies and connect them into the global economy?

What are the chances for even basic survival of a country not possessing such a future generation?

Current circumstances point to the need for international cooperation in the education of science teachers, with the question of quality dominant. What sort of cooperation and toward what type of educational systems is needed? Given the criticalness of the current and approaching needs in education, should the present system be expanded or replaced with something else? Proposals for the development of greatly expanded traditional educational systems and increased numbers of traditionally trained teachers assume that the models currently available are efficient, a claim disputed by many. It has been argued that traditional methods of schooling, remarkably similar throughout the world, are generally inefficient and not cost-effective. It has also been observed that teacher training programs may be similarly weak. The ease with which the more developed nations of the world have themselves produced large numbers of inadequately trained science teachers makes consideration of the complex issues surrounding international cooperation in teacher education essential.

Such consideration may be examined through two questions:

1. What are the demonstrated needs both for the training of science teachers and within the training process, which may be addressed through international cooperation?
2. What are the known and potential shortcomings of that process?

THE NEED FOR SCIENCE TEACHER EDUCATION

There are several approaches to ascertaining the need for science teacher education. One way is through examination of national agendas as stated by governments. This is fairly straightforward in some countries. For example, the Thai government produces five-year economic and social strategies. Its next, the seventh plan, describes universal primary education as a national goal. A proposal by one of the country’s major teacher education institutions currently offers to develop a primary teacher education programme incorporating science and environmental studies training as core courses.

National agendas in some Commonwealth island nations concentrate on the development of coastal and off-shore resources, which eventually produce a demand for educational emphasis on the sciences and technologies that will support such development. The Commonwealth of Learning plays a critical role in such situations, as it identifies specific national priorities and matches them with individual agencies and institutions able to assist them.

A second way of ascertaining the need for science teacher education is through examination of state agencies. In some Commonwealth countries individual states have responsibility for education and training. State legislatures, anxious to bond education with economic development, identify specific local subjects for educational emphasis: oil in one state, communication technology in another, mining in a third. Again, the role of an agent such as the Commonwealth of Learning can be critical in accurately identifying training links in support of these state priorities.
A third method of needs assessment is through examination of corporate agendas, which may be local, national or multinational, or all three. Corporations, particularly those involved in science and technology-based activities, are often large employers. State governments may link the state’s economic identity to widespread corporate activity, such as occurs for example in British Columbia, Canada, and may recognise that economic stability might be maintained if local citizens are employable by corporations. Corporations and the wide range of supporting businesses that grow around them often have local needs acquiring specific training. In some states, corporations play an active role in local education and training, funding programmes and offering training guidelines to schools and colleges. Examination of these can indicate the types of science education required within a state or large population area, and thereby provide guidance regarding appropriate science teacher education.

A fourth issue in needs assessment is that of national and local priorities. These are often closely linked to government funding of training programmes. Currently, debates range across India about the relative national and state priorities that should be given to literacy, science education and English. The issues are complicated by the difficulty of finding the right balance between educating a huge population for basic survival and training a proportion of that population in skills that may lead the country forward in science and technology.

A fifth way of assessing the need for science teacher education is the examination of what potential partners have to offer. Unsure of which direction to take, local educators may accept offers from international partners that might result in new directions. If, for example, Canada can offer primarily agricultural science education through the University of Guelph and aquacultural science education through Memorial University, then perhaps that is acceptable.

All of these five methods of assessing the needs that may exist for science education and, therefore, for science teacher education, have one thing in common: recognition that the final decisions regarding who is trained, what they are trained to teach and who is most suitable to cooperate in training them will be based upon political, social, cultural, economic, physical and personal factors. It follows that any agencies contemplating international cooperation in science teacher education may most efficiently identify needs through examination of such factors.

NEEDS WITHIN SCIENCE TEACHER EDUCATION

Assuming that examination of the need for science teacher education programmes in a particular country or state may result in the establishment of such programmes, a second, equally important need must be examined, namely, the instructional needs within the programme. What are the instructional components of an effective science teacher education programme, and how can international cooperation help in obtaining them?

Science is not the exclusive domain that traditional education would have us believe it to be. Understanding of it is entirely dependent upon literacy. Science has social and cultural contexts, and both theoretical and practical applications. Teaching it well is a complex matter. Training people to teach it, either as a subject in its own right or as a component within a larger context, is extremely difficult.
To be effective, a teacher education programme must have the following components:

- clearly stated goals
- well-delineated and accurately sequenced objectives
- a well-researched theoretical base
- a properly designed curriculum
- instructors who are active practitioners and researchers
- an appropriate instructional environment
- appropriate instructional technologies and resources
- formative and summative evaluation processes
- a committed and enthusiastic group of students.

The absence of any one of these basic components may seriously undermine the effectiveness of the entire programme.

Science teacher education is particularly demanding in these components. Goals must be related to current knowledge and research, and specific objectives must be clearly focused on attainable outcomes with practical applications. The global knowledge base in science changes rapidly; the subject cannot remain static. The research base, instructional practice and entering knowledge of both new faculty and students must be accommodated through curricular and programme modifications. While high quality is essential, the demand for very large numbers of trained science teachers in some countries requires that sometimes scarce resources be very efficiently utilised and modified whenever possible with local resources.

It is particularly important also that the experiences and theories conveyed in the programme have practical significance to the students. Absence of these characteristics can be detrimental to the instructional experience of the students. This was well demonstrated in Kenya in the 1970s and 80s. Science courses utilised local plants, soils, minerals and biological specimens easily obtainable by students to enrich printed materials. Meanwhile, the British Open University science course resources were mailed in large wooden boxes at great expense to the students, who were not required at any time to make any connection between the science they were learning and their own environments.

Thus science teacher education requires quality in design, efficiency in resource utilisation and practical applicability to the students.

Shortcomings

Most of the shortcomings in science teacher education are the result of inadequate funding, which may reflect government priorities, financial hardship or a variety of economic, cultural and social factors. While it may be the case that a history of the West Indies or a literary analysis by Narasimhaiah is as rich in an old text as in a new one, the same cannot be said for either the printed materials or learning resources of the sciences. Practice and experimentation are extremely important. They require money and facilities if they are to be of any lasting value either nationally or within a global scientific and technological society.

Lack of funding is very apparent in the science teacher education establishments of the more developed countries and often critically absent in the institutions of some less developed nations. This leads to the evolution of funding-based attitudes toward the teaching of the subject. Macro topics and issues may only be dealt with theoretically; experimentation and investigation may only involve simple, local processes and objects;
emphasis on the teaching of "grassroots" sciences dominates the process of educating
science teachers out of necessity rather than desire. Even the value of international
cooperation may be called into question. Three critical questions arise here:

1. Are the teachers produced by this process the types of teachers, educational leaders
   and policy makers who are required by a society, or are they little more than
   reflections of a compromise?

2. Do the terms "science" and "technology" mean the same things to teacher educators
   in northern and southern institutions?

3. Can it be assumed that an underfunded science teacher education programme in a
   northern institution has anything substantial to offer a similarly underfunded
   science teacher education programme in the South?

Factors such as those listed above are often the realities that modify the ideal
characteristics of a teacher education programme. Clearly stated goals, which ideally
should focus on investigative and research skill mastery toward the production of a
scientifically and technologically literate society, may remain rhetorical. Objectives
may be modified to focus on local, achievable ends that rarely move the students beyond
their own familiar environments. Programmes particularly in some less developed
countries may not have a well-researched theoretical base. Libraries of more than 2,000
volumes are unusual, and little current data can be read by those not fluent in English or
French, which are the languages of published research.

What then might the curriculum reflect: idealistic goals or practical realities? If
practical realities, will the graduates actually be the types of science teachers a society
needs, or will they be reflections of that society’s inability to produce the teachers it
needs? Is it possible under such conditions for instructors to be active practitioners and
researchers? Can an appropriate instructional environment be constructed?

The matter of the selection and acquisition of appropriate instructional technologies and
resources for science teacher education is a particularly difficult problem. Science
textbooks quickly become electronically outdated. Current information is stored and
retrieved electronically world-wide. Illustration, example and above all else, simulation,
modelling and theoretical experimentation are conducted with computers and interactive
video systems. If the gap between what one nation knows and another needs is ever to
be closed, can it be done without access to these information storage and dissemination
technologies? This is a problem of funding at both the macro and local levels.

Current information systems require national infrastructures; nations lacking these
cannot network. During the past six years, India’s telephone system has been digitised.
Within that brief period, the country has gone from an industrial to a post-industrial
capability and networked into the global information system. It is far more likely that
the computer and video systems needed for science and technology will be incorporated
into educational programmes in India than is likely to be the case with some other
countries. The many nations that cannot afford to equip their science teacher education
programmes with these technologies are at a great disadvantage and may not be able to
claim that they are producing the types of science teachers they really need. In this
context, both formative and summative evaluation processes may serve as constant
reminders of the growing gap between what exists and what is needed.

Who, then, will enrol in science teacher education programmes such as these? Part of
the world education crisis centres on the fact that the brightest students rarely enter the
education profession. What will it take to make them change their minds?
SOLUTIONS AND STRATEGIES

One of the characteristics of our increasingly technological society is that it offers some solutions for the problems it poses. The same devices and electronic processes that separate nations may also be employed to bring them together. Never before have people around the world known as much as they now know about each other. The possibilities for cooperation have never been better. A combination of international cooperation, the efficient utilisation of available information, and distance education technologies can and should be employed to resolve the problem of inadequate science teacher education. Since any cooperative venture has political, cultural and social ramifications, the effectiveness of international teacher education ventures depends considerably upon an effective planning strategy. The main component of cooperation is the sharing of resources.

Regarding science teacher education, the resources that can be shared North-South and South-South include most of the components for effective programme design previously mentioned. Where cooperation is between institutions in a developed and a developing country, goals will be those of the developing country, reached by local educators who have had access to the research and libraries available to their colleagues in the developed country. Objectives can be well delineated and accurately sequenced by local educators in collaboration with colleagues who may have had actual experience in establishing and realising them. The library resources of the more developed institution can all be made available to local colleagues. Laboratory access and sharing of research and instructional methodologies can be arranged through exchange visits. Thus the well-researched theoretical base becomes available to both partners, and a properly designed curriculum can emerge from collaborative action. On-line telecommunications connections can link partners directly and provide computer-based access to libraries and professional databases. Collaborators do not always have to travel great distances in order to work together. Joint research projects can be established, making local instructors active practitioners and researchers. Joint applications can be made for funding to develop appropriate instructional environments and to acquire necessary skills in using new information technologies. Distance education practices can be employed in which entire programmes of courses can be jointly developed and shared between institutions. Instructional design methodologies and evaluation methods can be shared. Students can even be exchanged. Local, national and multinational corporations can be drawn into the design, developmental, instructional and apprenticeship processes. In this way, the resources and experiences of the more developed institutions become available to the less developed institutions.

How can such a rich and complex range of collaborative activities be realised? There are models that can serve as guides. During the past decade, several collaborations between institutions in developed and developing countries have been funded by such agencies as AID, CIDA, ADB, the British Council and the World Bank. The British Open University has been linked with Allama Iqbal Open University (Pakistan) and with Indira Gandhi Open University (India). Simon Fraser University (Canada) has been linked with Universitas Terbuka in Indonesia (Setijadi, 1988); Chulalongkorn University (Thailand) with the University of Victoria (Canada) and Universiti Sains Malaysia with Murdoch in Australia. International collaborations involving the use of distance education instructional processes and video and computer software have been established at Sukhothai Thammatirat Open University (Thailand) and are currently being introduced at the University of the South Pacific (Potter, 1990).
DISTANCE EDUCATION

Most of the international collaborations just listed involve distance education. Now well-established in several countries, distance education is currently viewed as a cost-effective way of improving educational access in all countries. It is being examined particularly closely in some developing countries where traditional educational systems cannot provide required levels of schooling and training. Distance education is a viable option in international ventures in science teacher education because it:

- facilitates cooperative planning and instructional design
- uses either the student's home or established local educational centres, rather than requiring classrooms
- focuses on self-directed learning rather than teacher-managed instruction
- utilises appropriate delivery technologies ranging from print and correspondence packages to videotape, audiotape, radio, and computer-based and on-line instruction
- permits the organisation of course content in modular forms, providing for flexibility in student use
- permits the sharing of resources
- will soon facilitate the sharing of courses internationally in its electronic forms.

Regarding science teacher education, distance education may offer the following:

- an inexpensive and flexible way through which institutions in various countries can share information about goals and objectives in science teacher education, as well as jointly plan curricula
- a means of internationally sharing instructional materials and science resources
- a cost-effective method of delivering packaged course materials to students who cannot enrol in traditional institutions, but can work on their own or in small groups at home
- incorporation of local agencies, industries and individuals into the students’ learning experiences on a cooperative learning or apprenticeship basis
- In-service upgrading of science teachers throughout their careers.

EDUCATIONAL TECHNOLOGIES

It is particularly important that science teachers be aware of current information technologies. A substantial portion of all scientific knowledge is now stored and disseminated electronically. Science teachers who do not have access to the networks and equipment that facilitate this exchange, and who are unable to make their own students aware of it, operate at a disadvantage compared to those with such access. At the very least, science teachers should be aware of these technologies, even when they lack access to them.

The information technologies most frequently employed in science teacher education are: print, computers and visual technologies such as film, slides, videotapes and interactive video discs. Stand-alone databases on CD ROM are also valuable. On-line accesses to professional and international science databases are particularly valuable. In some countries, many of these information technologies are networked through fibre-optic, satellite and telecommunications systems. Many countries lack the infrastructure for this. However, digitised telecommunications systems, recently established in India and Southeast Asia, are gradually emerging world-wide and are the basis of much networking.
Each information technology possesses specific qualities and facilitates certain pedagogic activities. Bates (1987) has categorised them in the following manner:

<table>
<thead>
<tr>
<th>Pedagogic Characteristic</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentational</td>
<td>Teleconferencing</td>
</tr>
<tr>
<td>Permanence</td>
<td>Audiotape</td>
</tr>
<tr>
<td></td>
<td>Videotape</td>
</tr>
<tr>
<td></td>
<td>Print</td>
</tr>
<tr>
<td>Structure of teaching material</td>
<td>Print and video computer-based systems</td>
</tr>
<tr>
<td>Degree of interaction</td>
<td>Teleconferencing</td>
</tr>
<tr>
<td></td>
<td>Face-to-face meetings</td>
</tr>
<tr>
<td>Deep comprehension</td>
<td>Print</td>
</tr>
<tr>
<td>Distributional capabilities</td>
<td>Print and video</td>
</tr>
</tbody>
</table>

Regarding instructional purposes, information technologies offer the following strengths:

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Instructional Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery of factual, statistical and interactive information</td>
<td>Computer</td>
</tr>
<tr>
<td>Delivery of written articles</td>
<td>Print</td>
</tr>
<tr>
<td>Delivery of case studies, illustrated lectures</td>
<td>Videotape</td>
</tr>
<tr>
<td>Recorded lectures and summaries</td>
<td>Audiotape</td>
</tr>
<tr>
<td>Weekly seminars and discussions</td>
<td>Teleconferencing</td>
</tr>
<tr>
<td>Laboratory applications</td>
<td>Local work experiences</td>
</tr>
<tr>
<td>Face-to-face interaction</td>
<td>Study centres and short courses</td>
</tr>
</tbody>
</table>

It is worth noting that distance education utilises the same communication models and learning theories that are used in traditional, classroom-based instruction. It simply employs them differently.
ESTABLISHING INTERNATIONAL LINKS

The establishment of international links is an extremely complex process. Success has been largely due to sensitive planning that has taken into account the wide range of political, social, cultural, economic, physical and personal factors, which combined constitute the environment within which an international cooperative programme is designed and executed. The experiences of commercial and government agencies involved in failed technology transfer activities during the past four decades reveal quite clearly that the primary cause of such failure has been a lack of attention to these six factors.

Successful activities have virtually always been those in which close attention was paid in the planning stages to these six factors. A strategy for promoting successful international cooperation in distance education-based science teacher education is detailed below.

Collaborative planning. The guiding principle behind successful international cooperation in the development of a teacher education programme is that of comprehensive planning through collaborative investigation and research. This avoids the pitfalls of the traditional donor-dominated relationship. It is in all ways completely equal and collegial and leads to a sharing of collective knowledge about teacher education. Information exchange and transfer are delicate processes involving the interweaving of information, values, priorities, cultures and equipment. Before they can be actualised, they must be preceded by balanced communication to produce mutual understanding. Rogers (1971) presented one of the most comprehensive analyses of the ways in which innovations are communicated through a society and the multitude of factors that prevent diffusion even at early stages. His observations, together with those of Hawthorne (1970) and the Marga Institute (1975), underscore the importance of thorough collaborative planning.

Focus. Regarding science teacher education, such collaborative planning should focus on the three following major questions:

1. What are the stated science education needs of the nation requiring the teacher education programme?

2. To what degree is the collaborating nation able to support progress toward meeting these needs?

3. What is the political, social, cultural and educational infrastructure within which the planned collaboration will function?

Obtaining answers to these questions might involve collaborative research in six phases:

1. A description of the programme required, including:
   - each course in the programme
   - identification of available instructional resources
   - models, simulations and examples of all software required for the local or distance teaching of the courses
   - an initial assessment of the local technical support system available.
2. Identification of the current status of science teacher education materials production in the recipient nation. It may be hypothesised, for example, that current levels are inadequate to meet the proposed programme’s needs as identified in 1 above. If so, where are the deficiencies and what is required to overcome them?

3. Identification of the political, cultural, economic and social characteristics of the recipient nation that interact with science teacher education. This process requires examination of the following:
   - specifications of local educational systems with regard to science teacher education
   - statements of government policy toward science teacher education
   - indications of the means by which such policy is translated into educational objectives, and the relationship between those objectives and science teacher educational practice
   - indicators of the economics of achieving those objectives
   - elements of educational practice, i.e., instructional methodologies in science teacher education, especially those which utilise instructional technologies
   - indications of where and how science teacher education objectives are achieved, i.e., colleges, universities, etc.
   - the kinds of science teacher education programmes that currently exist
   - documents describing the recipient nation’s past experiences with international cooperation and distance education.

4. Identification of the types of instructional design and where appropriate, distance education design that will function most productively in the recipient nation.

5. Modification of existing courses in science teacher education.

6. Design of new courses.

From initial planning such as this, there may emerge international cooperation that will qualitatively and quantitatively improve science teacher education because it will have evolved from and within the society for which it is designed, rather than having been imposed from the outside.

THE FACILITATIVE ROLE OF AN EXTERNAL AGENCY

The role of an external facilitating agency is critical in establishing international collaboration in science teacher education. There is a fundamental difference in cultural and educational terms between science and many other subjects: the universality of the basic concepts. International cooperation should flow more smoothly in the education of science teachers than it might in other subject areas. This should encourage international cooperation for the following reasons:
   - the similarity of goals
   - the similarity of objectives
   - the similarity of terms and language simplifying collaborative instructional design
   - the similarities in basic resources, particularly in chemistry, physics, and human and animal biology, simplifying content design and resource sharing
   - similarities in evaluation and testing, and the interchangeability of testing methods.
The greatest international differences lie in the following areas:

- knowledge of instructional models and current learning and teaching theory
- access to current research
- programme management
- instructional methods
- availability of resources
- access to information technologies.

It is in these six areas that science teacher educators in less developed nations may greatly benefit from contact with and experience in institutions of the more developed nations.

The external agency provides a major service to science teacher education if it can facilitate the placement of educators from less developed nations in institutions where they may gain a deeper understanding in the areas of greatest difference; and if it can locate instructional designers and science educators from the more developed institutions in less developed nations to cooperate in areas where there is more common ground. This approach may make the most efficient use of limited funds.

References


CHAPTER 5

ISSUES IN THE ORGANISATION OF DISTANCE TEACHER TRAINING IN MATHEMATICS AND THE SCIENCES

Denis Wall

INTRODUCTION

The organisation of distance teacher training in mathematics and science is of primary importance. It should comprise various autonomous, self-organising systems, whether these be national, regional or local projects.

The notion of “autonomy” is becoming an important concept in discussions of education, and in developing the relationship between educational systems and the communities served. In speaking of South Africa and the transformation of education in that country Gerwel states: “...the meaning and content of the concept “autonomy” represent issues which are going to be central in debates about building and establishing democracy in our society” (1991, p. 125).

My point of departure is this: should we organise a distance education system into autonomous units from the level of the role of international agencies through to the local delivery level? This may be a key to our understanding of sustainable development.

A STARTING POINT: THE ORGANISATION

As a social scientist interested in Aboriginal education in Canada, in distance education as a means of transforming the power relationships in an educational system and in remote communities, I am forced to try to relate it all to the discussion at hand.

We need an approach to the organisation of distance education for science and mathematics teachers which recognises that at each level in the system integrity, cohesion, and the ability to adjust in a self-organising way to the environment are key elements. As a result, there will be a feeling at each level by those involved that they are empowered to operate autonomously, supported by an environment that has the same meta-goals in view.

A successful local distance education project could be characterised as a system including the developers, the deliverers, the students, the families and community of the
students, all of whom work together to accomplish the goals of further education. Such a project will have to exist within a supporting environment, perhaps, provided by government or a large institution.

On the other hand, regional distance education organisations, like the European Association of Distance Teaching Universities (EADTU), should fulfil a unique roll that supports local member projects.¹

Autonomy and self-organisation at each level are important to recognise, but so too are the relationships between levels, that is to say, the essential interdependence between them.²

THE CULTURAL ISSUES ATTENDANT TO SCIENCE EDUCATION

There is in some circles of thought an argument that training in science and of science teachers is a “cultural” endeavour (Elton, 1982; Badzing, 1987). In other words, science should be intimately linked to the political, economic and social environments in which we live.

It is on the relationship between science education and our everyday social world that I would like to concentrate. This approach to science education is well illustrated in a recent report by a Commonwealth expert group (1991, p. 76) titled Beyond Apartheid. Under the rubric of science, technology and mathematics education (STME), the report indicates that in countries such as Zimbabwe, Kenya, Tanzania and Uganda the adaptation of inherited foreign syllabi to local needs has “involved more creative use of mathematics, relating it to social experience and social needs taking cultural perspectives into account, as well as developing syllabi that relate directly to African people and their needs.”

Science-Technology-Society (STS) courses have been developed as senior secretary academic courses, the report continues. Also, it states “(s)ome aspects of indigenous technology have recently been introduced in the junior courses in Botswana, for example, on house construction.” However, the report admits, financial constraints have hampered STME implementation, as have assumptions that local technology is somehow inferior.

Mahaffy (1992) explores the contextualisation of scientific concepts in introductory science texts. His conclusions are that instead of creating only positive myths about science, teachers should be realistic in describing social, political and economic aspects of science relevant to the student, issues like environmental degradation or genetic reproduction.

Ten years ago, Elton (1982, p. 26) was quite clear about the need to link science, technology and society: “The teaching of science has never been properly linked to the society in which it is taught and which it must influence.” Edington (1990, p. 117), in speaking about international distance education projects, reinforces this point when he cautions that “major international initiatives for manpower development could be in danger of ignoring the cultural and social contexts in which course development, teaching and learning take place.”

Some, such as Young (1982), have gone so far as to say we need public debate about what kind of science is taught, to create an even more intimate link between science and
society. Public science will enlighten and inform all involved, and will promote a coalitions between the community and the educational system. This is not a narrow debate between a department of education and the professional science community, but a more broadly based discussion involving parents, students and community members as well.

I think we can surmise that the cost-effectiveness, increased capacity and consistent standards of regional cooperation will be to little avail if the diverse historical and social contexts in which distance education and science teacher training are delivered and ignored, diminished and forgotten.

Both Elton and Mahaffy state that we must develop teachers of science who are aware of the full range, positive and negative, of social and economic effects of science.³

What does this mean to the education of teachers of science? The training of teachers in science needs to create enthusiasm and assist them in fostering such enthusiasm in their students. The implication here is that such enthusiasm can be strengthened by relating the curriculum, of both student teachers and their students, to their understood social, political and economic worlds.

Elton, for his part, says that to do this most effectively, "(w)e must avoid early specialisation and single subject degrees for those intending to become science teachers."

The point to be made is quite clearly this: that local people who are close to a resource may have developed collective concepts and practices, which can inform the training of wildlife biologists, other scientists, and yes, even local teachers.⁴

Knowledge exchange is at least a bi-directional event: both parties are learning something. In distance education, however, we often talk about knowledge transfer as though it were a one-way transmission (Asian Development Bank, 1987). We forget that knowledge is not one-dimensional and it will not be transferred in one direction. We need to increase our emphasis on an exchange of knowledge between the educational system and the local knowledge system.

Fulmes (1989) calls for such an exchange. Working with the Department of Mathematics and Science Education at the University of British Columbia, she wrote a Master’s thesis titled "What Do Native People Want Taught in Science Classrooms to Reflect Indigenous Science?" The conclusions of her study are that the approaches of the Gitksan people to science are based on a world view that believes in

... the interdependence of the Gitksan people, the land and the spirit. Participants accepted the definition of indigenous science as the traditional knowledge of Mother Earth.... Science includes the understanding of the Gitksan way of life, philosophy, values and social structure. Participants emphasised a fundamental belief in the interdependence of all life and that we are a part of nature not separate from it.

However, it is very likely that many teachers in distance training programs will be from remote communities. As a result, they are not going to teach science or mathematics alone. They will teach other subjects as well. Teachers in such communities might not have as
their first mandate a professional kind of science teaching assignment. This provides further argument that their training should "avoid early specialisation and single subject degrees."

WHOSE KNOWLEDGE IS IMPORTANT?

I would now like to turn to why I feel it is important to incorporate local views in science curricula for teachers who will teach in remote communities.

On the one hand, Elton (p. 44) maintains that because we have prepared teachers to teach science for scholarship, they are unprepared for students who relate their understanding and questions to their immediate surroundings: "...children view science from their ordinary socialized learning in the world, something that is almost never touched upon in the training of teachers." And he adds: "If it (course content) doesn't agree with what they know is right, they don't believe it." This is a perspective that recommends local examples be used to bolster traditional, academic science concepts.

On the other hand, there are arguments to be made for the consolidation of alternative science concepts. In Canada, there are attempts to unite local knowledge and contemporary university/academic notions about resource management. Aboriginal people in northern Alberta are beginning to participate in forestry and wildlife management in some national parks, for example, Wood Buffalo. In the Northwest Territories, there are resources co-management schemes. It is assumed that co-management can bring a wider range of experience and expertise. This is also a highly political issue involving Aboriginal claims to the land (Freeman, et al., 1988).

The inclusion of the Native perspective sends a clear message that tribal heritage enriches our abilities to better understand each other and our planet.

Fulmes calls for the teaching of a curriculum that respects and recognises Aboriginal views of the natural world. This, again, is an argument for the intimate tying by the teacher of the curriculum to the life experiences of the students in order to increase the relevance of the educational endeavour. Of course, the incorporation of local knowledge systems in science curricula will often be problematic and difficult. Teachers-in-training must learn that alternative views of the world are possible and must be respected. "Whose knowledge?" is an important question to raise in science teacher training.

It seems that one possible key to the sustainability of programmes lies in the place where there is structural coupling between the educational system and the local social system. More precisely, we should be trying to build a coalition between the community and the system. These arguments are not only relevant to science curricula, but also to governance and management, to teaching/learning methods, to teacher-student and to school-community relationships.5

The first reason for including a respect for local knowledge in science curricula is to relate science to the real world of the students and thereby show respect for the students' knowledge base. The second reason is that remote communities will eventually demand that their perspectives be reflected in the education their children receive. Their demands can be supported by action.
THE POLITICS OF COMMUNITY

If a community’s collective views and perspectives are not accounted for in an educational system, then goodwill and the development of a cooperative relationship may not be possible. Herein lie the politics of the educational endeavour. The politics of this relationship may be more important to the success of a distance education project than the need for a relevant curriculum. The development of a science curriculum in partnership with the community is part of creating a political relationship. In fact, in Canada it is the domination of the education of Aboriginal peoples by non-Aboriginal people that has been a keystone issue in the discussion of political autonomy and land claims.

There are three points to consider. The first is that people in remote or rural areas can be organised in cohesive communities not necessarily identified by geographic indicators, but more likely by social criteria, such as kinship, political organisation or like-mindedness. If this is the case, then my second point is that eventually they are likely to demand control over, or at least considerable influence over, most aspects of the education they receive. My third point is that for distance education teacher training programmes to be most effective, they must have significant participation by these communities and by the student teachers from them in virtually all aspects of the programme.

To illustrate the demands that can be made on the educational system by communities, I would like to explore Aboriginal education in Canada.

It has been a long struggle for Aboriginal peoples in Canada. Education has been a mechanism of liberation and of cultural domination. Under the latter, their languages have been denied, their histories distorted or misrepresented, and so on.

In response to this situation, a recent report by the Assembly of First Nations (1988, p.53) on First Nations’ education is typical. It points out that “(m)ost First Nations would like mechanisms to enhance local jurisdiction over programs so as to have jurisdiction over delivery, planning, budgeting, evaluation, choice of language of instruction, teaching methods and curricula” and “(m)ost First Nations believe that a school should be the focal point of cultural, social and educational activities of a community” (p. 57).

The report goes on to say that there are basically two goals of education. The first is to teach children the skills necessary for living and for contributing to the community. The second is to reinforce the child’s cultural identity.

There is also the demand that education be of as high a standard as that provided to non-Aboriginal children. Aboriginal peoples realise their children must compete and that the regional or national curriculum is important to the learning process (Alberta Education, 1987).

Other groups of Aboriginal peoples throughout Canada have also demanded stronger forms of governance and control over what is taught and how it is taught. Examples include the Métis and First Nations people of Northland School Division in Northern...
Alberta (Wall, 1993) and the Inuit people of Nunavik in Northern Quebec (Nunavik Educational Task Force Report, 1992). The latter begin their report with this statement:

For a time our independence has been threatened by institutions over which we have had little control. Inuit have the strength and resolve to manage their own lives and to change things for the better, as demonstrated by history, and these characteristics will enable the communities of Nunavik to become wise and self-sufficient again. (iii)

The incredibly high dropout rates for Aboriginal students from secondary school (up to 75%) are attributable in part to the lack of parental, community and political control exerted over the system, including what teachers teach and whether or not they remain teachers in a particular community. This historical lack of influence by Aboriginal peoples in Canada is changing now so that Aboriginal languages and perspectives are gaining a foothold in schools.

The foregoing discussion illustrates three points:

1. Large and small groups of people who feel their educational interests are not being met are organising around that issue. They are looking for autonomous control, but recognise that they live in national and regional contexts, unless we are talking about secessionist or nationalistic movements. I suspect this is not just a Canadian situation and that in many countries there is an increasing shift toward organised political input into educational systems from small and large self-referencing groups (part of a process I think of as “retribalisation”).

2. No matter how much managers and developers of educational systems feel the urge to provide top-down leadership, the organised community will demand that its interests and need for control be met.

3. Science teacher training must be designed and taught at least in part with respect for the perspectives of a remote community. The training must also enable teachers to understand how political events can affect how they teach, what they teach, how long they teach, and how management and administration are performed. This means that a significant social science grounding is important.

CONCLUSIONS

The following five conclusions are reasonably brief. They include comments on how we should organise distance education systems with derivative recommendations suggested for the Commonwealth of Learning on the role of remote communities, comments on curricula for science and mathematics teachers, and on the role of teachers in remote communities.

1. Organisation of distance education and the notion of “autonomy in context”

In his discussion of the proposed South Asia Distance Education Centre (SADEC), Taylor (1990, p. 91) states “(t)he extent to which goodwill exists among nations in South Asia is fundamental to the success of the project.” I can only agree that goodwill is fundamental.
If distance science and mathematics teacher training is to be sustainable, these organisational recommendations appear to be important:

- We must maintain good will at each level in the system, which is not an easy task because it will require the development and maintenance of trusting relationships.
- We must recognise the need for autonomy, self-organisation and adaptability at different levels in the system.
- We must recognise that each level will perform a unique role in support of the others.
- We must recognise the interdependent relationships between levels.

These factors may well constitute key indicators of sustainable development.

It should be noted that the organisation, planning and maintenance of a distance education system requires the assistance of a social science perspective. Ideally, individuals experienced in intercultural education, including the sociology and anthropology of education, will be members of development and management teams.

These conclusions lead directly to recommendations for The Commonwealth of Learning.

2. Recommendations for The Commonwealth of Learning

It is hoped that the following recommendations will help in creating a sustainable Commonwealth distance teacher training organisation in science, mathematics and technology.

Because the most successful science and mathematics teacher education projects are likely to be small, specific and autonomous initiatives supported by in-country departments of education or tertiary institutions, the Commonwealth of Learning should provide support to national distance education systems, including the provision of consultancies:

- on management planning and development
- on the organisation of a cohesive distance education system for science, vocational and mathematics teacher training within a country
- to assist with the design of specific teacher training projects in the context of national systems
- to gather and facilitate the flow of information relevant to national systems
- to assist with monitoring and evaluating national systems, regional and institutional systems, and individual local projects.

The Commonwealth of Learning could play a role in financing national projects, assuming the structure of the national system meets certain basic criteria developed by member countries. The criteria should include an assessment of the “sustainability” of national and local projects. This paper suggests some indicators of sustainability.

The Commonwealth of Learning should develop a monitoring system to assess the changing needs of national distance education systems.

The Commonwealth of Learning could support conferences, publications and the like, which specifically address the issues relevant to various international groups. For
example, it could organise conferences on issues relevant to the organisation of national systems or in-country regional and local projects, or conferences focusing on issues relevant to specific groups of Commonwealth countries. Any number of combinations are possible.

And finally, it is perhaps most imperative for the Commonwealth of Learning to come to terms with the unique role it can and should play in supporting various national distance teacher training systems, including those with a mandate for science, vocational and mathematics teachers. This Round Table is part of the process of discovery. It will, however, take more than one meeting. At some point, representatives of national governments will have to meet to discuss and agree upon a unique role for COL in the context of science teacher training.

3. A role for local community in the science curriculum and elsewhere

With regard to the role of remote communities in the general organisation of distance education teacher training systems there are three points to consider:

- The first is that people in remote or rural areas can be organised into cohesive communities not necessarily identified by geographic indicators, but more likely by social criteria such as kinship, political organisation or like-mindedness. This is further support for the employment of management team members with social science backgrounds. They could use their skills to recognise these communities.
- If this is the case, then my second point is that eventually remote communities are likely to demand control over or at least considerable influence over most aspects of the education they receive.
- My third point is that for distance education teacher training programmes to be most effective, they must have significant participation by these communities in virtually all aspects of the programme, especially in the development of curriculum concepts.

Also, it is imperative that local science concepts (for example, house construction or resource management techniques) find a solid presence in the curricula.

4. A role for the teacher-in-training in the organisation of the programme

If we take the notion of the integrity of a project seriously, then teachers-in-training must perform a role in the organisation as well. Student teachers should be involved in the development of their training as science and mathematics teachers. They will very likely be teaching either in or from remote communities, and they will have opinions and perceptions about their own locales that can inform the curriculum.

Contemporary adult education theory (Havenga, 1987, p. 77ff.) supports this view. Relating the theory to teacher training and distance education, Haughey (1992, p. 36) focuses on the importance of the relationship between adult learners and the distance education system. She emphasises the need for greater awareness by distance educators of adult learner needs when she states that “we have to recognize their historical and political context, their gender and ethnicity.” She goes on to quote a colleague: “Cultural values and ways of knowing also need to be seriously considered in determining the role of the student in distance delivered courses ....”

5. Curriculum for mathematics and science teachers-in-training

Since many of the teachers-in-training may be from remote communities, they are likely to teach subjects other than professional and single-subject science and mathematics.
Because of their role in the community, these teachers will not require singularly specialised training in mathematics or science. General science and mathematics courses may suffice.

Science courses for teachers should address alternative science perspectives. It is imperative that local examples illustrating the relevance of science to the everyday lives of both science teachers-in-training and the students they will teach be incorporated and explored fully in the science curriculum (National Council of Educational Research and Training, New Delhi, 1977). Science teachers will require pedagogic training on how to relate science and mathematics to the community. They will be required to explore the social and historical aspects of the community. Their pedagogic training must provide them with an ability to research and explore the community, and to draw on community resources and resource people.

There is a need for social science (sociology, anthropology and political science) course work on the politics of remote communities and on the social issues that will affect the teacher's performance and acceptance. Too often teachers in remote communities forget or do not recognise that education can be viewed as a highly political activity, and that they may be viewed by the community as representatives of a system that is colonial in nature. Teacher professional unions can play a role here.
APPENDIX: SOME EXAMPLES OF ORGANISED DEMANDS FOR POWER SHARING

The following examples of distance education projects concern Canadian Aboriginal communities. The first two are teacher-training programs in northern Alberta and Newfoundland/Labrador; the third is a strategic plan for the secondary schools in a northern Alberta school system.

The first, a proposal for a distance-delivered, Aboriginal teacher-training programme has dealt poorly with the organisational aspects and is not yet operational.

The second case illustrates a distance teacher-training programme delivered from Newfoundland by Memorial University to Montagnais and Innu teachers-in-training in Labrador. It illustrates reasonably good organisation.

The third case is a distance education, high school programme strategic plan, which illustrates the demand by a remote Aboriginal “community” for an autonomous and self-organised programme supported by the provincial government.

1. Teacher-Training Proposal for Alberta

The draft proposal (Alberta Advanced Education, 1989) for an Alberta Aboriginal teacher-training program was first proposed by an Aboriginal-controlled school system, Northland School Division. The administrators wanted a community-based teacher-training programme for their teaching assistants and other local residents. The administrators and the Board of the system demanded significant control over the proposed programme. Negotiations were long and difficult. The stakeholders, including the three teacher-training universities in the province, eventually agreed to a proposal. The provincial government, however, has not yet committed funds to the project, and I strongly suspect it will not do so if the current proposed organisation is maintained.

This proposal describes a direct link between local, isolated Aboriginal settlements and the three teacher-training universities in Alberta. The proposal describes in minimalist terms a potentially unwieldy organisation in which cohesion and integrity would be difficult to sustain. I am not surprised that it is not being supported by the government; it is at best a risky business.

There is some discussion now about reorganising the programme to include an intermediate delivery system. The government could provide financial support; the universities would form a coordinating group; smaller Aboriginal colleges would be able to relate to Aboriginal communities more intimately and, as a result, successfully deliver the programmes. Assuming that this structure represents three autonomous and self-coordinating levels of organisation, the programme will have a chance of being sustainable. The levels would be interdependent, each with a different role to fulfil and with the “power” to make the necessary decisions.
In this particular context, I offer this warning, that when there is a critical sense of “community” locally and when that community is concerned about autonomy, distance education programmes (indeed, any education programmes) will not work or be sustained unless there is a sharing of power, a sense of good will and a sense of trust among the participants. In this case, I suspect that Aboriginal colleges have a much greater chance of developing this sort of relationship than the universities do.

In any event, the proposal suggests that Aboriginal teacher training must be local and community-based to be efficient and effective. In other words, the teacher-training programme must account for the social context within which the student lives. The authors suggest that student teachers must work with professionals, teachers and other resource people with whom they already live and interact. These co-residents would be the students’ tutors, counsellors, and colleagues. Local elders would be part of the cultural learning process and support network for students. Local people would also be involved in the selection of candidates.

In this proposal there is an attempt to build intimate and sustainable links to the community. From this perspective, the programme could be successful. It is the organisation, the management of the programme and the environmental supports that are extremely problematic and poorly accounted for in the original proposal.

2. Teacher Training in Labrador and Newfoundland

The second example is an operating Aboriginal teacher-training programme described by Sharpe (1992). It is a distance teacher-training programme delivered from Memorial University to Innu and Montagnais individuals who are already active teachers in their remote communities in Labrador but now, due to a previous, short-term training programme, need further training and legitimate certification.

In a very practical way, the local communities of the students do affect the delivery of distance education programming. Sharpe (p. 79) shows that the scheduling of courses must account for local school times, church meetings and other community activities, such as fishing or hunting. He says this is a “seemingly, small issue, but one that could change course outcomes for the better.”

Sharpe also indicates that the predominant language of the community and the students is an important factor to be considered in programme delivery. Of the two groups of Aboriginal peoples involved, the Innu students require translators. The courses, need to be designed, therefore, to offer more face-to-face interaction.

Sharpe suggests the administration of the programme has to be flexible enough to test different approaches, including the use of tutors, the length of courses offered, the location of courses, combinations of course delivery methods and the support facilities needed by the students, namely, local counselling, local master teachers, local day care facilities and local communications facilities. Another level, that of university regulations and procedures, also needs to be accounted for.

What is again illustrated in this example is the integrity and autonomy of a flexible teacher-training system in the context of support from Memorial University.
3. An Aboriginal-Controlled School System and Distance Education

This last case describes the development of a distance education strategic plan (Wall, 1990) for a northern Alberta school jurisdiction, Northland School Division. It is operated by an elected board of twenty-four trustees, most of whom represent remote and isolated Aboriginal communities.

First, some background is required. Northland School Division is territorially the largest school jurisdiction in Alberta. It is a highly political jurisdiction with many diverse communities working together for the education of their children.

Some administrators and the Board are very protective of the “community,” which is seen in some respects as operating in a colonial context. Quite simply, government “power” over some of the affairs of the jurisdiction is a perpetual issue. For example, the Minister of Education hires the Superintendent of Education, a situation that exists in no other school jurisdiction in the province, under normal circumstances.

Given this situation, the administration and the Board decided not to participate in the provincial distance education network for school systems in northern Alberta. They wanted to operate their own distance education system because the methods and content could be controlled to meet the needs of the local residents.

The curriculum, although beginning with what the government had to offer (a centralised and pan-provincial curriculum) required an attendant, a significant developmental process, so that in the end a local community-based curriculum would be the focus, supported by the standard provincial curriculum. Government supports also came in the form of special grants to get the project off the ground.

The important issue here is that those served by the system perceive themselves to be a “community” of twenty-four “settlements.” This community considers itself at odds with the provincial government and other non-aboriginal school systems. Power over the system is a de facto issue.

Again, this example supports the contention that remote communities can demand significant control over their educational systems. These are demands for autonomous, self-organising projects that have a close relationship with people served and survive in a supportive environment. In this case, the environment received both provincial government support (curricular and financial) and institutional support from the Board of Trustees.

4. Summary

These examples clearly show the need to organise distance education teacher-training programmes and other distance education initiatives with respect for the autonomy of each level, expecting that each level will form an integrated and adaptable system with unique roles. Also illustrated is the need for environmental supports at each level. Particular emphasis must be placed on the relationship between the local community and the educational system.
Notes

1 It is important to state here that a regional coordinating mechanism, like a South Asian Distance Education Centre (Taylor, 1990), which would develop and distribute courseware should not have, as Taylor (1990, p. 90) suggests, as its primary justification cost-effectiveness through obvious economies of scale. The first criterion should be whether or not such a mechanism can and will provide an environment that supports, and does not encumber, the successful operation of individual member projects.

2 In support of this argument, Sharma (1990, p. 24) suggests that to be considered genuine an international regional organisation would not “prejudice ... individual cultural aspirations.”

3 To reinforce this point about the need for the relevance of knowledge Havenga (1987, p. 84) states that “students see university as a very formal institution concerned with the transmission of ‘scientific knowledge’ and evaluation thereof. They quickly realise this is not what the real world is like. In the real world experience is both useful and important. They therefore take no responsibility for learning and their work becomes formal, abstract and arid....”

4 This mutualistic approach is difficult to initiate. I remember a nutritionist recently explaining that she was having a problem reporting the results of a northern survey because the government wanted the eating habits of the indigenous populations framed in terms of four seasons, while some of those investigated spoke and thought in terms of six seasons. Professionals have a tendency to think their views are the most important. And why not? It is the job of a professional to study and to form opinions. As managers and developers of systems, however, we have the overriding responsibility to create management structures that allow different points of view to be heard.

5 When we begin to speak about educational relationships, we begin to think about protocols for interaction, which leads to consideration of socially acceptable behaviour that must itself lead to a consideration of cultural interaction and cross-cultural communication.

6 We must remember there are numerous studies of groups around the world that resist domination in some way by others (Rigby, 1989). Domination by the educational system is no exception.

7 There are three main groups of Aboriginal peoples in Canada: Status Indians, the Inuit and the Métis. These are designations deriving from the administrative history of Aboriginal peoples by non-Aboriginal people.

In the early 1970s, the Assembly of First Nations (National Indian Brotherhood), a national organisation representing Status Indians in Canada, questioned who controlled the educational systems their children encountered. The conclusion was, of course, that the education of Aboriginal peoples in Canada was an element of “internal colonialism.”

At the same time, came the regrouping, reorganisation and strengthening of Aboriginal peoples – socially, economically and politically. This movement continues today and is getting stronger. Its renewed strength demands equal control over institutions affecting Aboriginal peoples. Education is no exception.
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CHAPTER 6

DEVELOPMENTS IN SCIENCE TEACHER EDUCATION IN PAPUA NEW GUINEA

Jane Mogina

INTRODUCTION

Education in Papua New Guinea occurs at three levels: primary, secondary and tertiary. Primary schools, called Community Schools, provide education for the first six years, with the starting age ranging from 7-9 years. The secondary system is two-tiered: the Provincial High Schools form the lower tier, lasting four years, and the upper tier, known as the National High School, lasts two years. The tertiary level provides a variety of education that includes teacher training, technical and university education.

The science curriculum in Community Schools is “enquiry”-based, aimed at providing the children with “discovery experiences.” The course is developed around local knowledge, skills and material. It has forty minutes per week programmed time and a radio broadcast. In reality, many programmed lessons are not taught.

The lower-secondary science curriculum is an integrated course consisting of biology, chemistry, physics and geology components. There are detailed, lesson-by-lesson, planned Teachers’ Guides as well as equipment kits specifically provided for the different components of the course. The course is content based, but qualitative. There are five forty-minute lessons programmed. There is an exam at the end of the fourth year, which is used as an entry requirement for National High School and other tertiary institutions, including the Community School Teachers’ Colleges. In the National High Schools, science is taught as subjects of chemistry, biology and physics. It is highly content based and more quantitative. There are two-hour per week lessons programmed in Grade 11 and three-hour per week lessons in Grade 12.

TEACHER TRAINING

a) Primary

All qualified teachers are trained in nine Community School teacher training colleges. Until 1990, the duration of the certificate programme was two years; since then it has been extended to three years. The minimum requirement is a pass at Grade 10 level. The curriculum is structured in three
sections: Subject Areas, Professional Studies and Teaching Practice. The subject areas taught at the colleges correspond very well to the subject areas taught in the Community Schools (Avalos, 1991).

b) Secondary

Secondary teacher training is done in two institutions: the Goroka Teachers’ College and the Faculty of Education of the University of Papua New Guinea. Goroka offered a two-year programme until 1988. The minimum entry requirement was Grade 10, but students had to pass a preliminary programme to qualify for a two-year diploma. The programme has now been extended to three years with a minimum requirement of a pass at Grade 12. Although the science content component corresponds closely to the foundation year at the university, its time allocation for the same content is half of what is done in the foundation year.

The university offers three programmes. The Pre-Service Bachelor of Education programme is for National High School graduates to qualify as high school teachers. It is a four-year programme, in which three years are done in a field of academic specialisation and one year in Professional Studies. The second programme is a two-year, in-service programme, which allows teachers with a Goroka diploma to gain degree status. The post-graduate diploma in Education allows graduates of Science to gain qualification to teach in either the Provincial High Schools or the National High Schools.

TEACHING SCIENCE

From my experience of teaching in National and Provincial High Schools, I found science teaching exciting, enjoyable and most rewarding. The students are enthusiastic, and there is a wealth of traditional scientific information in the surroundings to base my teachings on.

However, the experiences of the majority of science teachers contradict mine. Science is consistently reported to be the most difficult subject for teachers, both during training and later in the field (Wilson, 1977). A report by Ross (1988) indicated clearly that more teachers experience difficulty with science than with any other subject.

In the Community Schools, where the curriculum is developed around local resources, very few teachers attempt to teach science. The teachers associate the difficulty with “lack of material and equipment rather than lack of subject knowledge.” Teachers fail to supplement with imaginative and creative use of what is around them. Many obviously lack the ability to improvise because they do not have the subject knowledge. Many of the teachers in Community Schools have virtually no science background (Wilson, 1977). This is to be expected as many students entering teachers’ colleges come from the lower half of the Grade 10 population, particularly in science. This means that they are also less capable in science than in mathematics and English. Formalistic teaching style is predominant (Guthrie, 1981).

In Provincial High Schools the scenario is not much different. The SISS study (Wilson, 1984) indicates 75% of the teachers teaching Grades 9 and 10 are dissatisfied with their
level of understanding of the subjects they teach. The same percentage of teachers claim
that they have not studied science content beyond Grade 12. The units that teachers find
the most difficult are those requiring application of scientific principles.

The most frequently used methods of teaching are teacher talk (73%) and copying notes
(62%). Teacher demonstrations and small group experimental work also take place
when material is available.

Since the teachers described above are the products of teacher training institutions, the
quality of subject matter taught and the teaching skills imparted are a matter of serious
concern. It has been noted (McLaughlin, 1988) that there is a close correlation between
the emphasis on skills contained in course outlines of subject matter and the contents of
the teaching skills course in the Community School Teachers’ Colleges. Obviously, the
skills used by teachers for teaching are those that were used when they were taught as
students.

Goroka teacher training is also largely based on the Provincial High School Syllabus. It
is not surprising, therefore, that the science teachers in the schools adhere very closely
to the Teachers’ Guide, using lesson-by-lesson recipes in their teaching. Apart from
initial training in the Training Colleges, there are no other avenues open to science
teachers to further develop their knowledge or skills. Until 1991, even the in-service
programme at the university was unattainable to the science teachers. In the SISS
Survey (Wilson, 1987) only 60% of the teachers took part in science in-services within
their schools. However, these in-services revolved around new curriculum materials.
The survey also indicated that reading of journals on science and science teaching was
non-existent. There are two journals that teachers could find useful, namely, the
Journal of Education and Science in Niugini. However, the teachers either did not
know of the existence of these journals or thought the contents were irrelevant.

ATTEMPTS AT IMPROVEMENT

At the University of Papua New Guinea, there used to be an in-service education
programme for teachers. The teachers entered the programme by going into
mainstream courses at the foundation-year level. However, in the last ten years no
teacher has gone further than the first semester of the programme. The reasons for this
are twofold: firstly, the teachers had been in the field too long, had forgotten much of
their science and, therefore, did not catch up quickly enough to do well in the first
semester. Secondly, many teachers found that they were in the same courses as some of
the students they had taught in high school, who were doing much better than they were
and consequently, were quite discouraged.

Between 1988 and 1990, the programme was revised, and after many often tough
negotiations with the university and the science faculty, the revised programme was
approved. The revised programme consists of units in biology, chemistry, physics and
mathematics tailored to extend the teachers’ required knowledge for teaching in the
high schools. The units are taught by members of the education faculty and those in the
science faculty who were sympathetic to the teachers’ needs. Although the content is
similar to the foundation-year science, the teachers are taught separately.

Five teachers enrolled in 1991 for biology, geology, mathematics and an education unit.
In the biology unit, which also includes psychology students, the teachers achieved the
top five grades; in the geology unit, which is a mainstream unit, the teachers did not do
as well, but none failed. The geology professor noted that the positive attitudes of the
five teachers toward work had affected the whole class. This year, the five students are
doing chemistry, physics and microbiology, another mainstream unit. Although it is
only eighteen months since the programme started, I have no doubts that it is very
successful. The only drawback at the moment is that the numbers of teachers entering
the programme remain small due to limitations in the National Department of
Education's sponsorship. In order to overcome this problem, I have plans for making
some of the units in the programme available externally. The biology unit is already in
the process of being written, but none of the others is, as no interested personnel have
yet been identified.

The training institutions are already in the process of reviewing the quality of their
training. The colleges have increased their training by one year. They are also revising
their subject content, a project in which the university is involved with the evaluation.
Recently, a national body was established to monitor the academic quality within the
training institutions. The institutions have also been made aware of the formalistic type
of teaching reinforced at the training institutes and are making every attempt to move
toward more reflective types of teaching.

Although there are genuine attempts being made to improve the quality of initial teacher
training, other forms of professional development for science teachers beyond initiate
training are yet to be realised in Papua New Guinea. Several approaches are worth
exploring. First, there are avenues available within the educational system for school-
based and institution-based, in-service activities. At the moment, these are not fully
utilised. The institution-based, in-service programmes often lead to certain academic
qualifications and are, therefore, lengthy and costly. Thus only few teachers are able to
attend. The school-based in-services, on the other hand, lack input from informed
teachers or subject specialists. What is urgently needed is a collaborative effort of
science educators to develop worthwhile in-service programmes and participate in them.
These programmes should be based locally in schools or regional institutions, using
resources of the locality. The programmes should take into account the academic
background of the teachers involved, as well as their interests. A network of reflective
and informed teachers needs to be established to provide initiatives.

Secondly, there are teachers who have innovative ideas that they use, but there is no
existing network to disseminate their ideas. A newsletter would be ideal for sharing
ideas, requesting information or just maintaining general interest.

In conclusion, the inadequacies and deficiencies of teacher development in science
education in Papua New Guinea have been identified. They were in some cases quite
obvious. What is lacking is remedial action along with evaluation and follow-up of
these actions. The remedial actions should include continuous school-based or regional-
based in-services on subject content and different lesson procedures—the areas most
needed by teachers. Networks for information dissemination are also essential. Without
support in terms of funding and informed personnel, many of these much needed
changes will not be implemented for a long time to come.

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CHAPTER 7

AN APPRAISAL OF KEY ISSUES AND PROBLEMS IN THE RECRUITMENT AND TRAINING OF TEACHERS FOR MATHEMATICS, SCIENCE AND TECHNICAL/VOCATIONAL STUDIES IN THE COMMONWEALTH OF THE BAHAMAS

James Murray

GEOGRAPHY AND DEMOGRAPHY

The Commonwealth of the Bahamas contains some 700 islands and cays, with an estimated land area of 5,359 square miles dispersed over 500 miles of ocean. The archipelagic nature of the country creates problems of transportation, communication and mobility for the people of the Bahamas, who live on thirty of the Family Islands. The islands have few natural resources of significance apart from those of sun, sand, sea and people. More than half (67.35%) of the total population of 254,684 (1990 census) resides in New Providence. On this island of barely eighty square miles, is situated the capital city, Nassau. Most of the other inhabited islands are sparsely settled. In these conditions, the provision of quality education is a herculean task. Between 1980 and 1990, there has been a continuous movement away from the Family Islands to New Providence. The result of this situation has been an unevenness in the quality of education, given the difficulties of providing it in less populated areas, where the delivery of education is expensive, the range of curriculum narrowed by the lack of specialist teachers, and the emphasis on post-secondary education reduced.

ECONOMY

The tourist industry has formed the dominant sector of the economy since the post-World War II period, and its phenomenal development has depended heavily on infusions of foreign capital to provide the necessary infrastructure. More recently banking, insurance and the registration of international companies have assumed increasing importance. Since 1967, the government has signalled economic diversification as a desirable objective, emphasising the possibility of agricultural development and light industry. Future growth in the economy will increase the demand for higher education in administration, banking, accounting, foreign languages, management, and the performing and visual arts. The demand for craftsmen,
technicians and engineers will increase, placing emphasis on training in applied science, technical and vocational studies (College of the Bahamas Self-Study Report, 1991, p. 5).

THE EDUCATIONAL SYSTEM

There are 226 schools in the Bahamas with and enrolment of approximately 60,000 students. The school system is organised into two levels: primary (ages 5 to 11) and secondary (ages 11 to 16+). The main institution for tertiary learning is the College of the Bahamas, established in 1974. There are also the Technical Training Centre and the Hotel Training College. All teacher training is carried out by the Education Division of the College of the Bahamas. From 1983 to 1992, an average of 100 students per year have applied to become teachers. In 1989, there were 113 accepted into Teacher Education. The majority of them are graduating this year (1992).

ISSUES AND PROBLEMS

The teaching subjects of the final year (1991-1992) for student teachers in the Teacher Education Division of the College of the Bahamas, located in Nassau, show the following distributions:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>40</td>
</tr>
<tr>
<td>Secondary</td>
<td>46</td>
</tr>
</tbody>
</table>

Secondary Teaching Subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Art and Crafts</td>
<td>1</td>
</tr>
<tr>
<td>Business Studies</td>
<td>6</td>
</tr>
<tr>
<td>English</td>
<td>10</td>
</tr>
<tr>
<td>English Religion</td>
<td>6</td>
</tr>
<tr>
<td>French/English</td>
<td>2</td>
</tr>
<tr>
<td>French/Spanish</td>
<td>1</td>
</tr>
<tr>
<td>General Science</td>
<td>2</td>
</tr>
<tr>
<td>Mathematics/Religion</td>
<td>2</td>
</tr>
<tr>
<td>Mathematics/English</td>
<td>1</td>
</tr>
<tr>
<td>Mathematics/Computer Science</td>
<td>4</td>
</tr>
<tr>
<td>Music</td>
<td>1</td>
</tr>
<tr>
<td>Social Studies</td>
<td>10</td>
</tr>
</tbody>
</table>

Of these students, both primary and secondary, 17.4% are in mathematics, science and vocational studies. It is obvious that the overall output is low and that a shortage of teachers in science is a major concern.

There is no programme at the College of the Bahamas for the training of technical teachers, due mainly to limited interest in this area among school graduates. At present, there is at the Nassau Industrial Training Centre an in-service training programme for faculty. There, key faculty personnel have been given opportunities to upgrade their skills and methodology, and in turn pass on these skills in short modular exercises to their colleagues. Although this approach is successful, it is recognised that there are limitations to the training of craftsmen and technical teachers as instructors.

Because of this low output of locally trained teachers, the Ministry of Education, under whose portfolio the staffing of the twenty-eight government secondary schools falls, has to mount recruitment exercises in Britain, Canada and the USA. The recruitment officer estimates that 100 new teachers are needed every year in the secondary schools to fill the vacancies caused by retirees, transfers to the private sector and the expansion of programmes. The majority of these vacancies are in the areas of mathematics, science and technical/vocational studies. He has informed this author that the 1992 recruitment
exercise has met with limited success, citing the low salaries (in the range of US$16,500 to US$23,000) as one of the main causes. There is no incentive policy in place to attract teachers for key areas in demand. Although the Bahamas has no income tax, the relatively high cost of living, stemming from import tax on consumer goods, and the initial expenditure of taking up residence have added to the difficulty in recruiting teachers.

In addition to the disparities between the salaries in the private sector and the teaching profession, two other factors need some consideration. First, as is common to many countries, the teaching profession as a career choice suffers because of the low esteem and prestige it has among the population in general and particularly among school graduates. In 1985, when asked to rank sixteen professions as their choice of career, a total of 2,812 Bahamian school graduates put the secondary teacher as 11th and the primary teacher as 12th. These were sandwiched between the policeman and the fisherman (Adams, 1985, p. 15). Second, the expanding economy of the Bahamas, especially in the areas of tourism and finance, during the early 1980s opened up for the first time to young Bahamians a wider range of career choices. It is important to note that three out of every five jobs in the Bahamas are related directly or indirectly to tourism (CARICOM Survey, TVET, p.1A, 12).

Hence, it is evident that certain strategies must be put in place to attract young Bahamian school graduates to the teaching profession. One such strategy in the process of implementation is that of the formation of a Teacher Corps within the upper grades of the secondary school. The main objective of such a programme is to identify interested and intellectually competent high school students, who might show a positive attitude toward teaching as a career. This would be followed by an enrichment programme involving academic help alongside exposure to the classroom situation under the guidance of master teachers.

The quality of students entering the Education programmes at the College of the Bahamas needs some mention. It does not compare favourably with those entering the other divisions. From 1985 to 1990, 80.6% of graduates of the College completed their programmes with a Cumulative Grade Point Average (CGPA) between 2.0 and 2.9, with 4.65% of those in Education achieving a CGPA of over 3.0 compared with 16.5% in Technology, 18.6% in Business and 27% in the Natural Science Divisions (The College of the Bahamas Self-Study, 1991, p. 11). In the 1991 Mathematics Competency Test designed by the Joint Board of Teacher Education of the University of the West Indies, only 40.2% of all primary and specialised secondary teachers were able to attain a competency pass of 80%.

It is necessary to consider what the best approach to the training exercise would be, given the low numbers of student teachers and their average abilities. At the College of the Bahamas, the training of teachers is centralised within the Education Division. Out of a staff of thirteen, there are two lecturers in Mathematical Methods and one in General Science Methods. There are no lecturers of Technical Studies or Vocational Studies within the Education Division. All student teachers complete a three-year Associate Degree/Teachers' Certificate Programme based on the credit-semester system common to American colleges and universities. The new selection of teaching subjects offered for secondary students in the areas of science, mathematics and vocational studies is as follows:

- Biology and Agriculture
- Biology and Chemistry
- Business Studies
- General Science
Mathematics and Computer Studies

Secretarial Studies

The main objectives of these three-year programmes are to raise the academic level of the student teachers, to expose them to the classroom experience, and through specific education courses to make them aware of a variety of teaching strategies based on pedagogic principles. An interesting point to note is that prior to the inception of the College of the Bahamas in 1974, all teacher training was carried out in two specific Colleges of Education. Programmes within these institutions were designed to emphasise the integration of content and methodology in specialised areas that would be needed to teach the secondary curriculum. Courses were taught by lecturers, all of whom were certified teachers with classroom experience. High emphasis was given to practical classroom experience. Under the present system of training, students in specialised areas complete ten courses in their content areas, followed by one specified methodology course. Teaching practicums are now restricted to four hours per week for fourteen weeks (one semester) compared with the block time of six-week practicums in the previous system. The effectiveness of both systems is subject to debate, but it is generally accepted that for the student teacher of average ability an integrated content-methods approach produces the better teacher product.

The College of the Bahamas, basically a two-year tertiary level institution, is in the process of planning to move to a four-year college or university. It is visualised that the four-year degree/certification programme designed for teacher training will have high emphasis on subject content for specialised subjects and practical teaching techniques with much less emphasis on educational theory. Many critics of Educational Curriculum for teachers note that too many programmes over-emphasise theoretical studies such as child development, multicultural studies and special needs at the expense of practical work (British Sunday Telegraph, April 17, 1988). Many go to the extreme, such as Edwin Meyer (Phi Delta Kappan, October, 1986) when he says: “Why don’t schools of Education and Government admit what any teacher already knows that the study of “education” is worse than worthless and that a radical restructure of teacher preparation is long overdue.”

Here, solid guidelines might be provided by The Commonwealth of Learning to the College of the Bahamas for establishing an effective four-year programme for teacher training, especially in specialised subject areas.

A programme for the training of teachers must be accountable to the school system in which the teachers will work. The complexity of this educational system in the Bahamas is often overlooked. Most of these schools at the primary and junior high level are guided by a curriculum supplemented by American textbooks and teachers’ manuals. At the senior high level, there is a change to mostly British texts to prepare students to sit the new examinations based on the United Kingdom’s General Certificate of Education. Many young Bahamians use their GCE ‘O’ level passes along with SAT results to enter American colleges. Others, on the basis of their performances at the College of the Bahamas, are often able to obtain exemptions from courses in a range of colleges and universities in other countries, including Canada and the United States. However, education students often find themselves at a disadvantage, as many institutions are reluctant to accept education courses related to methodology and practicums.
CONCLUSION

If the Bahamas intends to take full advantage of its membership in the Commonwealth to seek assistance in the training of teachers for specialised areas, it will have to go beyond the exchange of educational materials such as videotapes and other communication technology. Workshops, although beneficial, only seem to scratch the surface. The setting up of a Commonwealth College of Education, similar to or an extension of the United World Colleges concept, initially specialising in the training of teachers in mathematics, science, technical and vocational studies, deserves a feasibility study. Such an institution might serve as a model for training programmes in developing countries. Through such an institution, a framework for accreditation, common courses, grading and evaluation could be established.

The offer to at least ten school graduates from each of the developing countries to study for an international Bachelor/Teachers' Certification might go a long way in raising the prestige of the teaching profession in the Commonwealth of the Bahamas.

References


*British Sunday Telegraph*, April 17, 1988, n. pag.


CHAPTER 8

THE PURSUIT OF QUALITY
IN BASIC FORMAL EDUCATION

The experience of Trinidad and Tobago (1989-1992) in providing In-Service Teacher Education (INSET) with particular reference to Mathematics, Science and Technical/Vocational Subjects

Kenrick Seepersad

DEFINITIONS

Basic education

The term "Basic Education" is taken to mean the activities of primary and junior secondary schools, as well as programmes of out-of-school education at an equivalent level, both for children and for adults.

Quality

Three major thrusts in efforts to improve the quality of basic education are:

1. raising the academic performance of students in the various subjects offered in schools with the currently available resources. Such efforts are often referred to as attempting to improve the "internal efficiency" of the schools.
2. providing children with education that is most likely to help them improve the quality of their lives when they become adults. This would include developing the skills for survival, security and growth. This approach is often referred to as attempting to raise the "external efficiency" or the "effectiveness" of schools.
3. increasing the rate of school enrolment by providing more school places and reducing the inequalities of educational opportunity that currently exist between the sexes and between different regions in a country. For some Commonwealth countries this goal has been translated into the universalisation of primary education.

Formal

"Formal" (as distinct from "non-formal" and "informal") refers to the School System of Education. In Trinidad and Tobago, there are 481 government and denominational primary schools with approximately 190,000 students in the age group of 5-14 years. There are nearly 7,000 teachers, 85% of whom have completed a two-year programme.
at a Teachers' College. At the secondary level, there are 101 schools plus twenty private schools catering to almost 120,000 students in the 12-18 age group with 5,000 teachers, 50% of whom are university trained.

Non-Formal

This term refers to out-of-school programmes, e.g., adult education classes, continuing education classes.

Informal

This term refers to the dissemination of information via the media: newspaper, radio and television.

RATIONALE

Teacher renewal is essential for the successful pursuit of quality of basic formal education. In particular, developing countries like Trinidad and Tobago act on the belief that teachers and teaching are important factors in the success or failure of children in schools. Therefore, in its IDB Loan Agreement document for primary education in Trinidad and Tobago (1987-1992) one will find listed inter alia:

- the updating of 4,800 primary teachers
- the training of senior personnel at the Faculty of Education, University of the West Indies, St. Augustine
- training of at least one teacher in each primary school in library skills.

Teacher education in Trinidad and Tobago has received an unprecedented stimulus since 1989, especially with regard to in-service training. Between July 1989 and March 1992, 1,100 and 1,500 primary teachers completed twenty-five hours in mathematics and science, respectively. The programmes of March 1992 are attached in Appendices 1 and 2.

According to the anecdotal reports of the principals and supervisors, these programmes have re-introduced the use of concrete apparatus as the dominant methodology in some classes. School organisation has been positively affected. In the upper classes (age group 9-11) of the primary school, a semi-specialist approach to teaching is replacing the custom of one teacher for all subjects. This deployment of staff to teach some subjects at the primary level according to their preferences is leading to greater job satisfaction among teachers. An evaluation of these programmes is in progress, and the extent of the gains will be revealed in the near future.

It should be pointed out that these programmes were conducted on Saturdays and during the school vacation so that the pupils did not have to pay a price. The financial cost included tutors' fees, workshop materials and lunch for all participants on workshop days.

With regard to technical/vocational/subjects, the coming on stream of the junior secondary schools in 1972 created a need for teachers in Industrial Arts. This need was satisfied by recruiting primary teachers who had successfully completed the Industrial Arts elective subject at one of the various Teacher Training Colleges. The decision makers at that time felt that the Industrial Arts teachers did not possess the necessary knowledge, skill and attitude to teach the content of the junior secondary school Industrial Arts syllabus.
Subsequently, a one-year Industrial Arts Course was conducted to upgrade the knowledge, skill and attitude of the Industrial Arts teachers. From the evidence gathered, it would seem that only one such course was conducted.

The Teacher Training Colleges continue to offer Industrial Arts as an elective subject up to about 1986. At that point in time, it appeared as though the junior secondary schools were fully staffed and that there was no need to train teachers for the teaching of Industrial Arts (Woods/Metals). The closure of these courses at the Teacher Training College had its sequel about three years later. In 1988, the Secondary and Further Division of the Ministry of Education started to experience great difficulties in obtaining teachers with an elective in Industrial Arts to fill the vacancies created through retirement. The recruitment drive then focused on the Technical Institutes for persons with the Craftsman’s Diploma. The Technical/Vocational Education and Training Division has noted the strengths and weaknesses of these teachers and has responded by conducting in-service training for these teachers. In so doing, the Division hopes to improve the quality of teaching that takes place in the Industrial Arts Laboratory.

**ISSUES AND PROBLEMS**

Effective teaching requires that teachers continually assess and adapt to students. There is a need for training programmes particularly in specialised subjects like mathematics, science and technical/vocational subjects to emphasise different approaches to be used with students who require varying degrees of structure. “Structure” refers to how much the teacher is responsible for the learning activity (the more responsibility, the higher the structure), but variation in specificity of instructions and degree of pre-organisation of material are also important. Highly structured environments are teacher-centred; they include pre-organised material and involve very specific instructions and approaches. In short, there is a need to sound the death knell of sameness and resurrect more diagnostic teaching and differentiated learning experiences. With specific reference to science and technical/vocational subjects, the availability of materials for practical experience in the classroom provides a major challenge in developing countries with very limited resources for educational supplies.

The role of school supervisors, principals and senior teachers as monitors and facilitators is critical for the transfer of training. Distance from the classroom is the reality as senior personnel entangle themselves with the “frills” and “drills” at the expense of the skills of teaching and learning.

There is a shortage of the “trainers of trainees,” especially in the technical/vocational subject areas. Further, should new technology education replace the traditional technical/vocational subjects, there will be a dire need for teachers to adapt themselves. Drs. Boehm and Lenhart describe the challenge of translating development objectives into meaningful learning experiences:

*Technology cannot be separated from Technical/Vocational elements in the Curriculum. Skills of handling tools and materials must be incorporated in any technical curriculum. These skills become part of general education; they are not only an occupational element.... Cognitive and attitudinal goals are equally important for achieving the development objectives. Attitudes are developed by involving people in concrete actions instead of “chalk and talk” activities. The technology approach linked to Technical/Vocational Knowledge and Skills is suited best to achieve the attitudinal goals. Especially, the
notion of self help/self reliance, a positive work ethic and commitment to productivity and efficiency, is developed in a hands-on experience rather than by chalk and talk or moral appeals. (Technology Education in Trinidad and Tobago, p. 9)

SOLUTIONS AND STRATEGIES

Increase the Human Resource Capital

It is imperative to augment the cadre of trainers and trainees. As a rule, it is advisable to begin with one trainer in a particular subject and watch for exceptional performance among the trainees. Those trainees will be potential trainers, a role for which they will require additional training. Whenever affordable, a number of suitably qualified persons may be withdrawn from the classroom for a specified period and be trained at university-level or technical institutes. Technical aid in the form of appropriately qualified personnel may be necessary, especially in Teacher Education.

Materials Development Using Indigenous Materials

The principle of self-reliance should be encouraged. Trainers and trainees should concentrate on making teaching aids using inexpensive materials and especially those available in the immediate environment. Printed materials for workshops can be produced by typewriter, scanner, photocopier and duplicator. Increasingly, these four pieces of equipment are becoming available in schools and/or use of them for central offices and low-cost production of training materials should be encouraged.

Preparation of Standardised Training Packets

Mathematics, science and technical/vocational subjects lend themselves to the production of a core of standardised training packets. Printed courses with objectives, suggested activities and guidelines for evaluation can be prepared to be used in other places and at other times. Packets should include radio cassettes with slides and TV videotapes focusing on a “How To” series.

Laboratories and Workshops

Many laboratories are underutilised in developing countries. Maximum utilisation of existing capacity in non-traditional hours of work should be explored, e.g., evening classes, weekends and school vacation period. Corporate citizens should become more involved in the provision of small and inexpensive types of equipment used in the world of work. Where laboratories and workshops exist, there is a need for proper maintenance to prolong the life of the tools and equipment contained in them. Equipment aid may be necessary in some areas where laboratories and workshops do not exist.

Distance Education

In our global village, the exchange of ideas and sharing of expertise have been facilitated by the development of recent communication techniques. The developing world’s shortage of trained teachers in mathematics, science and technical/vocational subjects requires urgent attention. Distance education provides some hope. For example, the Organisation for Co-Operation for Overseas Development (OCOD) started a project for young teachers in four states of the Eastern Caribbean, based in St. Lucia,
to upgrade their skills in mathematics, science, English and social studies, so that they can write the CXC General Level Examination. Certainly, there are many examples in other places that can provide opportunities for adoption and adaptation.

RECOMMENDATIONS AND SUGGESTIONS

The Commonwealth of Learning should organise regional meetings to focus on the preparation of teacher training packets to improve the number and quality of the "trainers of the trainees" in each of the specialised subjects. The production of videotaped lessons on special topics in science and technical/vocational subjects will provide models for fledging Material Production Units. COL should coordinate this effort to make these items available and affordable. In the shortest time possible, it should provide assistance to individual states or clusters of states that are willing to use distance education techniques to offer certificate courses in the following areas:

Teaching of Primary Science
Teaching of Primary Mathematics
Teaching of Technology at the First Cycle of Secondary Education
Teaching of Industrial Arts at the Junior Secondary School Level
Teaching of Computer Literacy.

Diploma courses should be provided in:

The Principal as a Transformational Leader
Diagnostic and Remedial Work in Numeracy and Literacy
Making and Using Classroom Tests

The challenge for educators in the immediate future is to anticipate what their responses will be to the question, "How much quality and especially 'internal efficiency' did you achieve in your pursuit of Basic Formal Education for All by the year 2000?"
APPENDIX 1: MATHEMATICS WORKSHOPS FOR PRIMARY SCHOOL TEACHERS

TOPIC: MAKING AND USING MATHEMATICAL AIDS AND RESOURCES

TARGET GROUP

Teachers who attended a Teachers' College more than five years ago.

OBJECTIVES

At the end of the sessions, the teachers will be able to:
- make any four aids to teach mathematics
- use the aids to teach mathematics
- plan other activities using the aids
- make and use any other aid from a list that will be supplied.

METHOD OF PRESENTATION

- short, plenary sessions
- demonstration by facilitators
- explanation and illustration
- "hands-on"
- short presentation

MATERIALS

The participants are required to obtain the following:
- two sheets of Bristol board
- two sheets of straw-board or cardboard boxes
- cutting knives
- rulers
- piece of board 15x15 cm
- 100 nails (3 cm headless)
- hammer
- one hundred crown corks
- twenty drinking straws
- plastic soft drink bottles
- pieces of wire and pliers

LIST OF AIDS

- fraction inset board
- geoboard
- set of three-dimensional shapes
- crown corks to make string counters
- place value chart with soft drink plastic bottles
- the hundred board
- balance (with plastic litre bottles)
- stairway strips
- geo-strips
- protractors
- decimal multiplication and division board
- nets
- aid to show the circumference of a circle and pie
- aid to show the area of circle
- number line
APPENDIX 2: MINISTRY OF EDUCATION/IDB  
TRAINING OF PRIMARY SCHOOL TEACHERS  
MARCH 1992 SCIENCE PROGRAMME

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>DETAIL</th>
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</thead>
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<tr>
<td><strong>PRE-TEST:</strong></td>
<td></td>
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<tr>
<td>Introduction to Primary School</td>
<td>lecture</td>
<td>1 1/2 hours</td>
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<tr>
<td>Science Syllabus:</td>
<td></td>
<td></td>
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<tr>
<td>- process approach</td>
<td></td>
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<tr>
<td>- definitions of processes</td>
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<tr>
<td>- advantages and disadvantages</td>
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<tr>
<td>(hand-out on low-cost equipment to be given to participants)</td>
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<td></td>
</tr>
<tr>
<td>Teaching tactics</td>
<td>discussion, hand-out</td>
<td>1 1/4 hours</td>
</tr>
<tr>
<td>Hands-on</td>
<td>activities, discussion</td>
<td>1 1/4 hours</td>
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<tr>
<td>Behavioural objectives</td>
<td>lecture tasks, hand-out</td>
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<tr>
<td>Hands-on</td>
<td>activities, discussion</td>
<td>1 1/4 hours</td>
</tr>
<tr>
<td>Questioning techniques</td>
<td>discussion, hand-out</td>
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<tr>
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<td>activities, discussion</td>
<td>1 1/4 hours</td>
</tr>
<tr>
<td>Process: observing</td>
<td>discussion, hand-out</td>
<td>1 1/4 hours</td>
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<tr>
<td>Low-cost equipment</td>
<td>activities</td>
<td>1 1/4 hours</td>
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<tr>
<td>Planning and investigation</td>
<td>discussion, hand-out</td>
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<tr>
<td><strong>POST-TEST:</strong></td>
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<td>Programme Evaluation</td>
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<td></td>
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<tr>
<td>Displays</td>
<td></td>
<td>2 hours</td>
</tr>
<tr>
<td>Closing Sessions</td>
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</tr>
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</table>
SCIENCE

RATIONALE

We live in a world where science and technology touch every facet of our lives. The children of today need to be able to understand how science relates to everyday life. They must also be prepared to deal effectively with the wider decision-making and problem-solving needs of the future. Science education can promote the development of such abilities and provide the necessary background in science and its application.

Learning science at the primary level can help children to understand the world around them, to acquire the basic skills of science and to develop a positive attitude toward it. A child leaving primary school with a good foundation and a positive attitude to science is likely to have fewer problems in pursuing the study of science at the secondary level and enjoy doing the subject.

The science programme for primary schools takes the foregoing into account as well as the curriculum goals for primary education, as enunciated in the Education Plan 1985-1990 of the Republic of Trinidad and Tobago. These goals are for the students to:

1. develop a basic understanding of the physical properties of common materials as well as the basic laws of Nature, and use their knowledge of these laws and properties to harness the forces of Nature to their own advantage.

2. be able through an understanding and appreciation of technology to adapt to life in a world where new developments in science and technology occur daily, exerting tremendous effects on people’s lives.

AIMS

The programme aims at enabling students to:

- use the processes of science in simple investigations of objects and events
- develop an understanding of the scientific terms, facts and concepts appropriate to their age and ability
- extend the skills of language and numbers
- develop their ability to think
- examine the physical properties of common materials
- develop an understanding of the basic laws of nature
- apply or relate scientific ideas to situations in everyday life
- display a positive attitude toward science
- acquire positive attitudes toward oneself, others and the environment
- demonstrate the ability to work cooperatively with others.

OVERVIEW

The science syllabus provides an outline of topics and specific objectives for each year (class) of primary education. The specific objectives are expressed in terms of students’ performance; they form the instructional and evaluation base of the science programme.
The placement and sequencing of the objectives is based on the cognitive development stages of students in different age groups. The topics are chosen mainly from the physical biological and earth sciences.

For each class (year), suitable activities have been provided by the Ministry of Education. The activities are designed for students to work individually and in small groups. Instructions for carrying out the activities are also included in the Teachers’ Guides.

To facilitate learning, the science programme stresses the use of hands-on activities. The hands-on experience will also help students to form positive attitudes toward science. They will become curious, ask questions about objects and events, and show interest in the outcomes of experiments. They will demonstrate critical thinking, as they learn to base their conclusions on evidence. They will show precision as they express the need to examine a problem from more than one point of view. They will show responsibility as they demonstrate willingness to share knowledge with others.

The materials needed for each activity are listed in the Teachers’ Guides. They are generally inexpensive and readily available. Use of common household items and discarded materials has been encouraged. However, some traditional equipment, such as hand lenses and weighing and measuring instruments, must be acquired.

**PROCESS APPROACH**

Science is both a method and a body of knowledge. The method of scientific inquiry involves the use of certain skills — the processes of science. A process approach to science emphasises the development and use of the process skills of science, rather than the memorisation of the facts of science. The need to stress the processes becomes apparent when one considers the changing nature of scientific knowledge. Moreover, through the use of process skills, students will be able to obtain, interpret and test information to derive intelligent conclusions in everyday situations. Since the syllabus objectives specify the content and process outcome for a particular topic, it is essential that teaching be focused on the objectives rather than the topic only. The activities and teaching strategies suggested in the Teachers’ Guides will assist teachers in this regard.

Brief descriptions of the processes used in the science programme are given below:

- **Observing:** Using the senses — seeing, tasting, touching, hearing and smelling — to find out about objectives or events in the environment.
- **Using Space/Time Relationships:** Perceiving and describing objects in terms of their shape, motion, position or location. Perceiving and describing events in terms of sequences, duration, period of time between them and other events.
- **Measuring:** Finding out about an unknown quantity by comparing it with a known quantity.
- **Classifying:** Grouping objects or events using one or more observed properties.
- **Communications:** Conveying information by means of oral or written descriptions, pictures, graphs, maps, demonstrations, etc.
- **Inferring:** Figuring out an explanation based on observations of an object or event.
- **Predicting:** Describing in advance the outcome of an event based on a pattern formed from previous observations.
- **Hypothesising:** To construct a tentative answer to a problem from generalised observations.
- **Interpreting Data:** Explaining the meaning or the significance of information regarding an object or event.
• **Controlling Variables:** Discriminating among factors that will, and will not, affect the outcome of an experiment.

• **Defining Operationally:** Constructing a definition from what has been done and what has been observed.

• **Experimenting:** Designing and carrying out procedures to obtain reliable information about inter-relationships between objects and events.

At Level 1 – (Infants to Standard 2), the main emphasis is on developing processes such as observing, classifying, communicating, etc. The rated processes, e.g., defining operationally, controlling variables are emphasised at Level 2 (Standard 3 to Standard 5).

**LOW COST APPARATUS**

• 1 plastic clothes-hanger, string, 2 large covers
• 1 plastic clothes-clip, 2 brass paper fasteners
• 1 wooden clothes-clip, 1 empty condensed milk tin
• Kodak film cans (These are given away at any photography depot where films are developed.)
• 1 only 2-litre soft drink container with black base
• Small soft drink container or plastic cover
• Small soft drink container or 1 large balloon, 1 small balloon
• 1 medium-size cereal box, 1 piece of aluminum foil (30 x 4 cm approx.) small UHU stick glue
• 1 PVC tubing 20 cm long x 1.6 cm outer diameter (or a wooden dowel of the same size), 1 PVC tubing 20 cm long x 2.2 cm outer diameter, approx.
• piece of straw-board (40 x 10 cm approx.), 1 brass paper fastener
• old ball point pen, 4 paper cups, 1 paper plate
• 1 Cheers chocolate plastic container, Large toothpaste tube (not plastic type). Cut lengthwise and use all toothpaste, then wash clean.
• Circuit tester – 1 only 1.5V bulb, 1 size C 1.5V dry cell
• 1 ice cream container with lid, filled with sand
• 3 small screws, string, plastic margarine container (Flora or any other type). Piece of wood (50 cm long x 3 cm thick), 2 sticks white chalk, small screwdriver. Size C 1.5V battery, piece of onion, 6 sheets graph paper, 1 Ex-Lax tablet, 1 large sewing needle, piece of red sorrel flower.

Resource Books: Copy of Syllabus – Primary Science. *How to Teach Primary Science. Primary Science for the Caribbean*, Series 1-7 by Douglass and Abder
References


CHAPTER 9

THE TRAINING OF TEACHERS OF MATHEMATICS, SCIENCE AND TECHNICAL/VOCATIONAL SUBJECTS

Leton Thomas

INTRODUCTION

In this paper, I intend to deal briefly with the possibilities of educating and training teachers to meet the present and future demands of teaching, and helping student teachers move from educational concepts to professional action. I shall raise a few issues and problems and offer ideas, which may suggest a possible way forward. The suggestions should be seen as part of a search for productive, imaginative and innovative ways of organising, selecting, and developing content and teaching strategies to meet the challenges of schools and teacher education institutions.

The education and training of teachers as currently practised broadly consists of three strands, namely:

1. The substantial body of knowledge, commonly referred to as professional knowledge, which teachers need to function as practising members of the teaching profession, e.g., educational psychology, child development, assessment and evaluation, etc.

2. The mastery of knowledge, that is, the concepts and information that make up the content of the instructional programme, referred to as "curriculum studies."

3. The classroom skills and teacher behaviours needed to function effectively in a variety of learning/teaching situations.

If we single out the last of the three strands, we will find that it is in this area that criticism of the outcomes or the product of our teacher training institutions is strongest. A brief examination of the situation shows that quite a discrepancy exists between the form in which the student teacher or teacher receives information (largely through lectures and printed material) and the form in which he or she must actually use the information (through the development of patterns of class behaviour).
Some of the most relevant writings of Caribbean educationalists speak eloquently to the following needs:

- re-examination of the lecture method as a teaching strategy in teacher training institutions
- interdisciplinary approaches to the treatment of curriculum in teacher training institutions and
- as one educator puts it: “It is true that they learn about teaching methods and write about them in answer to examination questions, but when they return to schools as teachers this seems to have little effect on their actual practice.”

Basic to the concerns of some Caribbean educationalists is the apparent vagueness about the objectives of the training programmes and the low level of professional expertise in the classroom. Criticisms of teacher education and training are sufficiently fundamental to make us come up with new questions or rethink old questions. It is clear that improvements cannot be obtained by making minor revisions to syllabi and teaching methods. We need to ponder the questions: What type of teacher do we need to produce in order to satisfy present and future requirements? What is he or she expected to do after a period of training that could not be done before?

**ISSUES AND PROBLEMS**

Teacher education in St. Lucia and in many parts of the Caribbean is undergoing expansion and innovation. It is becoming abundantly clear that the declining resources available for education will not permit our Caribbean societies to satisfy their rising expectations for more and better education simply by a physical or linear expansion of the existing system for training teachers. An invitation to discuss the education and training of teachers is seen as an invitation to explore innovative concepts, strategies and practices.

Certain key concepts basic to considerations of innovation, such as: life-long education, educational informatics/technology, self-instruction, integrated studies, accountability, etc., have not seriously challenged the conventional thinking of many teacher practitioners, teacher educators, educational administrators and teacher education institutions.

An imperative in teacher education must be to provide teachers with the appropriate experiences that will enable them to be professionally competent in schools. Competence is used here in the sense that their performance can be observed, analysed, commented upon and measured in some manner. The focus in our teacher education programmes should be a well-organised and closely integrated programme of clinical experiences. These experiences should serve three major functions, namely:

1. They should illustrate and demonstrate the principles of practice.
2. They should involve the application and testing of teaching and learning theory.
3. They should provide opportunities to develop competency in the full range of teacher tasks.

The effectiveness of clinical experiences depends, however, on the extent to which they are an integral part of a comprehensive teacher education programme.
We seem to be caught up in a series of dilemmas:

- The student teacher must have specialist knowledge and skills to function as an all-round practitioner and in his or her specialist subject discipline.
- The student teacher must be a mature person, sensitive to the refined values.
- The student teacher must have leisure to experiment, develop and grow.

Unfortunately, we cannot do all that needs to be done in a two- or three-year programme. Certain choices must be made and more importantly, by the teacher training institution. A way out of these dilemmas may be a form of organisation that emphasises the essential role of teacher education and training institutions. What would happen, for example, if:

- we substituted “themes” for traditional course categories?
- the programme as a whole were “problem-oriented”?
- the lecture approach were abandoned in favour of organised workshops and seminars?
- “curriculum studies” became the core of the programme?
- courses were developed by teams rather than by individual tutors?

It seems to me that we need to devise models that reflect a comprehensive application of the implications of these questions.

It should not be thought that if teacher education institutions were successful in carrying out their essential functions, we would have effective schools. Changes relating to management of schools, the organisation of schools and the use of staff are urgent if we are to see improvements in the use of specialist subjects. Some links and articulation at the level of content and strategies, both in classrooms and teacher education institutions, is called for. Moreover, the links must take into consideration how the teacher’s training can have some continuity before, during and after having pursued training at teacher education institutions.

Teacher educators are largely self-taught, self-selected and self-generating. We should put first things first and institutionalise constant refreshment and renewed study for the teacher educator. Moreover, all staff concerned with teacher educator should be aware of the findings of research and endeavour to pass on the results to students. This is not the case at present. Keeping up-to-date is more than knowing the literature. Teacher educators may need to update their own study techniques and thinking skills, and must themselves reflect educational practice at its best.

**A WAY FORWARD**

In North America, educational research has made good progress in providing a basis for educational policy and practice. By contrast, a CARICOM Advisory Task Force was appointed to prepare for the consideration of ministers of education responsible for education in the CARICOM region recommendations for the development of Caribbean Education for the Future. It became clear to the Task Force that some studies would need to be undertaken in order to gain a better appreciation of:

- the strengths of the present educational arrangements
- difficulties faced
- considerations underlying present output and effectiveness
- objectives appropriate to education
• options open to Caribbean societies for achieving those objectives
• constraints to achievement and identification of packets of excellence.

A Caribbean researcher recently pointed out that “a major hindrance to creative thinking and curriculum work in primary and secondary schools seems to emerge from the sparse amount of research findings that can help teachers and curriculum developers in their work.” We do not have a tradition of initiating reforms based on research and development studies, so we tend to go for the “quick fix.” However, within recent years, we have seen valuable reports, including the Internal Evaluation of the Comprehensive Teacher Training Project, Progress Report on the Work of the Caribbean Community Advisory Task Force on Education and Foundation for the Future – OECS Education Reform Strategy, which can give us some ideas as to how to proceed.

It is generally agreed that the points of intervention must be in the area of curriculum development and teacher training, the lack of Caribbean research notwithstanding. Curriculum development is at the heart of the learning process as well as of the training process. Suggested needs in this regard are:

1. The development of simple, coherent and practical models that can be applied at any level to the design of learning experiences by the teacher or teacher educator. Experiments in curriculum development taking place in the Caribbean region point to the usefulness and importance of modules or units of work that begin sensibly with a clear set of learning objectives and instructions, well-organised resource materials to stimulate learning and tests through which learners can appraise their progress. The organisation and orientation of training and learning in this way holds promise for:

• individualising instruction
• spreading educational opportunity more readily
• orienting courses to the classroom
• rigorous selection of content
• achieving relevance and economy in terms of both time and outcome.

2. In an age noted for the spate of information overwhelming us, we run the risk of overburdening our training programmes with useless information and material, thus losing sight of the relevance of our curricula. We need to rethink training programmes for teachers of specialist subjects in terms of:

• defining course objectives, bearing in mind the duration of the programmes
• specifying our expected outcomes in terms of teaching competencies, skills, concepts and attitudes that specialist teachers need to function effectively.

It is on this basis that decisions can be made regarding what content is sufficient for the purpose or whether concepts and skills can be grouped around themes. Teachers have been aware of the effect of the social environment upon learning, but the implications for their job have seldom been considered. If these are not known, it would be difficult for them to be reflected adequately in a training design. Yet, calls for a closer relationship between educational institutions and the social environment continue to be made.

3. The workshop is a promising approach to increasing student participation in the planning of the learning task. The technique lends itself to any group and offers favourable outcomes. Unfortunately, academic staff are reluctant to abandon the lecture approach and so a useful beginning would be to model a workshop and plan its application for student teacher and teacher educator situations. The selective use of media, especially in this age of videotapes, needs to be incorporated into the training of
teachers in specialist subjects. In this respect, micro-teaching with videotape is another promising innovation that could be explored. It has the advantage of encouraging teamwork among staff by bringing "Foundations" staff into a functional relationship with the "Curriculum Studies" staff.

4. In the light of number 1 above, my experience inclines me to suggest that we should concentrate on the development of modules/units of work. The modular approach provides an opportunity to break away from the rigidity of subject divisions and encourages integration. It provides a basis for the selection and organisation of content; for orienting learning strategies, the multimedia activities and learners toward performance objectives. In the process, criteria such as economy, relevance and themes that stimulate learning at the highest thought levels can be accommodated. Due to rising costs, however, the main mode of learning for the vast majority will be self-instructional. In this context, worthwhile experiments are currently being conducted by the Organization for Co-Operation in Overseas Development (OCOD) in terms of content packages in basic academic disciplines for teachers and students who are planning to enter teacher education institutions.

The concentration on modules/units of work brings into bold relief arguments for and against the "textbook" on the one hand and the "lesson" on the other hand. The "textbook" tends to become all "content" to both teacher and learner. Moreover, textbooks require long-term and costly production. Concentration on the "lesson" has tended to fragment the learning process by its emphasis on what is taught rather than on what is learned. Concentration on modules/units of work provides the middle ground in that the module represents the core around which learning and instruction at any level can best be systematised.

A ROLE FOR THE COMMONWEALTH OF LEARNING

Because of the mandate given to The Commonwealth of Learning, it is in a position to:

- ensure that in the development of modules we do not re-invent the wheel, so saving us time and money. What may be necessary, however, is to invent a special set of "tires" bearing in mind the "terrain" over which the "wheel" must travel.
- attempt to develop Student Instructional Units (SIU), coupled with Student-Teacher Instructional Units (TIU), in a standardised format to facilitate dissemination within a region.
- be a centre for following-up the introduction of SIUs and TIUs within a system to ensure that they have been properly assimilated within the system.
- lend support to teacher educators in tertiary institutions to carry out action research, so that they can generate new ideas and be a focus in the educational system through which schools are kept abreast of the results of research in their specialised areas.

CONCLUSION

This paper has been a brief attempt to provoke thought about a number of ideas that, if brought together in a simple and coherent model capable of being applied to the problems of training teachers of specialist subjects, could shift teacher educators of specialist subjects from the security of polishing up traditional approaches to employing innovative and exemplary teaching methods and techniques. It is my hope that the exercise would engage our attention to the greater good of the region I represent.
CHAPTER 10

TEACHER EDUCATION IN THE SOUTH PACIFIC:
TRENDS, PROBLEMS AND PROSPECTS

Srinivasiah Muralidhar

INTRODUCTION

This background paper is in 5 sections. In the second part, I have attempted to provide an overview of teacher education in the South Pacific. The third section looks at the issues and concerns related to science education in the region. In the fourth part, I have discussed some solutions and strategies that can be put into effect by regional governments, and I have indicated the role being played by USP in addressing some of the issues. The paper concludes by noting the aspirations of science teachers and suggesting how these aspirations can be met.

AN OVERVIEW OF TEACHER EDUCATION

The Role of USP

The preparation of teachers to teach at secondary levels in Fiji and other island nations of the South Pacific made a real start when the University of the South Pacific (USP) was established in 1968 in Fiji. Indeed, for the first fifteen years of its operation, the major focus of the university, through its School of Education, was to prepare teachers for the junior and senior secondary levels in order to cater to the rapid expansion in the educational sector in member countries. This was also the period when many countries in the region were moving toward nationhood and, therefore, were anxious to localise curricula and create a pool of local teachers that would gradually replace expatriate teachers.

The need for qualified teachers was so great in the initial years that students opting to take the Dip. Ed. or the B.A./B. Sc. GCED programmes were offered government scholarships, and after completion, were automatically absorbed into the teaching service.

Table 1 provides a summary of secondary teacher education programmes offered at USP, and Tables 2 and 3 give the number of students who have gained the diploma and post-diploma level teaching qualifications at USP.
# TABLE 1

<table>
<thead>
<tr>
<th>PROGRAMME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diploma in Education (Dip. Ed.)*</td>
<td>3-year, post-Form 6 programme designed to prepare teachers for junior levels, specialising in Science, Arts, Home Ec., etc.</td>
</tr>
<tr>
<td>Degree of Bachelor with concurrent Graduate Certificate in Education</td>
<td>4-year, post-Foundation (Form 7) programme designed to prepare specialist graduate teachers with two teaching majors</td>
</tr>
<tr>
<td>(B.A./B.Sc. GCED)**</td>
<td></td>
</tr>
<tr>
<td>Bachelor of Education (B.Ed.)*</td>
<td>3-year, post-Foundation programme with one teaching major</td>
</tr>
<tr>
<td>Post-graduate Certificate in Teaching (PGCT)*</td>
<td>Programme specially designed for untrained graduate teachers in Fiji – jointly organised by the Institute of Education at USP and the Ministry of Education, and funded by the Australian Government</td>
</tr>
<tr>
<td>Post-graduate Certificate in Education (PGCE)</td>
<td>1-year, end-on programme for graduates</td>
</tr>
<tr>
<td>In-Service Programmes</td>
<td>Designed to upgrade experienced teachers with qualified status</td>
</tr>
<tr>
<td>Certificate in Education</td>
<td></td>
</tr>
<tr>
<td>Diploma in Education</td>
<td></td>
</tr>
<tr>
<td>Bachelor of Education</td>
<td></td>
</tr>
</tbody>
</table>

* Programme discontinued

**Programme replaced by one-year, end-on PGCE
### TABLE 2

**NUMBER OF STUDENTS AWARDED THE DIPLOMA IN EDUCATION (1971-91)**

| YEAR | ARTS | | | SCIENCE | | | HOME EC | | | IND ARTS | | | COMM ST | | | TOTAL | |
|------|------|---|---|--------|---|---|--------|---|---|--------|---|---|--------|---|---|--------|---|---|
|      | Fij  | Oth | Tot | Fij  | Oth | Tot | Fij  | Oth | Tot | Fij  | Oth | Tot | Fij  | Oth | Tot | Fij  | Oth | Tot | Fij  | Oth | Tot |
| 1971 | 8    | 2   | 10  | 5    | 1   | 6   | 0    | 0   | 0   | 0    | 0   | 0   | 0    | 0   | 0   | 13   | 3   | 16  |
| 1972 | 17   | 10  | 27  | 13   | 1   | 14  | 5    | 0   | 5   | 4    | 0   | 4   | 0    | 0   | 0   | 39   | 11  | 50  |
| 1973 | 21   | 10  | 31  | 18   | 0   | 18  | 4    | 2   | 6   | 6    | 0   | 6   | 0    | 0   | 0   | 49   | 12  | 61  |
| 1974 | 19   | 15  | 34  | 21   | 1   | 22  | 11   | 0   | 11  | 7    | 0   | 7   | 2    | 0   | 2   | 60   | 16  | 76  |
| 1975 | 25   | 6   | 31  | 32   | 4   | 36  | 9    | 4   | 13  | 9    | 0   | 9   | 4    | 0   | 4   | 79   | 14  | 93  |
| 1976 | 20   | 10  | 30  | 21   | 8   | 29  | 11   | 4   | 15  | 8    | 1   | 9   | 2    | 0   | 2   | 62   | 23  | 85  |
| 1977 | 26   | 7   | 33  | 32   | 4   | 36  | 14   | 2   | 16  | 5    | 1   | 6   | 10   | 0   | 10  | 87   | 14  | 101 |
| 1978 | 23   | 21  | 44  | 30   | 3   | 33  | 13   | 1   | 14  | 20   | 3   | 23  | 3    | 2   | 5   | 89   | 30  | 119 |
| 1979 | 23   | 22  | 45  | 39   | 4   | 43  | 18   | 2   | 20  | 20   | 0   | 20  | 15   | 2   | 17  | 115  | 30  | 145 |
| 1980 | 35   | 5   | 40  | 29   | 3   | 32  | 17   | 4   | 21  | 16   | 0   | 16  | 10   | 3   | 13  | 107  | 15  | 122 |
| 1981 | 28   | 18  | 46  | 39   | 1   | 40  | 16   | 3   | 19  | 19   | 1   | 20  | 15   | 7   | 22  | 117  | 30  | 147 |
| 1982 | 28   | 4   | 32  | 30   | 5   | 35  | 21   | 2   | 23  | 12   | 0   | 12  | 32   | 3   | 35  | 123  | 14  | 137 |
| 1983 | 26   | 1   | 27  | 24   | 3   | 27  | 14   | 2   | 16  | 14   | 0   | 14  | 2    | 1   | 3   | 90   | 7   | 97  |
| SUBTOTAL | 299 | 131 | 430 | 333 | 38 | 371 | 153 | 26 | 179 | 140 | 6 | 146 | 105 | 18 | 123 | 1030 | 219 | 1249 |
| 1984 | | | | | | | | | | | | | | | | | |
| 1985 | | | | | | | | | | | | | | | | | |
| 1986 | | | | | | | | | | | | | | | | | |
| 1987 | | | | | | | | | | | | | | | | | |
| 1988 | | | | | | | | | | | | | | | | | |
| 1989 | | | | | | | | | | | | | | | | | |
| 1990 | | | | | | | | | | | | | | | | | |
| 1991 | | | | | | | | | | | | | | | | | |
| SUBTOTAL | | | | | | | | | | | | | | | | | |
| TOTAL | | | | | | | | | | | | | | | | | |

Note: 1. Breakdown of students not available for years 1984-91.
2. Fij: Fijian students; Oth: students from other countries; Tot: total
3. The above figures were compiled from USP graduation lists.
### TABLE 3

**NUMBER OF STUDENTS AWARDED BA GCED, BSC GCED, BED, PGCT AND PGCE (1972-1991)**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>BA GCED</th>
<th>BSC GCED</th>
<th>BED</th>
<th>PGCT</th>
<th>PGCE</th>
<th>TOTAL</th>
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<tr>
<td></td>
<td>Fij</td>
<td>Oth</td>
<td>Tot</td>
<td>Fij</td>
<td>Oth</td>
<td>Tot</td>
</tr>
<tr>
<td>1972</td>
<td>6</td>
<td>2</td>
<td>8</td>
<td>0</td>
<td>0</td>
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<td>1973</td>
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<td>1974</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1975</td>
<td>19</td>
<td>3</td>
<td>22</td>
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<td>21</td>
<td>1</td>
<td>22</td>
<td>0</td>
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<td>1980</td>
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<td>2</td>
<td>15</td>
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<td>11</td>
<td>5</td>
<td>16</td>
<td>0</td>
<td>0</td>
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<td>1982</td>
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<td>1</td>
<td>11</td>
<td>0</td>
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<tr>
<td>1983</td>
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<tr>
<td>1984</td>
<td>18</td>
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<tr>
<td>1985</td>
<td>15</td>
<td>15</td>
<td>30</td>
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<td>1986</td>
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<td>1987</td>
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<td>0</td>
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<td>1990</td>
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<td>1991</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>205</td>
<td>66</td>
<td>271</td>
<td>173</td>
<td>20</td>
<td>193</td>
</tr>
</tbody>
</table>

Note: 1. Fij: Fiji students; Oth: students from other countries; Tot: total
2. The above figures were compiled from USP graduation lists.

### Regional Aspirations and Initiatives

The Fijian Government stopped sponsoring students for the Dip. Ed. programme in 1984 and the B.A./B. Sc. GCED programme in 1985. The policy of the government was:

From the beginning of 1985, no new students were sponsored... for teacher training at the University of the South Pacific. They are now being encouraged to do pure degree courses taking at least two teaching subjects. After graduating they will be redirected to a locally organised secondary teacher training course which will be more relevant and more specific to Fiji's need.

(Ministry of Education, 1986, p. 25)
This change in policy of the largest sponsor of students, coupled with the decision by some countries of the USP region to run their own teacher training programmes at the junior secondary level, brought an end to the Dip. Ed. programme. It also affected the viability of the concurrent GCED programme.

After the political upheavals in 1987, a number of local senior science, mathematics and industrial arts teachers left Fiji. At the same time, the number of students at the higher secondary level kept increasing. To meet the resulting shortage of trained teachers, the Ministry of Education started an in-service programme in 1990, with Australian assistance, to train graduate teachers who were without teaching qualifications. The structure of the programme is similar to the one used in the earlier PGCT programme in that participants remain in their schools during term time and attend full-time tuition only during school holidays.

Earlier this year, Fiji established a College of Advanced Education to offer both in-service and pre-service teacher training. A new two-year, pre-service diploma programme began at the college this year with an intake of 100 students with passes in the Fiji seventh form examination. This programme, initially under Australian aid, is intended to prepare teachers for the lower-secondary level. The college is using the buildings and facilities originally designed for the Nasinu Teachers’ College in Suva.

Table 4 provides a summary of the level of teacher training available in each of the twelve member countries of USP.

**TABLE 4**

**TEACHER TRAINING PROGRAMMES AVAILABLE IN USP MEMBER COUNTRIES**

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>LEVEL: Prim/Jr Sec/Sr Sec</th>
<th>POPULATION (YEAR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cook Islands</td>
<td>Primary</td>
<td>17,754 (1981)</td>
</tr>
<tr>
<td>Fiji</td>
<td>Primary/Jr Sec/Sr Sec</td>
<td>715,275 (1986)</td>
</tr>
<tr>
<td>Kiribati</td>
<td>Primary</td>
<td>63,883 (1985)</td>
</tr>
<tr>
<td>Nauru</td>
<td></td>
<td>8,042 (1983)*</td>
</tr>
<tr>
<td>Niue</td>
<td></td>
<td>2,532 (1986)</td>
</tr>
<tr>
<td>Solomon Islands</td>
<td>Primary/Jr Sec</td>
<td>285,796 (1986)</td>
</tr>
<tr>
<td>Tokelau</td>
<td></td>
<td>1,703 (1985)</td>
</tr>
<tr>
<td>Tonga</td>
<td>Primary/Jr Sec</td>
<td>94,535 (1986)</td>
</tr>
<tr>
<td>Tuvalu</td>
<td></td>
<td>8,364 (1983)</td>
</tr>
<tr>
<td>Vanuatu</td>
<td>Primary/Jr Sec</td>
<td>140,154 (1986)</td>
</tr>
<tr>
<td>Western Samoa</td>
<td>Primary/Jr Sec</td>
<td>162,200 (1987)</td>
</tr>
</tbody>
</table>

* Includes 3,078 migrant workers from other countries.

**The Institute of Education**

The Institute of Education (IOE) was one of the seven institutes established by the USP in 1986 to strengthen the university’s developmental role in the region and to complement the work of the schools of the university. The role of the IOE was seen as...
complementing the work of the Schools of Education (now School of Humanities), as well as supporting and coordinating educational development at all levels in the region. The activities of the Institute have grown over the years, and its contribution is now recognised both by regional governments and by international aid agencies. For a number of years, the Institute has been involved in the validation of the diploma programmes offered by the Teachers' Colleges in Tonga and Western Samoa. In 1990, the IOE played a major role in the review of the secondary diploma programme offered at the Solomon Islands College of Higher Education (SICHE). More recently, the IOE was involved in a joint consultancy with AIDAB in the Science Education Project in the Solomon Islands. These activities are in line with the university's policy to assist member countries in the development of their own programmes in higher education.

SCIENCE EDUCATION IN THE REGION:
ISSUES & CONCERNS

In the following discussion I have used the term "science" to include aspects of mathematics and technology as well. The importance of science and technology education in improving the well-being of Pacific Islanders is recognised by most governments in the region. Indeed, a number of countries have placed science and technology education high on the agenda in their development plans, and are attempting to improve the quality of and access to school science. In all these attempts, a number of issues and problems need to be addressed. These vary from one country to another.

My recent observations of science teaching in Fiji (Muralidhar, 1989) and in other countries of the South Pacific indicate that there are several issues common to all countries. Observations of students' and teachers' work in classrooms, and interviews with students, teachers and curriculum officers, indicate that several factors contributed to the mismatch between the aims of science curricula and their translation into action. Some of these factors are:

- lack of adequate facilities
- shortage of materials and equipment
- lack of teaching aids and resources for learning
- difficulty in managing science activities in the classroom
- poor management of existing materials and equipment
- teachers being unaware of the overall aims and intentions of science curricula
- inadequate subject background of teachers
- teachers' attitudes toward and perceptions of activity lessons
- teachers' lack of confidence in handling science activities
- mismatch between the aims of the curriculum and quality of curricular materials
- heavy teaching loads
- pressure to complete the syllabus
- influence of examinations
- lack of leadership from science HODs
- administrators not being sensitive to teachers' concerns
- shortage of professional staff in ministries, which leads to poor communication between policy makers and practitioners
- absence of in-service courses and support facilities

Some of these problems are more acute in primary schools than in secondary schools. In general, the aspects of "in-service training," "resource support" and "feedback mechanisms," which Fullan and Pomfret (1977) considered important for successful implementation of programmes, were the ones lacking in the implementation of science
curricula. The problems confronting science education seem immense at first sight, defying any easy solutions. I strongly believe that in the South Pacific, the most important resource in science education is the teacher, and that the strategies we adopt for solving the above problems must concentrate on the professional development of teachers. Pre-service education has a part to play in addressing some of the problems, but what is needed is a recognition of the role in-service education can play in improving teaching, curricula, examinations and learning.

SOLUTIONS AND STRATEGIES

In-Service Education

Very few teachers I interviewed had the opportunity to take part in in-service courses or workshops during their teaching career. For the majority, the only training received was through the pre-service courses. It is only after being in the field that teachers start to recognise the gap between theory and practice, and that is where the importance of in-service education comes in. Most of the teachers I spoke to expressed the desire to update their knowledge and techniques, but they did not have the opportunity to do so. As a matter of priority, the ministries need to establish an on-going, in-service programme for science teachers. Such workshops must be problem-centred and based on the knowledge of the observed curriculum. The problems teachers face in translating their aims into action, and the "omnipresent gap between intention and realization" (Westbury, 1983) are the issues that need to be discussed in such courses. Teachers must feel free to reflect on their experiences and to take a critical look at their practices. The emphasis in such workshops must shift from "how to teach" to "how to learn," because to be a good teacher, one has to be a good observer, a good listener and a good learner. As Arons has pointed out:

Time and again in our investigations, we have confirmed the empirical assertion that adults (pre-service and in-service elementary teachers) acquire the abstract reasoning patterns and the conceptual understanding conveyed in the elementary science curricula only by overcoming exactly the same obstacles, hurdles, and difficulties that are experienced by the children – and at no more rapid, and frequently slower, pace than they do. (Arons, 1983, pp. 113-114)

It is by becoming learners themselves that teachers will be able to better understand the problems their students face. Covering the syllabus is easy; "uncovering" it to students is difficult.

Opportunities must be provided for teachers to take a critical look at the quality and appropriateness of curricular materials and examinations in use. Teachers must be made aware of recent research studies on teaching and learning. It might also be useful to expose teachers to science curricula developed elsewhere so that they could compare the approaches used to develop similar concepts. It is not appropriate here to discuss all the themes that might be covered in teachers’ workshops. The point being made is that regular, in-service courses must be seen as an essential form of professional support for teachers, and for such courses to be effective and worthwhile, science teachers must also be involved in planning and contributing to them.
Staffing in Science Education

Developing a science curriculum is not simply a matter of writing pupils' books and teachers' guides, then supplying them to schools. A number of areas need attention for the proper functioning of the curriculum. Revision of materials based on the observed curriculum and feedback from teachers, establishment of support systems for teachers, improvement of examinations, and evaluation of the effectiveness of the curriculum, all of these demands call for an increase in the number of skilled science education personnel within the ministries. One way to tackle this problem is to identify primary and secondary teachers who have the necessary skills, and use their services part-time to supplement the ministry's resources. Other advantages in using this approach are: first, teachers are likely to relate well to their own colleagues because of their shared concerns; second, over a period of time this will create a large pool of resource personnel to draw from; third, these teachers can play a role in encouraging the sharing of resources and expertise between science teachers in different schools.

Distance Education and Professional Development

As a result of the drop in the number of pre-service enrolments in teacher education programmes in the mid-1980s, the Department of Education (now Department of Education & Psychology) at USP started developing a number of distance education courses and programmes designed to assist professional development of teachers in the field. There is a great demand in the region for our programmes in Educational Evaluation, Educational Administration, and Guidance and Counselling. We are also developing courses in Teaching and Learning in different subject areas, designed to upgrade the knowledge and skills of teachers in the region.

Attempts are also underway to equip regional USP Centres with science laboratories and computers, and to implement the recommendations of a recent survey of science teaching through distance mode (Pillai, Bonato, Muralidhar and Wah, 1991). With the availability of these facilities, science teachers in the region will be able to upgrade their content knowledge by taking science courses offered through the distance mode. These facilities can also be used for conducting in-service workshops for teachers. The availability of computers makes it possible to replace some traditional laboratory activities with computer-based activities in simulation and modelling. Attempts are also being made to improve the satellite-tutorial facilities for students in the region.

The Media Centre at USP and the newly established Centre for the Enhancement of Learning and Teaching (CELT) will have an important role to play in improving the quality of our distance education programmes.

CONCLUSION

I said earlier that the teacher is the most important resource in the science classroom and is the principal agent in communicating curriculum. My observations have reinforced that assumption and have revealed a number of factors that inhibit the work teachers and students do in science lessons. In their day-to-day work, science teachers
have to grapple with a number of demands and dilemmas. What Olson and Russell wrote about science teachers in Canada applies with even greater force in the context of the South Pacific:

Not all these teachers are trained scientists and not all work with ample resources, but all of them work with large numbers of children whose abilities vary considerably and whose home support varies even more. Teaching children with such a large range of social and psychological backgrounds is very demanding.... To ask teachers to change their methods and objectives without first considering the reasons they behave as they do in the first place is unwise, ...to put it mildly. (Olson and Russell, 1984, pp. 28-29)

What teachers said in interviews clearly indicated that the majority were not happy with the existing situation. They pointed both directly and indirectly at the constraints placed on their work, many of which were beyond their control: they wanted students themselves to do science activities, but they were short of equipment and materials; they wanted to move beyond the book and discuss matters that interested them and their students, but these were not directly related to exams; they wanted to spend more time with the weaker students, but they had to cover the work; they wanted to plan for alternative activities, but the exams were based on what was in the book; curriculum designers expected them to teach science in a certain way, but many teachers did not have the necessary skills to do so.

What is needed is the recognition of the key role teachers play in translating the curriculum. Those who make policies and those who design science curricula need to be sensitive to teachers’ concerns, and must seek ways to support and strengthen the work teachers do. As Holt has pointed out:

If we seek to improve the curriculum, we must help teachers to extend their professionalism so that they can identify curriculum problems, generate alternative solutions to them, justify defensible solutions....they are the essential matters on which effective curriculum building and effective learning depend. (Holt, 1984, p. 156)

In a similar vein, Hughes stresses the centrality of the teacher in the curriculum process:

No matter what process of design and implementation may be used, no matter what theory may lay behind it, the teacher remains in the central focus of communications.... No pattern of curriculum planning which ignores the role of the teacher can be realistic. (Hughes, 1978, p. 147)

Policy-makers, curriculum designers, school administrators, teacher-educators and teachers all have a part to play in addressing and responding to these challenges. The role of the Commonwealth of Learning in addressing these issues should become clear as a result of the discussions at this Round Table.
References


CHAPTER 11

TEACHER EDUCATION: THE INDIAN SCENARIO

K. Gopalan

RATIONALE

The education of teachers must keep pace with the ever-changing aspirations, needs and demands of society. Over the last few years, we have witnessed in India unprecedented debates revolving around the issue of relating education to national restructuring. These debates culminated in adoption of the National Policy on Education (NPE) in 1986, which has recently been under review. Critical analysis of India’s current socio-political situation and the state of its educational system has revealed several concerns relevant to teacher education.

Theoretical Rationale of Teacher Education

Many factors shape teacher education programmes. These range from historical and sociological forces to theories of education and learning. Concern with equality, democratic ethics, fulfillment of constitutional obligations, even the status of teachers and how they perceive their role shape a country’s teacher education programme.

The Changing Role of the Teacher

Teachers’ roles are not fixed; they change as our conceptions of educational goals and methods evolve. In view of current educational principles and priorities, the Programme of Action (POA) of the NPE has described the contemporary teacher’s role as follows:

As far as the whole-time teachers in educational institutions are concerned, their principle role is, and will be, teaching and guidance of their pupils, not only through classroom instruction and tutorials, but by personal contact and numerous other ways teachers have always employed for building the character of their pupils. Teachers at all stages have to be expected to undertake or promote research, experimentation, and innovation. Teachers have an indispensable role in extension and social service. They have also to participate in the management of a variety of services and activities which educational institutions undertake to implement their programme.
Assumptions Underlying Teacher Training

The general rationale for training teachers in generalised and specialised skills in the teaching of science, mathematics and technical/vocational subjects includes the following:

- The professional competence required of teachers is achieved through an organised programme of learning experiences; it is not merely a by-product of becoming a well-educated person.
- A broadly based general education should enable teachers-in-training to attain mastery of the subject matter.
- General education should contribute to personal growth. Specialisation should provide scholarly knowledge of the subjects to be taught. Professional education should teach the skill of professional performance.
- Prospective teachers must increasingly assume responsibility for their own education.
- Opportunities to work with adolescent learners must be an integral part of the professional preparation of teachers.

ISSUES AND PROBLEMS

Institutionalised teacher education loses its sociological and educational relevance if it does not keep up with the development of school education in its theory and practice. Teacher education programmes must adapt themselves to new curricular demands.

“Education for All”

In 1950 the Indian Constitution provided free and compulsory education for all children up to age 14. This goal, however, is yet to be realised.

Even more alarming than the failure to achieve universalisation of elementary education are the continuing disparities in education between regions, social classes and the sexes. Girls, the scheduled castes, the scheduled tribes, other undeveloped communities and disabled children are deprived of educational opportunities particularly in rural areas. Appropriate affirmative action programmes are necessary to rectify these unjust disparities.

Teacher education curricula should assist teachers in:

- working with parents and motivating them to send their children to schools
- developing sensitivity
- teaching oversized and multi-grade classes
- conducting surveys, micro-planning and school mapping exercises
- organising non-formal education classes and designing curricula for specific communities
- providing compensatory education for the disadvantaged children
- identifying the learning difficulties of disabled children in integrated settings and teaching classes with groups of mixed ability.
These needs are not being addressed in current teacher education curricula. Advanced communication technology must be employed in order to train sufficient teachers for universalisation of elementary education, especially in rural and remote areas. To achieve this objective, India must develop cost-effective facilities for distance education.

National Core Curriculum

The new curriculum provides the core elements necessary to preserve a national identity. It includes the history of India’s struggle for freedom, constitutional obligations, etc. These core elements are designed to promote the following values:

- India’s common cultural heritage
- egalitarianism, democracy and secularism
- equality of the sexes
- protection of the environment
- removal of social barriers
- observance of small family norm
- inculcation of scientific temper.

The incorporation of these elements into the school curriculum presents a challenge to course designers, syllabus framers, textbook writers and teachers. Modules could be developed and offered through distance education and as background reading materials.

Child-Centred Approach

The child-centred approach views education as a joyful, creative and satisfying learning experience rather than an inflexible system of rote instruction. Child-centred education:

- acknowledges the needs and interests of the child
- permits the child to learn at its own pace
- fosters investigation and discovery
- encourages learning through play
- provides remedial instruction.

The child-centred approach will transform the entire teacher education curriculum. The new programmes for teacher education, whether offered face-to-face or through distance mode, will have to devise appropriate methods and techniques to facilitate interactive processes of teaching and learning.

Teacher education curricula should reflect a concern for value development. Toward this end, teachers-in-training would require curricular and co-curricular inputs specifically designed to promote understanding of the psychological, sociological and philosophical bases of value acquisition. This goal would be difficult to achieve, however, through distance education.

A new role for teachers nowadays is that of “information organiser” – someone who collects, classifies, stores, retrieves and disseminates information. Computers are an essential “prop” for this role, and teachers must be adequately trained to exploit this technology to its fullest potential.
Issues of Quality, Quantity, Time and Cost

Qualitative improvement of teacher education depends on:

- the quality of students entering teaching
- the relevance of teacher education curricula to objectives of teacher preparation
- duration of teacher training
- the professional preparation of teacher educators
- the infrastructure support to teacher education institutions
- maintenance of quality control in teacher education.

Gross discrepancy between the theory and practice of education has undermined confidence in teacher training. It cannot simply be confined to pre-service training. Programmes must be created in which both pre-service and in-service training are integral parts of teacher preparation.

A proposal has been formulated in India to confer autonomous and statutory status on the National Council of Teacher Education (NCTE) with powers to maintain standards in teacher education and ensure the coordinated, integrated development of teacher education.

Specific Problems and Constraints Encountered in Training Teachers

The foregoing discussion of issues and problems suggests the following initiatives required in teacher training:

- programmes to integrate education of the disabled
- teacher training in non-formal education, multi-grade teaching and non-scholastic areas
- the training of female teachers to meet specific needs
- training in how to improve students’ learning attainment (Minimum Levels of Learning – MLLs)
- training in the teaching of integrated science
- training in early childhood educational needs.

SOLUTIONS AND STRATEGIES

Teacher education programmes in science, mathematics and technical/vocational subjects, specifically, are in need of total reorganisation. Priorities include:

- removing deadwood from the existing training courses to provide room for realistic and practical interventions
- redesigning of teacher education curricula to match the expectations of the school curriculum
- development of appropriate instructional material based on the revised curriculum content
- orientation of teacher educators to the new curricular demands
- developing educational technology support.
Strategies for Training of Teachers at Various Levels

In India, the national system of education is based on a model known as the “10+2” pattern, which provides 10 years of general, undifferentiated education followed by 3 years of diversified academic/vocational education (see Appendix A). The first 10 years include: 5 years of primary education, 3 years of upper-primary education and 2 years of secondary education. The primary and upper primary stages are referred to as elementary education.

1. Science and Mathematics Teachers up to the Secondary Stage

The various models of teacher education adopted for the preparation of science and mathematics teachers up to the secondary stage are outlined below:

One-year model

Various one-year models are being followed. Essentially a pre-service teacher education programme should comprise at least one academic year, preceded by an adequate general education. Examples include:

- 10 years of school education for the pre-primary level
- 10+2 years for the primary/elementary level
- A Bachelor’s degree for the secondary level
- A Master’s degree in a relevant subject for the higher secondary level.

Appendices B(a) to B(d) outline one such teacher education programme for the different levels, showing the length of time devoted to course components.

Integrated teacher education model

An integrated teacher education curriculum is divided into three areas: general education, professional education and content courses. Teaching languages as part of the general education in this programme enhances mastery of other subjects for which prospective teachers must have high levels of language comprehension, as well as effective verbal and written communication skills. Fluency in both the native language and in English is necessary for optimal teacher education. Social science is included in teacher training for science and technology in order to foster awareness of social phenomena as they pertain to the conceptual framework.

A content outline of the four-year science teacher programme is provided in Appendix C.

Internship model

It is now suspected in India that the conventional, institution-based model of pre-service and in-service teacher training may be inadequate to meet the challenge of universalisation of elementary education (UEE). The standard approach has several deficiencies:

- it is divorced from everyday reality
- links between theory and practice are weak
- infrastructure facilities are inadequate.

The emphasis ought to shift toward developing rather than simply training the teacher. In the internship model, training starts with a brief theoretical orientation in teacher
education institutions. This phase is followed by a three- to five-year internship in a school. Each trainee is attached as an intern to an experienced teacher who serves as a model. In the second and third years, supervision becomes less frequent, and the trainee functions more independently. During this phase of supervised teaching, the trainee is required to attend short sessions in teacher education institutions. The trainee is certified as a teacher after three to five years of continuous evaluation by supervisors and senior teachers.

The internship model provides a broader scope for the trainees’ development of skills and modes of thinking. At present, however, there are neither well-documented experiences with this model, nor studies examining the practical aspects of adopting it on a large scale. Its comparative advantages are, nevertheless, currently under discussion.

There are at present, no well-documented experiences of this model and the practical aspects for its adoption on a large scale. Its comparative advantages are, however, currently under discussion.

2. Science and Mathematics Teachers for the +2 Stage

To improve the quality of teacher education, a variety of courses designed to meet the specific requirements of teachers at particular levels of education is preferable to a single course for all. Higher secondary (+2) teachers need a professional course to acquire a command of the subject matter and hone teaching skills. To address this need, M.Sc.Ed. courses in chemistry, mathematics, physics and life sciences were instituted by the National Council of Educational Research and Training (NCERT) in 1974 (see Appendices D(a) to D(d)). Although the universities offer M.Sc. courses primarily aimed at producing scientists and research workers, many degree holders also accept teaching posts in colleges and schools. The M.Sc.Ed. courses, on the other hand, were developed with the objective of preparing individuals for the teaching profession, especially in higher secondary schools. They are not designed to prepare subject specialists. Teachers at the +2 stage need a general course to provide subject knowledge that is at least 95% as comprehensive as that of the M.Sc. courses taught at universities. They also require courses in pedagogy. The audit courses offered under “additional education” are only for recent B.Sc. degree holders.

3. Teacher Preparation for Technical/Vocational Subjects

There are no institutional strategies for the development of technical/vocational teacher education programmes in schools. The school curriculum provides for the teaching of work experience to all children until class X. There is also provision for offering pre-vocational courses from class IX, and vocational courses in classes XI and XII.

In 1958, the first attempts at teacher preparation for vocational subjects were made, following introduction of diversified school education (multi-purpose system). A four-year technology programme in the NCERT’s Colleges of Education was launched. It included engineering sciences and engineering trades. The former encompassed mechanics and engineering materials; engineering drawing and design; workshop technology and practice; and elements of engineering. The latter focused on the specific skills required for trades in these fields. In addition, one-year vocational programmes were offered in agriculture, home science, commerce and fine arts. Similar programmes in agriculture and commerce are still offered.

Unfortunately, an inadequate response by the school system to the introduction of vocational education impeded progress of the multi-purpose scheme, and the vocational
teacher preparation programmes fell by the wayside. In the absence of organised teacher
preparation programmes for vocational subjects, the current practice is to use expertise
available in the environment to offer courses in agriculture, home science, the
humanities, paramedical services, commerce and business, technology and engineering.

4. Roles of Distance Education and Communication Technology

Distance education in the pre-service training of teachers must be appropriate for the
subject matter. For example, a teacher education course in cognitive, affective or
psychomotor disciplines must foster development of knowledge, abilities, attitudes and
skills. Distance education techniques can achieve the cognitive aspects well; however,
they cannot impart those abilities, attitudes and skills without which the professional
preparation would be incomplete.

Nevertheless, if proper norms and appropriate methodologies could be established for
teacher training through distance education, it would prove to be a valuable mode of
teacher preparation, including in-service education. In fact, distance education is the
only feasible means for the periodic renewal of India’s 4 million teachers.
Corresponding print and non-print instructional materials would be necessary for this
purpose, as would a system of developing instructional methodology to provide these
programmes on a continuing basis. Opportunely, recent advances in telematics,
informatics, video technology and optical communication have created radically new
ways to convey education within and beyond the classroom.

5. Problems with Laboratories and Workshops

Components of teacher training that involve laboratories and workshops have suffered in
distance education programmes. This situation could be corrected by carefully selecting
a suitable geographical distribution of institutions that could make their facilities
available for the organisation of contact sessions with client groups in the region. Kits,
manuals and other support materials could be developed and provided at study centres
instead. Audio-video cassette programmes are also a possibility.

India did attempt to establish a model of in-service education for clearing a backlog of
untrained teachers during the period from 1964 to 1980. The aim of this programme,
called Summer School-cum-Correspondence Course, was to alternate the
correspondence education with contact sessions during two, two-month summer
vacations. These contact sessions were equivalent to regular courses offered in the non-
distance education mode. This programme gave untrained teachers the opportunity to
carn a Bachelor’s degree while in service.

6. Institutionalisation of In-Service Education

Under the centrally sponsored Scheme of Teacher Education, India is developing
infrastructures to institutionalise in-service teacher education. Noteworthy
initiatives include:

- the Programme of Mass Orientation of School Teachers (PMOST)
- establishment of District Institutes of Education and Training (DIETs)
- rejuvenating of Colleges of Teacher Education (CTEs)
- upgrading of some CTEs to Institutes of Advanced Studies in Education (IASEs)
- assisting State Councils of Educational Research and Training (SCERTs)
- creation of university Departments of Educational Studies.
These measures will vastly improve the quality of India’s teachers and revitalise teacher education, particularly the in-service education of teachers and teacher educators.

RECOMMENDATIONS AND SUGGESTIONS

Improvement in education is dependent upon teacher education programmes producing quality teachers. All countries must contend with this issue at a national level. International cooperation could prove valuable, however, especially with regard to exploiting the distance education mode. Possibilities to explore include:

- apprising Commonwealth institutions, agencies and countries of COL’s programmes and activities to enable them to draw upon the resources of COL
- disseminating print and non-print materials developed by COL or under its auspices to the institutions and countries concerned
- granting of complimentary permission to reproduce such materials copyrighted by COL
- assisting countries with the establishment of norms and standards for teacher education programmes offered through the distance education mode
- permitting enrolment of teachers in certain programmes offered on an international scale
- identifying areas of collaborative research, particularly in the area of distance education
- aiding member countries in developing print and non-print materials in order to accelerate their acquisition of expertise in these tasks
- coordinating the exchange of literature and other materials among Commonwealth countries to facilitate the development of open learning systems
- supporting distance teaching institutions through staff training, improved communications, an information service about distance education, and programmes of evaluation and research
- helping distance teaching institutions to improve study support systems and allow for the exchange of credits
- establishing regional units to promote cooperative partnerships and the sharing of resources
- utilising distance education as an instrument for development in new areas of science and technology, as well as a vehicle for learning of the humanities and social sciences
- working closely with colleges and universities of the Commonwealth
- arranging for much of COL’s work on the development of materials to be carried out under contract
- harnessing communication technology to widen access to education and improve its quality, with the ultimate goal of enabling anyone anywhere in the Commonwealth to study any distance teaching programme offered through any college or university in the Commonwealth.
Appendix A

EDUCATIONAL STRUCTURE IN INDIA
## EARLY CHILDHOOD EDUCATION (INDIA)

<table>
<thead>
<tr>
<th>Curriculum Components</th>
<th>Weight in terms of time</th>
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</thead>
<tbody>
<tr>
<td><strong>A. Foundation Courses</strong></td>
<td>20%</td>
</tr>
<tr>
<td>i. Education in Emerging India (the socio-cultural context of education)</td>
<td>10%</td>
</tr>
<tr>
<td>ii. Child Development and Adjustment (focus on age group 3 to 7)</td>
<td>10%</td>
</tr>
<tr>
<td><strong>B. Stage Relevant Specialisation</strong></td>
<td>35%</td>
</tr>
<tr>
<td>iii. Early Childhood Education Systems (Montessori, Froebel, etc.) and Integrated Child Development Services (ICDS) in India</td>
<td>5%</td>
</tr>
<tr>
<td>iv. Cognitive Development Activities (Piagetian and similar approaches)</td>
<td>5%</td>
</tr>
<tr>
<td>v. Language Development Dimension and Activities (spoken language sounds, vocabulary, sentence patterns)</td>
<td>5%</td>
</tr>
<tr>
<td>vi. Personal-Social Development/Dimensions and Activities</td>
<td>5%</td>
</tr>
<tr>
<td>vii. Reading, Writing and Arithmetic (scientific treatments)</td>
<td>5%</td>
</tr>
<tr>
<td>viii. Readiness and Initiation (physical and major developments, work skills and health care)</td>
<td>5%</td>
</tr>
<tr>
<td>ix. Aesthetic and Cultural Development Activities</td>
<td>5%</td>
</tr>
<tr>
<td><strong>C. Practicum/Field-Work</strong></td>
<td>45%</td>
</tr>
<tr>
<td>x. Practical Work (with children and homes/community)</td>
<td>20%</td>
</tr>
<tr>
<td>xi. Internship in Teaching (in pre-primary and primary schools)</td>
<td>20%</td>
</tr>
<tr>
<td>xii. Co-Curricular Activities</td>
<td>5%</td>
</tr>
</tbody>
</table>
## PRIMARY/UPPER-PRIMARY EDUCATION (INDIA)

<table>
<thead>
<tr>
<th>Curriculum Components</th>
<th>Weight in terms of time</th>
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<tbody>
<tr>
<td><strong>A. Foundation Courses</strong></td>
<td></td>
</tr>
<tr>
<td>i. Education in Emerging India (philosophical and socio-cultural perspectives)</td>
<td>10%</td>
</tr>
<tr>
<td>ii. Elementary School Students – Learning Processes, Adjustment (Educational Psychology)</td>
<td>10%</td>
</tr>
<tr>
<td><strong>B. Stage Relevant Specialisation</strong></td>
<td>35%</td>
</tr>
<tr>
<td>iii. Elementary Education and Teacher Functions</td>
<td>5%</td>
</tr>
<tr>
<td>iv. Language Teaching (mother tongue and English)</td>
<td>5%</td>
</tr>
<tr>
<td>v. Mathematics Teaching</td>
<td>5%</td>
</tr>
<tr>
<td>vi. Environmental Studies Teaching (as related to Stds. I to V)</td>
<td>5%</td>
</tr>
<tr>
<td>vii. Health and Physical Education</td>
<td>5%</td>
</tr>
<tr>
<td>viii. Arts Education, Work Experience</td>
<td>5%</td>
</tr>
<tr>
<td><strong>C. Additional Specialisation</strong></td>
<td>10%</td>
</tr>
<tr>
<td>ix. Science Teaching and Social Studies Teaching/Pre-School Education</td>
<td>5%</td>
</tr>
<tr>
<td>x. Elective (one) : (Adult Education/Non-Formal Education/Social Education/Tribal Education/Multiple Class Teaching/Population Education/Special Education/Education Technology)</td>
<td>5%</td>
</tr>
<tr>
<td><strong>D. Practicum/Field-Work</strong></td>
<td>40%</td>
</tr>
<tr>
<td>xi. Practical Work</td>
<td>20%</td>
</tr>
<tr>
<td>xii. Internship in Teaching (in primary and upper-primary/pre-school systems)</td>
<td>20%</td>
</tr>
</tbody>
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# SECONDARY EDUCATION (INDIA)

<table>
<thead>
<tr>
<th>Curriculum Components</th>
<th>Weight in terms of time</th>
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<tbody>
<tr>
<td><strong>A. Foundation Courses</strong></td>
<td>20%</td>
</tr>
<tr>
<td>i. Education in Emerging India (philosophical and socio-cultural perspectives)</td>
<td>10%</td>
</tr>
<tr>
<td>ii. Educational Psychology (with focus on learner development and stages, learning, adjustment)</td>
<td>10%</td>
</tr>
<tr>
<td><strong>B. Stage Relevant Specialisation</strong></td>
<td>30%</td>
</tr>
<tr>
<td>iii. Secondary Education and Teacher Functions</td>
<td>10%</td>
</tr>
<tr>
<td>iv. A secondary school subject with prior specialisation</td>
<td>10%</td>
</tr>
<tr>
<td>v. A second secondary school subject/higher secondary education/primary education</td>
<td>10%</td>
</tr>
<tr>
<td><strong>C. Additional Specialisation</strong></td>
<td>10%</td>
</tr>
<tr>
<td>vi. Elective (one) (Adult Education/Secondary Education/Population Education/Distance Education/Library Services/Tribal Education/ Special Education – integrated and one category/ Health &amp; Physical Education/Art Education/ Work Experience/Educational Technology/ Action Research/Computer Education)</td>
<td>10%</td>
</tr>
<tr>
<td><strong>D. Practicum/Field-Work</strong></td>
<td>40%</td>
</tr>
<tr>
<td>vii. Internship in Teaching (including field assignments)</td>
<td>20%</td>
</tr>
<tr>
<td>viii. Practical Work (including working with community, and social service and work experience)</td>
<td>20%</td>
</tr>
</tbody>
</table>
## HIGHER SECONDARY EDUCATION (INDIA)

<table>
<thead>
<tr>
<th>Curriculum Components</th>
<th>Weight in terms of time</th>
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</thead>
<tbody>
<tr>
<td>A. Foundation Courses</td>
<td>20%</td>
</tr>
<tr>
<td>i. Education in Emerging India (with special reference to Higher Education)</td>
<td>10%</td>
</tr>
<tr>
<td>ii. Educational Psychology (with special emphasis on adolescence/learning, adjustment and personality)</td>
<td>10%</td>
</tr>
<tr>
<td>B. Stage Relevant Specialisation</td>
<td>30%</td>
</tr>
<tr>
<td>iii. Higher Secondary Education and Teacher Functions</td>
<td>10%</td>
</tr>
<tr>
<td>iv. Communication Technology and Media Resources</td>
<td>10%</td>
</tr>
<tr>
<td>v. Curriculum Transaction Strategies (one subject related to +2 stage)</td>
<td>10%</td>
</tr>
<tr>
<td>C. Additional Specialisation</td>
<td>10%</td>
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<td>viii. Internship Teaching (at the +2 stage)</td>
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### FOUR-YEAR, EIGHT-SEMESTER B.A. ED. COURSE (INDIA)

#### PANORAMA OF COURSES OVER THE SEMESTERS

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*Note: Total contact hours for the professional education courses do not sum up to the total hours listed in the table.*
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*Course common to Sc.Ed. (Chemistry)/M.Sc.Ed. (Mathematics)/M.Sc.Ed. (Physics)
## OUTLINE OF COURSE CONTENT OF M.Sc.Ed. COURSES
(INDIA)

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# OUTLINE OF COURSE CONTENT OF M.Sc.Ed. COURSES (INDIA)

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*Course common to M.Sc.Ed. (Chemistry)/M.Sc.Ed. (Mathematics)/M.Sc.Ed. (Physics)
### Appendix D(d)

**COURSE OUTLINE FOR ADDL. ED. EXAMINATIONS FOR RECENT B.Sc. ADMITTED TO M.Sc.Ed. CHEMISTRY/MATHEMATICS/PHYSICS COURSES**

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CHAPTER 12

TEACHER TRAINING AND
THE CONTEXT OF SCIENCE EDUCATION
AT THE ELEMENTARY STAGE

S. J. Rajput

OVERVIEW

Excellence in any learning centre—a primary school, teacher training institution or an
institution of higher learning—is directly linked to the commitment, willingness and
professional preparedness of the teachers. The Education Commission (1964-66)
observed that “of all the factors that influence the quality of education... the quality,
competence and character of teachers are undoubtedly the most significant.” These
attributes obviously are substantially dependent on the quality of initial training,
retraining, and the regular professional and technical support available to the teachers.
The National Policy on Education (NPE-86) places complete trust in the teaching
community. It calls for substantial improvement in the quality of teacher education and
emphasises teachers’ accountability to the pupils, the parents, the community and to
their own profession. It also envisages new programmes of teacher education, which to
emphasise continuing education and the need for teachers to meet the thrusts outlined.
These aspects have been reiterated in the revised Policy on Education (1992).

It may be worthwhile to have an idea of the magnitude of the task at hand. Out of
1,600,000 primary teachers, 89.84% were trained. Corresponding figures for the upper-
primary stage are 1,047,000 and 91.74%, respectively. In 1989-90 there were 400
secondary-level Teacher Education Institutions. Any new initiative in terms of policy,
curricular changes and introduction of innovative transactional strategies would
immediately require in-service training of the teacher educators, including the heads of
these institutions. Education of teacher educators and their continuous re-education is
to be viewed as crucial to any initiative intended to update and achieve qualitative
improvements in teacher education.

The Scheme of Restructuring and Strengthening Teacher Education was launched in
1987-88. It was proposed to upgrade Colleges of Teacher Education, establish Institutes
of Advanced Studies in Education, strengthen university departments of Education, and
augment and strengthen the State Councils of Educational Research and Training
(SCERTs). The most outstanding component of this scheme was the establishment
of District Institutes of Education and Training (DIETs). These are to provide
comprehensive support to all efforts in universalisation of elementary education. This
support would extend to wide quantitative coverage to ensure upgrading of the
professional preparedness of the teachers through direct interaction and of the children
by providing better equipped teachers and supervisors in schools. Non-Formal Education Centres and Adult Education Centres. The establishment of DIETs is widely acknowledged as a unique, dynamic and comprehensive effort initiated for the first time on such a large scale. If this effort fails or falters, the outcome will be a major set-back not only in teacher preparation, but in the national efforts to universalise elementary education. Improvements, both in participation and levels of achievement of children at the elementary stage, are now intimately linked to effective functioning of DIETs. These institutions are supposed to prepare professionally well-equipped and trained teachers with a commitment to the task of universal elementary education (UEE). The teachers and all other functionaries of the elementary stage of education would regularly interact with DIETs and their training would no longer be a one-time affair.

With the support of input from academicians, educationists and institutions, the central government and state governments together formulated the operational details of the scheme. The basic philosophy, objectives, structures and possible impact have been, by now, well internalised. DIETs are supposed to “provide academic and resource support at the grassroots level for the success of various strategies and programmes being undertaken in the area of elementary education and adult education.” This can be achieved only if DIETs, as institutions, achieve excellence in their functioning early, and take along with them other institutions also.

It may be worthwhile to mention the functions of a well-endowed training institution:

- pre-service and in-service education of teachers for the formal school system
- induction-level and continuing education of non-formal education and adult education instructors and supervisors
- training and orientation of heads of institutions in institutional planning and management, and micro-level planning
- orientation of community leaders, functionaries of voluntary organisations and others influencing school-level education
- academic support to school complexes and district boards of education
- action research and experimentation work
- serving as an evaluation centre for primary and upper-primary schools, as well as non-formal and adult education programmes
- provision of a resource and learning centre for teachers and instructors
- consultancy and advice, for example, to district boards of education.

In order to provide professional input to these district-level resource centres, it was resolved to strengthen the state-level SCERTs. It was decided that in view of the need and urgency, the focus in SCERTs would be on elementary education. This would include preparation of curricular and training materials; monitoring, planning and evaluation; use of educational technology; promotion of research, including action research and developmental research; resource mobilisation; community association and involvement. Essentially, this is to be a comprehensive, well-endowed, dynamic resource centre that can motivate the district level institutions in more than one way. It would maintain professional partnership with other institutions, including those at the national level, for example, National Council of Educational Research and Training (NCERT) and the National Institute of Educational Planning and Administration (NIEPA). They would also work in secondary education, but by seeking cooperation from other organisations and institutions.
The following points need to be taken into account while planning for the professional upgrading of the teacher educators:

- need to develop appreciation of the new role, culture and functions of teachers
- prepare the teacher to break the rigidity of curriculum transaction methods and procedures, and to replace these by those learned in the in-service training programmes
- prepare the trainees to break new ground and take up new initiatives to identify the community needs, and link these to the curriculum and the technological changes taking place
- make explicit attempts to promote dynamism, creativity and commitment among trainees through education in general and teacher education in particular
- prepare trainee teachers to interact with other resource institutions on a regular basis. They also need to be aware of other developmental initiatives taking place in the area and agencies working for the welfare of younger children in particular. A coordinated effort of all such initiatives would definitely help achieve the objectives of DIETs.

While elementary teacher training institutions have generally been following programme guidelines issued by the National Council of Teacher Education, there have been some very significant developments on a selective basis. New programmes in Bachelor of Education (Elementary Teacher Education) and Master of Education (Elementary Education) are two such initiatives. Products of these courses are expected to play a key role in innovative and research activities. In general, teacher education programmes at the elementary stage now have special elective papers on use of educational technology, environmental education, non-formal education, working with the community, education of the disabled, etc., which represent current needs and trends. Given the particular importance of training teachers in science, we shall attempt to identify the specific expectations of science teachers and teacher educators.

THE CONTEXT OF SCIENCE EDUCATION

Countries presently struggling to universalise elementary education are, in fact, attempting to universalise simultaneously science education as well. Environmental orientation to education with total integration of science and social science at primary and upper-primary stages has been accepted at policy level, and is being implemented with adequate care and caution. Accordingly, the training strategies have to be governed by both of these considerations. The teachers of science or environmental studies are not just the transactors of information and assigned curricula in the classrooms. They have a much wider role to play. Some of their roles include:

- curriculum developer
- curriculum transactor and partner in learning
- motivator
- resource mobiliser and improviser
- innovator and experimenter of new ideas
- evaluator of progress and learning attainments
- builder of school community relationship
- communicator of uses of science and technology in everyday life.

The science teacher prepares children for learning and life. As adults, these children should be able to understand the changes taking place in their immediate environment and also perceive the changes that are taking place globally. They should reject those
that are undesirable, but accept and maximise the desirable changes to improve the quality of life. For this purpose, some specific competencies are required of teachers. They include the following abilities and skills:

- develop an understanding of science and take a holistic view of science
- acquire and cultivate sound scientific literacy, scientific temper, and appreciation of social and ethical aspects of science
- formulate clearly the instructional objectives for each lesson
- analyse and organise the content in terms of texts, concepts, principles, activities and applications in everyday situations
- plan suitable science activities, mobilise resources, and promote spirit of scientific enquiry and experimentation
- design, identify and implement strategies aimed at developing science process skills
- relate learning experiences and learning activities to the age and developmental stage of the learner
- design and organise activities suitable to slow learners, gifted children, physically and mentally handicapped students
- adopt learner-centred and activity-based approaches
- utilise learning experiences from life and the immediate environment of the learners
- develop suitable tests, procedures and methods of evaluation, and use feedback for remedial action
- identify real-life situations, the solutions to which are undetermined and probably could be obtained by teacher and learner working together
- improvise, handle and utilise low-cost teaching learning aids to make the learning environment joyful
- familiarise oneself with the curricular changes taking place
- equip oneself to act as interpreter of new ideas and technologies to the community
- use competency-based teaching, learning and evaluation practises
- remain sensitive to improvement-oriented teaching, learning and evaluation
- perceive and utilise the relationships of science and technology to health, agriculture, industry, nutrition and other aspects of day-to-day living
- use scientific knowledge to erase false beliefs, prejudices and practises
- develop decision-making and problem-solving skills for common life situations.

The teacher educators normally could have to solve several problems in attempting to make the trainees absorb the above-mentioned components. They will have to respond to the trainees, who may have little understanding of the new curricular changes. The level of comprehension and willingness to learn may result in a group with varying aptitudes. At primary and upper-primary levels, particularly in understaffed schools, the teachers might never have learned science during their education and earlier training. To deal with this situation, the teacher educators will have to seek a variety of solutions. At the policy level, the curriculum of teacher education at pre-service as well as in-service levels has to be examined again and redefined.

In a large country, not all teacher-training institutions provide pre-service training of acceptable quality. Upgrading such institutions would be basic to the initiatives aimed at quality improvement. In view of the large numbers involved, teacher educators will have to be trained through a cascade model, in which key persons are prepared by national or regional institutions, followed by training programmes at state levels. A similar and much more comprehensive strategy would be needed in the case of in-service training/orientation of teachers. Media support could be synchronised in both situations. Effective steps have to be taken to minimise the dilution of the transfer of training and to maintain desirable levels of quality.
The expansion of learning centres for basic education, formal schools and the non-
formal education centres has resulted in considerable imbalance of resources within the
elementary education sector. An unusually large proportion of these resources is spent
on salaries of teachers, leaving hardly any scope for other academic and professional
inputs. The cost factor plays a big role, usually inhibitory. The absence of teachers
from the schools also causes disruptions, as no substitute teachers are provided. All of
these aspects need to be analysed while evolving strategies for teacher transformation.

EMERGING STRATEGIES

The teacher is the principal means of proper implementation of educational policy
and programmes. The effective transaction of curricula both within and outside the
classroom is, for all practical purposes, the total responsibility of the teacher.
Accordingly, the expectations of teacher educators are high and demanding. These have
been further enhanced by the rapid changes taking place on the social and educational
scene. The impact of scientific and technological changes and the urge of the masses to
participate in educational processes are mainly responsible for these developments.
When one examines the prevailing conditions for teaching science against this
background, it becomes clear that our science teachers:

- have less than average acquaintance and familiarity with the specific subject
  content
- have low motivation to accept the new and attempt to innovate
- face tremendous variations in the levels, backgrounds and approaches of the
  trainees/children
- find lack of adequate, suitable and relevant teaching-learning or training materials
- face non-availability of well-trained and skilled individuals to use the facilities of
  educational technology and equipment now available
- work in weak linkages with academic support systems, other institutions and
  professionals
- face archaic procedures and financial constraints
- receive inadequate support from heads of institutions and supervisory staff
- face problems of communication due to language differences between the
  teachers/teacher educators and the trainees/learners.

At the elementary stage, one of the major problems faced by this group is that of
linguistic abilities of the learners. It becomes very acute during the process of teaching
and learning science at this stage. The variation in dialects, as well as differences
between the spoken language and the language contained in textbooks create barriers.
The teacher and the teacher educators have to remain aware and alert to this situation.
The solution to this problem depends upon their own interests, aptitudes and creative
abilities. They can draw upon maximum support from their own reasoning powers and
scientific thinking, which help them receive and internalize new ideas, techniques and

technologies.

The structure and curricula of elementary-level, teacher-education programmes at both
the pre-service and in-service stages need to be examined periodically with respect to
the components, contents, methods, skill development and community involvement.
There are still training programmes at the elementary education level that provide
almost no training in science and skill development. This situation has to be quickly
remedied. Teacher education programmes must accept the universal role and place of
science in the life of every learner. They also have to respond to the growing interaction
between Science, Technology and Society (STS). These aspects have already received
considerable attention at various stages. At the elementary stage, however, this needs to be visualised as an interaction of Science, Technology, Society and Environment (STSE). While it can be argued that environment is included in science, technology and society, one would still like to keep it as a separate component for the sake of emphasis, which is so relevant at the current juncture.

In countries where the number of institutions and children at the elementary stage is considerable, large mobilisation of community resources is a must. Toward this aim, there is a need to generate community awareness, which should result in demand for education from those sections of the society that are still deprived in terms of education. To achieve this, the programmes have to be responsive to the community needs both at the basic educational level and also at the level of teacher training. A situation of mutual accountability of the learning system and the community has to be developed. This situation is to be sustained by the teachers; therefore, the responsibility of training institutions becomes significant. The concepts of learning centres, school complexes and institutions of training fully equipped to train in techniques and technical skills need to be developed and put into operation. These institutions should be willing to open up their facilities to the community. They need to be capable of analysing their needs and must attempt to build up training and learning situations that would solve both everyday and long-term problems. Individual teachers and teacher educators need to be prepared to take up innovative, experimental and action research projects. They must overcome their fear of research. Such activities would generate self-confidence among teachers and would be expected to achieve teacher transformation, which is basic to all teachers and teacher educators.

At the elementary stage, the importance of developing scientific temper, scientific outlook and a rational approach need not be over-emphasised. This is extremely relevant to the situation where communities still suffer from obscurantism, cultural inhibitions and traditional practices, not all of which are based upon scientific logic. The curricula of science and training programmes in science need to be updated against this background. Related to this is the idea of value inculcation in general terms. There has been a global acceptance of the need to strengthen the content of education relating to humanistic, ethical, moral and cultural values. It is now well-acknowledged that solutions to some serious problems (environmental degradation, consumerism, discrimination, poverty, population growth, exploitation and marginalisation of people) are to be found not only in eradication of ignorance and provision of education, but also in the preparation of people to face these challenges with intrinsic moral and ethical values. Science education must also play a crucial role in this respect. Training institutions have to take a critical look at the curriculum materials in each discipline and at each stage of education to assess their relevance, adequacy and potential for both value development and promotion. Similarly, the co-curricular activities, interaction with creative personalities, appreciation of available folklore, national heritage, including historical monuments, could be utilised to encourage a sense of belonging, pride and love of country in young learners.

TEACHER EVALUATION AND ACCOUNTABILITY

Teacher professionalism and the restructuring of school education testify to the extent of efforts being undertaken to reform teaching, learning and schooling. It is only through such efforts that focus is shifted onto identification of learners' needs and attempts to meet these requirements. Toward this end, the sensitive area of teacher evaluation for school improvement has been explored. Such studies must indicate the philosophy and purpose, performance criteria and standards, followed by evaluation procedures. While
the philosophy and purpose indicate, in practical terms, the role and function of teacher evaluation in education decision-making processes, the performance criteria and standards specify the expectations upon teachers in the performance of their professional roles. Any institution that regularly attempts to evolve and strengthen its teacher evaluation processes could justifiably aim to achieve improvement of the total school environment. This being a sensitive area, the purpose and process have to be adequately understood by each teacher.

Whereas teachers’ accountability was stressed in great detail over the past decade, the procedures and approaches to ensure this accountability remain to be specified. Ideally, teacher evaluation processes and procedures would describe accountability in precise, qualitative terms. These descriptions could be utilised for remedial inputs and action. Teacher evaluation should simultaneously foster the professional growth of new and continuing teachers. It should contribute substantially toward gradual improvement in the total learning environment of the school, as well as the enhanced learning attainments by larger numbers of students.

A professionally equipped teacher functioning in an environment conducive to higher learning attainments and personal development would be responsive to community needs. This could create a situation in which the sense of mutual accountability of the teacher and community is established. To develop these components, an ongoing action plan for teachers, teacher training, retraining and transformation needs to be developed. It may require mobilisation of available resources from various resource centres and adoption of different modes in teacher-learning interaction. Most countries have experience with correspondence courses and have developed the necessary expertise to strengthen this modality along with face-to-face training interactions. This expertise needs to be augmented through introduction to new developments in educational technology. Such initiatives will also have to be coupled with adequate managerial and administrative support. To cover large numbers and to provide training in the latest techniques and methodologies, every teacher and teacher educator would have to understand the learning needs adequately, precisely and consistently. Eventually, it comes down to strengthening the institutions of teacher training and education professionally, as well as preparing professionally competent, committed experts and teacher educators.

References


CHAPTER 13

TEACHER TRAINING IN SPECIALISED SUBJECTS: MATHEMATICS, SCIENCE AND TECHNICAL/VOCATIONAL

P.K.D.P. Kudaligama

RATIONALE

The need to improve scientific and technical education in Sri Lanka. The Sri Lankan educational system has had to face several challenges in the four decades following independence. However, the future development of the educational system in response to the changing social conditions and economic pressures of the modern age poses a far greater challenge. Sri Lanka has already achieved a very high literacy rate (87.5%) — perhaps one of the highest in Asia — and a reasonably high rate of employment. At the current rate of growth, the population of the country (which stands at 16.8 million) is expected to rise to 20 million by the close of the century. The present working-age population is approaching 10 million, or approximately 58% of the total population. The future growth and stability of Sri Lanka depend to a large extent upon the ability of the domestic economy to keep pace with rapid developments in the global economy, as well as with scientific and technological advances.

On-going developments in the agricultural sector place a significant demand upon the educational system to ensure that the agricultural industry takes every advantage of modern scientific techniques and innovations. The quality and scope of mathematical, scientific and technical education at the secondary and tertiary levels have to be continually updated in keeping with parallel developments on the international scene. Reciprocal expansion of the economy will have to be generated to ensure that the new industries launched in the country have complete access to modern technology.

Sri Lanka is aware of these situations and has adopted positive means to cope with these challenges through innovative measures in its educational system.

Steps Taken by the Government of Sri Lanka to Expand Science, Mathematics and Technical/Vocational Education

- A three-year, in-service teacher training programme is available in teacher colleges.
- The Distance Education Department of the National Institute of Education provides a three-year, in-service teacher training programme.
- Two education colleges (Siyane and Nilwala) provide a three-year, pre-service teacher education course in science and mathematics. The Nilwala College of Education also conducts a Home Economics course.

- The Open University conducts a two-year, post-graduate Diploma in Education programme in the distance mode to train graduate teachers, some of whom are in science, mathematics and technical/vocational subjects, which is supplemented by contact sessions at regional centres and in-plant teaching practice. In addition, a B.Ed. in Science programme will be implemented in October 1992.

- The Department of Teacher Education of the National Institute of Education (NIE) commenced a post-graduate Diploma in Education programme in 1989 to train graduate teachers in science, mathematics and technical subjects.

- The National Technical Teachers Training College, established in 1990, provides pre-service as well as in-service training to staff (instructors and lecturers) of the Technical Colleges and Technical Units.

- The Tertiary and Vocational Education Commission (TVEC), established in 1990, coordinates and monitors technical/vocational education at all levels commensurate with human resource needs of economy and also ensures that training and academic standards are maintained in all institutions providing technical/vocational education.

- Science, mathematics and technical/vocational subjects have been made mandatory disciplines in the secondary school curriculum. ("Life Skills" are taught at years 6, 7 and 8, while technical subjects are taught at years 9, 10 and 11.)

In addition to the above, vocational training in Sri Lanka is provided by a large number of agencies functioning under twenty ministries. Some of these are corporate agencies, while others are private. TVEC has identified 3,000 such training institutions providing tertiary and vocational education.

Conventional universities provide under-graduate and post-graduate courses in science and mathematics, which are available at seven universities, management and commerce are available at six universities, engineering at two universities and agriculture at three universities. The Open University also provides degree and post-graduate degree courses in science, mathematics and engineering technology.

The recently established, regional-affiliated University Colleges are expected to provide job-oriented diploma and degree programmes in technical and vocational subjects.

Need for Teacher Training

Teacher training has become a crucial issue in Sri Lanka with the government’s new policy to "ensure that the school system is wholly manned by trained teachers by clearing the backlog of untrained teachers." A recent study sponsored by the Asian Development Bank (ADB) has pointed out the need to establish planned measures for quality inputs in teacher education.

With the new recruitment of 35,000 teachers in 1989/1990, quantitative development plans became necessary. Universities and the NIE have taken on the challenge of increased enrolments in these programmes. The present urgent and crucial problem is the maintenance of qualitative standards.

The Sri Lankan government has taken some innovative steps with the establishment of institutions like the Tertiary and Vocational Education Commission (TVEC), the National Institute of Education (NIE), the National Technical Teachers Training College (NTTTC), etc. These institutions were created to improve and maintain
standards in scientific and technical/vocational education, but the ever-increasing school enrolment, teacher recruitment and teacher retirement have brought the government face to face with the crucial and severe problem of training teachers. The government had to initiate urgent and prompt measures to train the 35,000 teachers recruited in 1989/1990.

Index to the Appendices

Appendix 1  Student enrolment at each level
Appendix 2  Teachers available to teach various school subjects
Appendix 3  Training capacity of the various institutions

Accordingly, Appendix 2 indicates that even in 1991 approximately 45% of teachers remained untrained. Since institutionalised training has been found to be costly, the country depends greatly on distance training. The country's problem is in providing quality teacher education programmes through the distance mode.

It is only through quality, professional training that teachers of science, mathematics and technical/vocational subjects can acquire new knowledge, positive attitudes, and competencies necessary to identify learner problems and seek solutions to them.

Practical training and work habits would help to improve the learning process of teaching. Educational technology plays a vital role in the modern classroom. The use of computers and other media should form an integral component of all teacher training programmes. Professional training enables teachers to motivate student participation in the learning process. It equips them not only with knowledge, but also gives them the confidence to identify appropriate resources and devise suitable learning material.

Teachers should be encouraged to master techniques of micro-teaching, simulation, and role-playing and to realise their potential for student motivation. The need and use of scientific method in teaching science can never be over-emphasised. The importance of relating the teaching of mathematics to real-life situations has been constantly highlighted by most mathematics writers, and this point must be reiterated here, too.

Teachers must be capable of working in groups toward common goals. They should also be competent in evaluating student performance.

Current Position

In keeping with government policy, Sri Lanka has initiated measures to enrol 45% of its untrained teachers in the available teacher training programmes. Of this percentage, three-quarters are registered in distance education programmes of the Open University and the NIE. The popular demand is for distance education programmes. The system is also reinforced through in-plant training programmes.

Nevertheless, it has to be admitted that the administration of all distance education programmes, especially those related to the training of teachers in science, mathematics and technical/vocational subjects, is hampered and frustrated by the lack of qualified personnel, equipment and facilities. If quality training is the highest criterion in terms of the Asian Development Bank's report of 1990, then quality inputs should be the highest priority as far as the Sri Lankan educational scene is concerned.
PROBLEMS AND ISSUES OF TEACHER EDUCATION
IN THE TEACHING OF SCIENCE, MATHEMATICS AND
TECHNICAL/VOCATIONAL SUBJECTS

SPECIFIC

The inadequate numbers of professionally qualified lecturers/instructors in university
departments, NTTTC, colleges of education, teachers' colleges and the NIE has been a
perennial problem in Sri Lanka, and according to the ADB report for 1989, not quite
40% of the required number in these categories was available.

University departments have to contend with only half of the required cadre. The
position with colleges of education is no different; only 40% of the necessary staff is
available.

The NTTTC, which must develop curricula, train staff and develop resources of the
technical colleges, is under severe strain through lack of adequate staff. The current
position is that almost 50% of its qualified trained staff members have left the
institution. The rehabilitation course (HND) run by NTTTC is almost entirely manned
by visiting lecturers.

The Open University and the NIE are managing their programmes with approximately
half of the required academic staff in these subjects. Both institutions need trained,
qualified personnel to function as master teachers, regional tutors, etc. to conduct day
schools, tutorials, seminars, workshops, demonstrations and related practical work. The
scarcity of qualified, trained graduates in these subject areas in the indicated regions has
reached critical proportions in the last two decades.

Updating of Knowledge and Competencies of Lecturers/Instructors

Courses to update the knowledge and competencies of lecturers/instructors who teach
these subjects, both in terms of facilities and content, are inadequate. The importance of
equipping these lecturers/instructors with the latest in knowledge and skills to handle
modern technology can hardly be debated. The courses available in universities are few
in number.

Very few special workshops and seminars are organized by NIE, OUSL, or NTTTC, to
train lecturers/instructors and demonstrators of this category. Hardly any training
programmes are organised to update the teaching skills of lecturers of teacher colleges.

Support Staff

The inadequacy of the training received by support staff (laboratory assistants, workshop
assistants, field assistants, etc.) is evident in most of the institutions of teacher
education. Quite a number of them are unable to perform the tasks assigned to them
satisfactorily. Approximately 50% of them have not received any training specific to
their functions.
Facilities Available for Teaching

Given the available facilities and infrastructure, the conventional universities of the country are capable of training only about one-tenth of the science, mathematics, technical and vocational teachers required annually by the school system. Teacher colleges and colleges of education train about three-tenths and the balance of six-tenths is trained by the Open University and the National Institute of Education through the distance mode. Lecturers for technical colleges are trained by the NTITTC only.

Facilities available for the training of teachers have an effect on the learning process. In the NTITTC and colleges of education facilities such as laboratories, workshops and equipment are available for teacher training. But this situation does not prevail in most of the teacher colleges (NIE, Needs of the Teacher Training Programmes, 1989.) The quality of training could be said to have suffered in most of these institutions due to the lack of basic teaching facilities like laboratories, workshops, equipment, etc. The position has been further aggravated for want of financial support to maintain and/or repair the equipment available.

Distance education relies predominantly on printed material. However, where the teaching of science, mathematics, technical and vocational subjects is concerned, printed material has to be supplemented with laboratory work, workshop practice, field work, etc. Laboratory facilities of the OUSL are available only in the four regional centres. Twelve study centres of the OUSL have neither laboratory nor workshop facilities for teachers. If facilities were available at these study centres, then the practising teachers of science, mathematics and technical subjects would be able to try out practically what they had been learning in theory and pursue innovative lines of study. The distance education programme of the NIE depends mainly on school laboratories and workshops in the professional training of non-graduate teachers. Yet, most of the school laboratories and workshops available do not possess all of the facilities required for training teachers.

The facilities available in some of the universities are not properly exploited for the training of teachers of agriculture. It might be said that the Universities of Peradeniya and Ruhuna possess some of the best laboratory and workshop facilities, and the latest equipment that can be utilised for the training of teachers of agriculture.

There is one college of education that provides pre-service teacher training in agriculture. The facilities at the Siyane and Nilwala Colleges of Education could also be easily utilised for the training of agriculture teachers.

(According to the 1991 Census Report of the Ministry of Education, 6000 agriculture teachers are required, but only 2945 are available. Of this total, only 1713 are professionally trained.)

GENERAL

Training Costs

The cost of training teachers is very high in the case of institutional training. Distance training is cost effective in Sri Lanka, because with quality input and meticulous planning it can cater to a large clientele at lower costs. Where overall costs are considered, it is clear that training at the Distance Education Centres is considerably less expensive than at the more conventional colleges. Costing about one-sixth as much
as at the College of Education (pre-service) and one-third as much as at the teacher colleges (conventional in-service). ("The Cost Effectiveness of Distance Education for Teacher Training," *Bridges Report*. April, 1991.) However, in training teachers for mathematics, science and technical subjects, the need for more practical sessions, contact sessions, experiments and field work should be emphasised.

**Curriculum**

All teacher education curricula have to be subjected to continual reassessment and revision. They absolutely must be revised at least every five years and even sooner, if the need arises. It is also imperative that these revisions should keep pace with changes in the society and school curricula. Modern research findings on curriculum development and teaching strategies should be reflected in the revised curricula. They should be incorporated into the teacher education curriculum, just as government policies and philosophy are implemented in the school curriculum.

In Sri Lanka, the teacher education curriculum is somewhat outdated. Some of the old teacher education programmes, for example, the programme of the teacher colleges, has not been revised for nearly twelve years. Even the curricula of the College of Education and the Diploma in Education need urgent revision if these programmes are to keep up with advances in developed countries.

**Teaching Strategies**

It is only through the application of student-centred teaching methodology that the many objectives of teaching science, mathematics, technical and vocational subjects can be achieved. Lecturers who have acquired a professional foundation are proficient in the application of these methods. Student intervention and participation are both very important and essential aspects. Micro-teaching, simulation, programmed instruction, field trips, experiments and demonstration are some of the methods that could be used in teaching science, mathematics and technical subjects.

Lecturers who have mastered the process of learning make optimal use of these methods, taking care to plan and organise their lessons. Traditional methods of teaching are still being used by almost 60% of the lecturers in teacher education institutions of Sri Lanka. The teacher colleges devote the most time to conventional methods and theoretical issues. The reason for this is that these teacher educators have not been specifically trained for the task of teaching adults. Due attention must be paid to the practical aspects related to the craft of teaching. It might also be pointed out that lecturers do not utilise audio-visual equipment available in their institutions (ADB. *Education and Training in Sri Lanka*, Vol. I (1989), p. 105).

**SOLUTIONS AND STRATEGIES**

- A national plan should be formulated and national links established to coordinate the work of the various institutions and organisations that handle teacher education and training. This would ensure maximum use of available resources, avoid replication of work and generate tenable standards at common levels of programmes. The National Education Commission and Tertiary and Vocational Education Commission should help the government develop a common policy for teacher training in these subject areas.
• One of the existing teacher colleges should be converted to a college of education to provide pre-service training in technical education. The facilities of the two colleges that handle training in science and mathematics should be improved.

• The existing facilities should be upgraded and distance education programmes should take steps to enrol all untrained science, mathematics and technical/vocational teachers in service. Distance education programmes should utilise the laboratories and workshops of teacher colleges on weekends and vacations to conduct practical classes. Upgrading of facilities at regional centres of the Open University is necessary to accommodate the use of multi-media packages.

• The technical teacher training curricula should be revised in accordance with changes in the present school curricula. These curricula should introduce teachers to the new concepts, objectives and values.

• The competencies of lecturers should be upgraded and updated, so that they would be competent to apply new teaching/learning strategies, such as micro-teaching, simulation, role-playing, brainstorming sessions, group discussions, criticism lessons, experiments, etc. In the teaching of science and technical subjects, strategies should be evolved to establish links with the community, and lecturers should be motivated to apply student-centred teaching methods. Radio and television ought to be used to support distance programmes.

• Pre-service training programmes (B. Ed.) in science, mathematics and technical subjects should be initiated at the degree level in universities, whenever and wherever facilities are available.

• A fair percentage of funds ought to be allocated to the training of mathematics, science and technical teachers, as these areas have been much neglected.

• The production of teaching/learning material in these subject areas, including teacher guides, handbooks, modules, audio-visual material and other supplementary material should be improved.

• The staff of university departments, colleges of education and other institutions should be upgraded and incentives provided to ensure their continuance in these programmes. Study tours, attendance at programmes and seminars abroad, scholarships, promotions and other benefits should also be made available to them. Short-term, intense training programmes and mobile training could be implemented.

• All master teachers serving distance education programmes need to be trained in evaluation techniques, management skills and teaching strategies.

• The aim of educational technology is to ensure greater effectiveness of instruction. Distance education programmes should include multimedia packages. Revised and updated material should be supplied and supplemented by audio and video cassettes, slides and film-strips.

**RECOMMENDATIONS AND SUGGESTIONS**

Considering the large volume of untrained teachers, the distance method could be used more effectively with an increase in the number of contact sessions, functional classroom sessions, workshop training programmes, practical work and practice teaching. More contact sessions are also required in mathematics teaching.

Planning of programmes to suit local needs is indicated. Programmes must include use of audio-visual material. There is a need for greater financial inputs in the establishment and maintenance of laboratory and workshop facilitators.
WHAT THE ROLE OF THE COMMONWEALTH SHOULD BE

- There should be greater and closer cooperation between Commonwealth institutions, agencies, and universities in planning and implementing teacher training programmes in the relevant subject areas.
- The Commonwealth should form a panel of experts to advise on curriculum development, teaching strategies and evaluation of teacher training.
- Financial assistance to improve laboratories and workshop facilities needs to be provided.
- Commonwealth countries could help each other in the production of low-cost equipment and material needed in teacher training, and exchange expertise in the preparation of teaching/learning material.
- Short-term as well as long-term staff training programmes, ranging from perhaps two weeks to six months, could be organised.
- Staff exchange programmes and attachment programmes should be instituted.
- A research journal containing information and material on innovative programmes and new strategies worked out within the group could be produced.
- An annual evaluation of the progress of teacher training programmes in science, mathematics and technical/vocational subjects in Commonwealth countries is necessary.
- The Commonwealth could organise more workshops and seminars for administrators of teacher education programmes on quantity inputs and resource inputs.
Appendix 1: Student Enrolment at Each Level

Number of Government Schools and Pupils at Each Level – 1990

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Government Schools</td>
<td>9,864</td>
</tr>
<tr>
<td>Total Number of Secondary Schools</td>
<td>4,399</td>
</tr>
<tr>
<td>Total Number of Pupils</td>
<td>4,111,272</td>
</tr>
<tr>
<td>Total Number of Pupils in the Secondary Schools</td>
<td>1,861,250</td>
</tr>
<tr>
<td>Pupils in Advanced-Level Classes (Years 12 &amp; 13) Science &amp; Mathematics</td>
<td>50,761</td>
</tr>
<tr>
<td>Pupils in Advanced-Level Classes (Commerce)</td>
<td>54,885</td>
</tr>
<tr>
<td>Pupils in the Primary School</td>
<td>2,078,152</td>
</tr>
</tbody>
</table>

Appendix 2: Teachers Available to Teach Various School Subjects

Teachers Serving in 1991 – According to Qualifications

<table>
<thead>
<tr>
<th>Graduates</th>
<th>Trained</th>
<th>Certificated</th>
<th>Uncertificated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Science</td>
<td>7,560</td>
<td>Science 8,742</td>
<td>Languages 2,312</td>
</tr>
<tr>
<td>Biological Sciences</td>
<td>1,634</td>
<td>Mathematics 8,096</td>
<td>Science/ Mathematics 948</td>
</tr>
<tr>
<td>Mathematics</td>
<td>719</td>
<td>English 8,962</td>
<td>Commerce 116</td>
</tr>
<tr>
<td>Agriculture</td>
<td>254</td>
<td>Social Studies 1,427</td>
<td>Home Science 428</td>
</tr>
<tr>
<td>Home Science</td>
<td>95</td>
<td>Commerce 1,260</td>
<td>Handicrafts 25</td>
</tr>
<tr>
<td>Commerce &amp; Accountancy</td>
<td>3,001</td>
<td>Home Science 2,667</td>
<td>Agriculture 257</td>
</tr>
<tr>
<td>Social Science</td>
<td>727</td>
<td>Handicrafts (Wood/Metal) 734</td>
<td>Physical Education 329</td>
</tr>
<tr>
<td>Aesthetics (arts, music, dance)</td>
<td>1,257</td>
<td>Physical Education 937</td>
<td>Aesthetics 596</td>
</tr>
<tr>
<td>Religion</td>
<td>1,526</td>
<td>Special Education 727</td>
<td>Primary 35,853</td>
</tr>
<tr>
<td>Special Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 3: Training Capacity of the Various Institutions


<table>
<thead>
<tr>
<th>Institutions</th>
<th>Programmes</th>
<th>Mode</th>
<th>Science</th>
<th>Mathematics</th>
<th>Technical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universities</td>
<td>Post-Graduate Diploma in Education (In-Service)</td>
<td>Institutional</td>
<td>15</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>(Peradeniya, Colombo and Jaffna)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open University of Sri Lanka</td>
<td>Post-Graduate Diploma in Education (In-Service)</td>
<td>Distance</td>
<td>130</td>
<td>140</td>
<td>110</td>
</tr>
<tr>
<td>National Institute of Education</td>
<td>Post-Graduate Diploma in Education (In-Service)</td>
<td>Distance</td>
<td>80</td>
<td>70</td>
<td>62</td>
</tr>
<tr>
<td>Colleges of Education</td>
<td>3 years Pre-Service Training</td>
<td>Institutional</td>
<td>442</td>
<td>398</td>
<td>75</td>
</tr>
<tr>
<td>Teachers Colleges</td>
<td>2 years training (In-Service)</td>
<td>Institutional</td>
<td>415</td>
<td>416</td>
<td>267</td>
</tr>
<tr>
<td>National Institute of Education, Distance Department</td>
<td>3 years</td>
<td>Distance</td>
<td>280</td>
<td>246</td>
<td>-</td>
</tr>
</tbody>
</table>
References


CHAPTER 14

TEACHER EDUCATION IN PAKISTAN: TRENDS, PROBLEMS AND ISSUES

Qudsia Rifat

BACKGROUND

Like any other developing country, Pakistan has accepted science and technology as the keys to the “doors” of economic and social success. Provision of the best possible education in these subjects is viewed as the means to obtain these keys.

From the first Education Conference held during the early years of independence until the present day, major efforts have been directed toward the popularisation, expansion and improvement of both science education and science-based technical and vocational education in our country. Reforms started with the inclusion of science and mathematics in the school curricula as compulsory subjects and the introduction of diversified curricula in technical/vocational education both at school and college level.

During the last twenty-five years, efforts have been made to popularise, expand and improve science and technical/vocational education at school and college levels. Some achievements in terms of improvement in school curricula, provision of facilities and quantitative expansion have been made. For example, the output of secondary schools is now heavily weighted in favour of science subjects, with 45% of those who pass the secondary school examination doing so through the science stream. However, most matriculate students qualifying with science subjects pass with very low grades. Science is still not very popular among female students; 75% appearing for the SSC examination, do so through the Humanities streams and only 23% appear through the science stream. Technical, vocational and agricultural subjects are not very popular subjects among the secondary school students either. In 1986 only 12 candidates passed the Higher Secondary School Certificate through the agricultural stream.

There are several factors that can be attributed to deteriorating standards of science education and low participation of students in technical, vocational and agricultural subjects. However, a shortage of qualified, trained teachers and poor quality of the teacher education programmes for teachers of science are among the most important factors.

This paper gives an overview of the teacher education programmes at different levels, describing the issues and problems faced in the training of science teachers. At the end, some suggestions have also been made for improvements in teacher education programmes.
TEACHER EDUCATION: AN OVERVIEW

Programmes for pre-service and in-service training of teachers are organised by various institutions of the formal sector and also by Allama Iqbal Open University through its distance education system.

Pre-Service Training Programmes

Pre-service training is provided to acquaint the prospective teachers with pedagogy and to develop the skills, competencies and subject knowledge essential for a teacher.

Pre-service training is an essential prerequisite for teaching in primary, middle and high schools. However, no pre-service professional training is required for teaching at college level (the higher secondary and degree classes).

Pre-Service Training of Primary Teachers

Pre-service training of primary school teachers is undertaken by twenty-five schools and sixty-two elementary colleges of education. Allama Iqbal Open University also offers courses for primary school teachers.

Primary Teachers Course (PTC) is a one-year course and is offered to candidates who have completed their secondary school education, that is, matriculates. The major components of PTC offered through the conventional system and by Allama Iqbal Open University are almost the same. In both systems, the course is comprised of three major components: professional subjects, academic subjects and teaching practice. AIOU's PTC programme also includes a two-week compulsory workshop. The weight given to academic and professional course is 60:40. Academic subject courses have two parts: subject content and teaching methodology.

In the scheme of studies, the time and weight given to science and mathematics is the same as that given to other subjects. The programmes are based on the assumption that there are no separate science teachers, per se, in primary schools.

Pre-Service Training of Middle School Teachers

Elementary Colleges of Education and Allama Iqbal Open University conduct pre-service training courses for middle school teachers. The training course for middle school teachers is a one-year certificate course. Candidates who have completed their higher secondary (also called "intermediate") education can join this course. The course has two components: theory and teaching practice. Theory subjects include professional as well as academic courses. Professional subjects are included to equip the prospective teachers with the basic knowledge of principles and theories of education and to instruct them in the use of modern teaching techniques.

Academic courses are given in twelve different school subjects, including General Science, Mathematics, Arts and Crafts, Agriculture Education and Industrial Arts. The student selects four subjects of interest. Each of the special school subjects is divided into two parts: subject matter and methodology. The weight given to these parts is 60:40, respectively.
In the total scheme of studies, the weight and time given to science, mathematics and technical/vocational subjects is very little and inadequate for producing good teachers.

Practice teaching is a compulsory component of the C.T. programme in both the formal and non-formal systems. According to the Curriculum Document, it is designed to put theory into practice and provide the prospective teachers with a real feeling of teaching and the learning situation.

In the formal system C.T. programme, teaching practice lasts for six weeks; it is divided into a short term of two weeks at the start of the course and a long term of four weeks at the end of the course. AIOU’s C.T. programme includes a two-week workshop and a four-week teaching practice. The practical workshop is held to give training in lesson planning, preparation of teaching aids, evaluation, use of the library and to conduct practical work in science courses.

Pre-Service Training of High School Teachers

High school teachers are trained in Colleges of Education, Institutes of Education and Research, and Departments of Education. The latter two are affiliated with the universities. At present, there are fourteen Institutes of Education and Research, a number of Departments of Education and eleven Colleges of Education, which impart education to prospective high-school teachers. These institutes and departments offer one-year training programmes leading to the Bachelor of Education degree (B.Ed.).

At present, two types of B.Ed. programmes are available: a one-year B.Ed. (14+1 model) and a three-year B.Ed. (12+3 model). For admission into the former, a candidate must have a Bachelor degree in science or arts; for the latter, the entry requirement is only intermediate (twelve years of schooling). A three-year B.Ed. is offered in only one College of Education and it is hoped that in coming years the 12+3 model will replace the 14+1 model prevalent in most institutions.

At the secondary level, separate teachers of science and mathematics are recruited. Besides academic qualifications in the relevant subject, professional qualifications are also required. In the 14+1 model, prospective teachers study science and/or mathematics contents in colleges of general education, then follow one year of professional training with practice teaching in IER, a Department of Education or a College of Education.

In the 12+3 model, prospective teachers study a three-year course of integrated science content and pedagogy, including practice teaching with a superficial knowledge of liberal education.

In both models, science teachers specialise in two subjects. The three combinations in which they can specialise are as follows:

1. Physics and Chemistry
2. Physics and Mathematics
3. Chemistry and Biology

Looking at the present status of B.Ed. programmes, it appears that science and mathematics teachers receive their training in common with teachers of other subjects. There are no separate programmes for science and mathematics teachers.
The Curriculum Document’s 12+3 model of B.Ed. was introduced because of a long-standing need to integrate teaching content with methodology under one umbrella in the same institution. It is hoped that teachers trained through this model will be in a better position to comprehend the scope of their subject matter in relation to principles of teaching and learning. Students who have studied through this model receive a composite B.A., B.Ed. or B.Sc. degree, which enables them to study at the M.A., M.Sc. or M.Ed. level. This programme was specifically introduced to train science and mathematics teachers. The purpose of this comprehensive three-year programme is to give teachers-in-training a thorough grounding in educational theory and principles, to broaden their knowledge of the subject matter, and to develop skills and competence in teaching methodology.

Allama Iqbal Open University offers a two-year comprehensive pre-service B.Ed. programme. As yet, only one science course, Biology and its Teaching, has been offered. Other science courses are coming on stream and will be offered in 1993. This programme is also offered to in-service teachers.

In-Service Training of Teachers

In-service training of school teachers is organised by Education Extension Centres, Allama Iqbal Open University and Agha Khan Central Board (NGO). Education Extension Centres organise in-service training courses at their headquarters or in training centres established for this purpose. Education Extension Centres identify the areas of subjects for in-service training programmes. Duration of these programmes ranges from one to four weeks, depending upon the nature of the programme. For the most part, these programmes focus on training science teachers in the handling of curriculum materials and teaching methods.

The Agha Khan Education Board, through refresher training courses trains its teachers on a regular basis. However, their training programmes are meant for teachers who are teaching in AGKF schools.

Through its distance education system, Allama Iqbal Open University is providing in-service training to thousands of teachers at all levels. Primary Teachers' Orientation Course (PTOC) is one of its oldest and most popular in-service training programmes. It was initiated in 1976, and as of 1990, 83,638 teachers have completed this course. This course is now being revised and reorganised and will be offered in 1993 in limited areas as a pilot project with restricted enrolment (500 during the pilot phase). This programme is being funded by NORAD.

AIQU’s other in-service programmes are the same as those discussed under pre-service training programmes. These programmes are intended for both pre-service and in-service teacher training. In fact, for admission to these programmes, in-service teachers are given preference. It is important to note that until now, AIQU has not offered any programme exclusively for science and mathematics teachers. There is still no training programme for teachers of technical and vocational institutes.

AIQU’s B.Ed., C.T. and PTC programmes include science courses organised either as general science courses (PTC, C.T. and PTOC) or as separate disciplines of biology, chemistry, physics and mathematics courses (B.Ed.). The weight given to these courses is the same as that given to others in the programme. In fact, in practical workshops and teaching practice very little time and weight is given to science and mathematics. In the C.T. programme, General Science is included as an elective subject. The enrolment figures (approximately 200 students per year) show that this course is not
very popular among students. At the B.Ed. level, the only science course offered is Biology and its Teaching; however, other courses are under development. Biology and its Teaching was initiated in 1991. This course has two parts: subject content and methodology. Both parts are given in consecutive order and are not integrated.

As with the PTC and C.T. programmes, students are required to participate in a two-week practical workshop and four weeks of practice teaching organised by tutors. Student supervisors (two per group of twenty to twenty-five students) also help the tutors in conducting the workshops. Workshop activities are based on elective subjects and include preparation of lesson plans, teaching and learning aids, achievement tests, and observation of lessons delivered by tutors and supervisors. Student teachers also deliver lessons and obtain feedback from other student teachers, supervisors and tutors. If planned and organised properly, these workshops can be used to train teachers in teaching methodology.

ISSUES AND PROBLEMS

The existing facilities and programmes of teacher education are inadequate to provide quality of education for the number of teachers required in science, mathematics, technical and vocational subjects. There is a paucity of trained science teachers at all levels. Even those who have undergone pre-service or in-service training often lack the knowledge, skills and competencies needed for teaching science and technical/vocational subjects. There are several reasons for these shortcomings in current teacher education programmes.

- One of the reasons for the acute shortage of science and technical/vocational teachers is that science graduates and those with qualifications in technical and vocational subjects do not want to take up teaching as profession. They do not find the profession lucrative or attractive status-wise. According to statistics on the highly educated unemployed in 1986, there were 10,000 science graduates who were unemployed and could have been inducted into teaching, given adequate incentives.

- Output of conventional teacher training institutes is grossly inadequate to meet the needs of the expanding educational system. There are approximately eighty-seven teacher training institutes for primary and high school teachers. Their annual output is 12,000 – 15,000 teachers. Yet, the rate of expansion in the educational system demands that approximately 30,000 new teachers be prepared each year.

- Training facilities for technical and vocational teachers are not sufficient to meet the needs. At present only polytechnics are turning out vocational teachers or the IERs produce a handful of M.Ed. graduates in Industrial Arts.

- In-service training facilities for both science and technical/vocational teachers are grossly inadequate. There are four Education Extension Centres in the country, which provide in-service courses, a few newly established Training Wings (total 93) and one Technical Teachers Training College for training of technical and vocational teachers. The annual output of these wings and the college averages less than one hundred teachers. The number of Education Extension Centres is also inadequate to complete a five-year retraining cycle. The Training Wings have also failed to train technical teachers, since with 40% of posts lying vacant, technical teachers cannot be spared to attend in-service training.
The duration of in-service and pre-service training programmes is too short to develop professional skills, insight, interest and maturity in educational theory.

Due to overcrowded curricula and the short duration of programmes, little time and weight is given to special subjects. The teachers, having been rushed through these programmes, cannot be deemed to have acquired proper and full professional training and knowledge of the subject.

At present, with the exception of one college, no teacher training institution offers a separate programme for science teachers. Science teachers obtain their training in common with teachers of other subjects.

Science subjects are offered as elective subjects in C.T., B.Ed. and M.Ed. courses in both formal and non-formal systems. Due to overcrowded curricula, the time allocated for these subjects in practice teaching and theory classes is too short to expect the teachers to benefit from these courses.

Science courses are mainly theoretical. There is no separate time allocated for practicals to be performed by the teachers.

The training institutions lack laboratory facilities.

Science courses have two parts: content and methodology, but they are offered separately. Teaching methods are described in an abstract way without giving concrete examples of their application. Due to the short period of practice teaching, teachers cannot apply different teaching methods to put the theory into practice. Thus, the usefulness of teaching methodology remains minimum.

The selection of areas/fields for in-service training is not based on the survey of teacher competencies and is, therefore, frequently irrelevant to the needs of practising teachers.

In-service training courses/workshops organised by the Education Extension Centres do not provide intensive training because they are of short duration, poorly planned and suffer from shortage of experts in science education.

In-service training programmes offered by conventional institutions are not helping the teachers to upgrade their academic and professional qualifications and thus are not providing vertical mobility for career advancement.

Practice teaching, a compulsory and most important component of teacher education programmes, as presently organised, is not proving very useful for imparting skills and competencies needed for teaching science.

The training being provided is divorced from real problems of teaching in overcrowded and ill-equipped classroom situations. The training courses do not train teachers in the preparation of low-cost improvised materials, nor do they equip them with the skills to teach science concepts through simple activities and experiments.

Teachers' guides for school science subjects and mathematics are not available to help teachers in teaching these subjects.

There is a dearth of literature on science education in Urdu. There is not a single journal devoted to science education.
SUGGESTIONS AND RECOMMENDATIONS

The existing facilities and programmes for teacher education need to be expanded, revised and reoriented to meet the needs of teacher education in general and science teacher education in particular.

The conventional system of face-to-face education cannot meet the current need to train masses of teachers, nor can it be expanded and strengthened overnight to meet the immediate needs of science teacher education.

Allama Iqbal Open University, by virtue of being a distance education institution, can reach large numbers and provide on-the-job, intensive training in the most efficient and cost-effective manner. AIOU has played a significant role in the in-service training of primary and middle school teachers. However, its role in training teachers of science, mathematics, technical and vocational subjects has remained minimal. Being a multimedia institution with the capacity to train great numbers, the university can make a very useful contribution to the training of science and mathematics teachers. The Department of Science Education at AIOU has the following plans for training teachers of science and mathematics:

- Development of orientation courses patterned on PTOC for science teachers of middle and high schools. These courses would be focused on imparting competency-based knowledge, educational theories and principles, philosophy and history of science education, learning theories, evaluation in science education, actual classroom teaching skills and science skills.

- Organisation of compulsory practical workshops of two weeks' duration for these courses. The trainees in these workshops would be given opportunity to perform practicals; to deliver, observe and evaluate lessons; to improvise and use low-cost materials and audio-visual aids.

- Development of correspondence texts, to help student/teachers develop competency and enable them to handle new curricula. Audio-visual aids such as slide-sound programmes on various concepts included in school science curricula, video programmes demonstrating various teaching methods, audio-cassettes with workbooks, etc. These and other similar teaching and learning aids can prove very useful in the training of Master Trainers as well as teachers.

- For successful implementation of orientation courses prior to launching these programmes, the following activities will also need to be undertaken:
  - holding of short-term training workshops for Master Trainers
  - development of science kits for the orientation courses
  - researching the competencies of practising teachers to identify areas that need improvement
  - investigating possibilities of cooperation between institutions of formal education and AIOU for launching teacher training courses with a practical orientation

- Development of pre-service courses leading to a certificate and degree in science and technical/vocational education.
• Development and launching of training courses/workshops for supervisors and science educators to develop a cadre of science educators who can contribute as experts in both formal and distance education teacher training programmes.

• Development of practical guides, video programmes and practical workbooks to help train teachers of these subjects.

• Development of literature on science education in Urdu for the teachers of middle and high school classes.

POSSIBLE AREAS OF COLLABORATION BETWEEN MEMBERS OF COL

Members of COL can share their expertise and experience to develop viable distance education programmes for in-service and pre-service training of teachers. The members states can collaborate in launching of the following projects:

• a survey researching teachers’ competencies in order to identify areas requiring improvement

• a survey exploring the areas in which formal and non-formal educational institutions can share facilities, expertise and experience to launch teacher training programmes

• the development of Teacher-Training Packages consisting of: self-explanatory printed text, workbooks, teachers' guides, teachers' kits, audio-cassettes and practical workbooks on performing science experiments, and video programmes demonstrating various teaching models

• an evaluation of distance education teacher-training programmes and workshops to identify strengths and weaknesses of the system.
References


Appendix 1: Structure of the Educational System (Formal Only)

<table>
<thead>
<tr>
<th>Grade</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
<th>IX</th>
<th>X</th>
<th>XI</th>
<th>XII</th>
<th>XIII</th>
<th>XIV</th>
<th>XV</th>
<th>XVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Age</td>
<td>5/6</td>
<td>6/7</td>
<td>7/8</td>
<td>8/9</td>
<td>9/10</td>
<td>10/11</td>
<td>11/12</td>
<td>12/13</td>
<td>13/14</td>
<td>14/15</td>
<td>15/16</td>
<td>16/17</td>
<td>17/18</td>
<td>18/19</td>
<td>19/20</td>
<td>20/21</td>
</tr>
</tbody>
</table>

- Primary
  - 1 Year of Education
  - Supervised Training in Industry

- Middle
  - Intermediate

- High
  - Technical Teacher Training (Industrial Art)
  - Certificate

- Diploma
  - Commercial/Technical
  - M.Ed.
  - B.Ed.
  - M.Ed.
  - Masters Degree

- Bachelor or Medicine/Surgery
  - Dentistry
  - Bachelor of Dentistry
  - M.S.
  - B.Sc.
  - M.Sc.
  - B.Sc. Honours
  - Agricultural Engineering
  - Agricultural Education

- Engineering Colleges and University
  - B.Sc.
  - M.Sc.
  - Engineering

- Agricultural Colleges and University
  - B.Sc. Honours
  - Agricultural Engineering
  - Veterinary Medicine

- New Scheme (1973-1974)
  - Diploma (Associate B.Tech. Pass Engineer)

- Vocational Institute
  - Certificate (Skilled Workers)
  - Vocational Trades
Appendix 2: Structure of Teacher Training in Pakistan

Pre-service

Primary


Education Extension Centres

PTGC of A.I.O.U.

RTS of A.I.K.E.

Secondary

Education Extension Centres


Administrator, Planner, Supervisor

A.I.P.A.M.

College of University Teachers

Elementary School Teachers

C.T.

P.T.C.

G.T. (General Education)

G.T. (Professional Training Center)

Distance Education 14-2 Model

B.Ed.

B.A.A. and B.Ed.

B.Ed. 14-1 Model

N.A.H.E. of U.G.C.

Colleges of Education Developers

Allama Iqbal Open University

F.T. of A.I.K.E.

Colleges of Elementary Education

Courtesy: Designed by Dr. R.A. Farooq, Joint Director A.P.A.M.
### Appendix 3: Pakistan Education Key Indicators – 1991

<table>
<thead>
<tr>
<th>AREA</th>
<th>SQ. KILOMETRES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pakistan</td>
<td>796,095</td>
</tr>
<tr>
<td>N.W.F.P.</td>
<td>74,521</td>
</tr>
<tr>
<td>Punjab</td>
<td>205,344</td>
</tr>
<tr>
<td>Sindh</td>
<td>140,914</td>
</tr>
<tr>
<td>Balochistan</td>
<td>347,190</td>
</tr>
<tr>
<td>F.A.T.A.</td>
<td>27,220</td>
</tr>
<tr>
<td>Islamabad</td>
<td>906</td>
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*POPULATION DENSITY 1989*

<table>
<thead>
<tr>
<th>Per Sq. Km</th>
<th>Pakistan</th>
<th>137</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>N.W.F.P.</td>
<td>193</td>
</tr>
<tr>
<td></td>
<td>Punjab</td>
<td>299</td>
</tr>
<tr>
<td></td>
<td>Sindh</td>
<td>175</td>
</tr>
<tr>
<td></td>
<td>Balochistan</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>F.A.T.A.</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td>Islamabad</td>
<td>487</td>
</tr>
</tbody>
</table>

**ADMINISTRATIVE UNITS**

- Provinces: 4
- Divisions: 24
- Districts: 104
- Tehsils/Talukas: 391
- Villages: 47,586

*Note: Includes Islamabad*

*POPULATION, 1990 (in 000)*

<table>
<thead>
<tr>
<th>Female</th>
<th>Both Sexes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>53,660</td>
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<tr>
<td>Rural</td>
<td>37,218</td>
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</table>

*Estimated

### SCHOOL LEVEL POPULATION
(5 years & above by Level 1990)

<table>
<thead>
<tr>
<th>PRIMARY</th>
<th>Female</th>
<th>Both Sexes</th>
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<tbody>
<tr>
<td>Total</td>
<td>8,566</td>
<td>18,080</td>
</tr>
<tr>
<td>Rural</td>
<td>6,327</td>
<td>13,051</td>
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<table>
<thead>
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<th>MIDDLE</th>
<th>Female</th>
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<table>
<thead>
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<table>
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<th>INTERMEDIATE</th>
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<tr>
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LITERACY, 1981 (IN PERCENT)

<table>
<thead>
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<td>Urban</td>
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SCHOOL EDUCATION, 1989-90

<table>
<thead>
<tr>
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<tr>
<td>Total</td>
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</tr>
<tr>
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*Estimated*
### Appendix 4

#### Enrolment (In 000)

<table>
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<table>
<thead>
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<th>No. of Teachers (In 000)</th>
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<tbody>
<tr>
<td>Total</td>
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#### MIDDLE

<table>
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<th>Total</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>7,161</td>
</tr>
<tr>
<td>Rural</td>
<td>1,749</td>
<td>5,877</td>
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</table>

<table>
<thead>
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<th>Enrolment (In 000)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>661</td>
<td>2,397</td>
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<tr>
<td>Rural</td>
<td>151</td>
<td>1,059</td>
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</table>

<table>
<thead>
<tr>
<th>No. of Teachers (In 000)</th>
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<th>Both Sexes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>21</td>
<td>68.2</td>
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#### HIGH

<table>
<thead>
<tr>
<th>No. of Schools</th>
<th>Total</th>
<th>Both Sexes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,749</td>
<td>5,877</td>
</tr>
<tr>
<td>Rural</td>
<td>639</td>
<td>3,136</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Enrolment (In 000)</th>
<th>Female</th>
<th>Both Sexes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>232</td>
<td>820</td>
</tr>
<tr>
<td>Rural</td>
<td>29</td>
<td>256</td>
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#### INTERMEDIATE COLLEGES

<table>
<thead>
<tr>
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<th>Both Sexes</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Colleges</td>
<td>88</td>
<td>227</td>
</tr>
<tr>
<td>Enrolment (In 000)</td>
<td>21.9</td>
<td>70.2</td>
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<tr>
<td>Teachers</td>
<td>1,332</td>
<td>3,542</td>
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#### SECONDARY VOCATIONAL

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>No. of schools</td>
<td>191</td>
<td>385</td>
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<td>Enrolment (In 000)</td>
<td>11.2</td>
<td>53</td>
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<tr>
<td>No. of Teachers</td>
<td>116</td>
<td>1,612</td>
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#### TEACHER EDUCATION

<table>
<thead>
<tr>
<th>No. of Teacher Training Institutions (Below Degree Level)</th>
<th>Female</th>
<th>Both Sexes</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Teacher Training Institutions (Below Degree Level)</td>
<td>228</td>
<td>543</td>
</tr>
<tr>
<td>Training Capacity (In 000)</td>
<td>22.1</td>
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#### HIGHER EDUCATION DEGREE COLLEGES

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</tr>
</thead>
<tbody>
<tr>
<td>No. of Colleges</td>
<td>122</td>
<td>348</td>
</tr>
<tr>
<td>Enrolment (In 000)</td>
<td>143</td>
<td>399.3</td>
</tr>
<tr>
<td>No. of Teachers</td>
<td>4,448</td>
<td>13,805</td>
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*Includes Mosque Schools
## Appendix 5

### UNIVERSITIES

<table>
<thead>
<tr>
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<th>Both Sexes</th>
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<tr>
<td>No. of Universities</td>
<td>22</td>
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<td>Enrolment</td>
<td>10,310</td>
<td>73,382</td>
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<td>No. of Teachers</td>
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<td>4,304</td>
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### AGRICULTURAL EDUCATION

<p>| | |</p>
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<tbody>
<tr>
<td>No. of Universities</td>
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<td>Enrolment</td>
<td>8,656</td>
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### TECHNICAL EDUCATION

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<tbody>
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<tr>
<td>No. of Engineering Colleges</td>
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<tr>
<td>Enrolment</td>
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<td>No. of Colleges of Technology</td>
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<tr>
<td>Enrolment</td>
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<tr>
<td>No. of Poly/Monotechnics</td>
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<td>Enrolment</td>
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### MEDICAL EDUCATION

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<td>22</td>
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<td>Enrolment (000)</td>
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### BUDGET 1990 – 91

(Rupees in Millions)

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<th>Non-developmental</th>
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<td>1,498.9</td>
<td>9,523.6</td>
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<td>Secondary Education</td>
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<td>1,167.3</td>
<td>4,929.5</td>
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<td>Colleges</td>
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<td>2,050.9</td>
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<td>801.7</td>
<td>1,359.5</td>
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<td>% of GNP</td>
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### PARTICIPATION RATES – PER CENT (1990)

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<tr>
<td>Middle</td>
<td>25</td>
<td>34</td>
<td>15</td>
</tr>
<tr>
<td>High</td>
<td>19</td>
<td>25</td>
<td>12</td>
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### PUPIL – TEACHER RATIOS

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<th>Middle</th>
<th>High</th>
</tr>
</thead>
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<td>40</td>
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<td>33</td>
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<tr>
<td>High</td>
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<td>8</td>
<td>7</td>
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### PUPILS PER SCHOOL/COLLEGE

<table>
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<th>High</th>
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<tbody>
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<td>Primary</td>
<td>95</td>
<td>91</td>
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<td>Middle</td>
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<td>351</td>
<td>297</td>
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<tr>
<td>High</td>
<td>140</td>
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Source: Central Bureau of Education, Ministry of Education, Government of Pakistan, Islamabad
Table 1: No. of Middle Schools and their Teachers/Science Teachers in Punjab

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<tr>
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<tr>
<td>Male</td>
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<td>3,719</td>
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<tr>
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<td>729</td>
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<tr>
<td>Male</td>
<td>100</td>
<td>174</td>
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<tr>
<td>Female</td>
<td>10</td>
<td>41</td>
<td>51</td>
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</table>

Source: Pakistan Science Education Project for Secondary Education (1986)

Table 2: No. of High Schools and their Teachers/Science Teachers in Punjab

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<td>Female</td>
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<tr>
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<td>1,390</td>
<td>2,860</td>
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<tr>
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<td>2,611</td>
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<tr>
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<td>673</td>
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<td>2,063</td>
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<tr>
<td>Female</td>
<td>51</td>
<td>497</td>
<td>548</td>
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</table>

Source: Pakistan Science Education Project for Secondary Education (1986)
CHAPTER 15

TRAINING TEACHERS FOR SCIENCE AND MATHEMATICS: SOME EXAMPLES FROM AFRICA

Peter E. Kinyanjui

INTRODUCTION

The problems and constraints associated with the teaching and learning of science and mathematics in the developing countries are well known. They include the following:

- general poverty
- poor teaching and learning facilities
- lack of appropriate books and other learning materials
- lack of laboratory facilities, equipment and materials
- shortage of qualified and experienced teachers
- poor conditions and terms of service for teachers
- lack of efficient and effective teacher support services
- lack of incentives
- faulty curricular and examination systems
- lack of clear policies on science and technology
- unresolved gender-related issues in science and technology
- underdeveloped science culture.

These problems do not come singly; indeed, many of them are multilateral and self-perpetuating. They often manifest themselves in a number of vicious circles that are difficult to break.

In spite of (and sometimes because of) these problems and constraints, a number of innovative African projects have been devised to provide possible solutions or alternative methods in the teaching of science and mathematics. This paper describes selected examples of these projects, which illustrate possible growth areas in the training of teachers for science and mathematics.

KENYA SCIENCE TEACHERS' COLLEGE (KSTC)

The Kenya Science Teachers' College was created in 1965 through Swedish technical assistance. The College offers a two-year diploma course in science subjects and mathematics, and aims to produce teachers who are equipped with both the academic knowledge and pedagogic skills to teach in the Kenya secondary education system. The
course ideally prepares teachers to teach at least two subjects up to Form 4 or 'O' level. The Diploma in Education Certificate is awarded to successful candidates by the Ministry of Education.

All candidates take two teaching subjects selected from a list of science and mathematics subjects. In addition, they take Education as a two-year course, while in the first year they take courses in Science and Society, Development and Social Studies, Library and Study Skills, and a Workshop Practical Course.

For the Workshop Practical Course, students use the facilities of the School Equipment Production Unit (SEPU), which was established in 1967. SEPU's main objective is to assist in the improvement of teaching both in content and method, and in adapting teaching aids to Kenya's needs in line with the available resources.

SEPU was created as an independent company under a board of directors, but with the Ministry of Education owning all the shares. The objectives of SEPU are outlined in the Memorandum of Articles of Association, as summarised in Box 1.

### Box 1: Kenya School Equipment Unit (SEPU)

**Aims and objectives:**

- to manufacture and produce assorted equipment and teaching aids, including science kits, glassware, furniture, etc.
- to import all types of equipment and chemicals
- to retail, wholesale and export the above
- to act as adviser to schools for selection and use of equipment
- to do anything for schools, colleges and other institutions of learning for the purpose of:
  - furthering educational goals
  - promoting science education and education in general.

SERVICES OFFERED BY SEPU

SEPU'S main objective is to assist all schools in the improvement of teaching science and education in general. Among the various services offered to schools by SEPU are:

1. **Chemicals**
   SEPU directly imports a wide range of chemicals for use in schools. The chemicals are imported in suitable packs or in bulk for repacking.

2. **Glassware and Other General Laboratory Equipment**
   Simple glassware equipment is produced by SEPU technicians and at times, with the help of hired experts. Specialised items such as microscopes, balances, etc. are imported directly for schools.

3. **Repairs and Maintenance**
   Most of the repairs of laboratory equipment for schools are done by SEPU personnel. A part-time technician from KSTC is used for few major repairs and maintenance of:
   - Power packs
   - Electrical balances
   - Microscopes
   - Stop-watches
   - Broken glassware

4. **Auxiliary Services**
   For some time now, SEPU has been offering the following services to schools:
   - Laboratory gas fittings
   - Laboratory water fittings
   - Laboratory furniture
   - Fire-fighting equipment

5. **Primary School Equipment**
   SEPU has continued to design and manufacture the following items:
   - Blackboard rules
   - Blackboard set squares, protractors and compasses
   - Primary School Science Kit
   - T-squares, drawing-boards, etc.

6. **Practical Examination Materials**
   SEPU has continued to design and manufacture some of the required practical materials for local practical examinations. It has also been engaged in the importation of other items required for the same purpose.

Through the practical workshop courses conducted at SEPU, the teacher trainees at KSTC are able to familiarise themselves with the type of equipment and materials they are likely to find in their schools. They are also able to develop their own improvisation in cases where no equipment exists.

SEPU has also been instrumental in the design and development of distance education courses for the new B.Ed. (Science) External Degree programme of the University of Nairobi. This programme is a sequel to the B.Ed. (Arts) degree programme, which was launched in 1985. The subject of Mathematics is common to both programmes. A sample of the topics covered in Mathematics is provided below in Box 2.
Box 2: Course ECT 201: Methods of Teaching Mathematics

CONTENTS

Introduction .......................................................................................... (iv)
Lecture 1: Mathematics: Its Nature and Aims of Teaching II ................. 4
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Lecture 3: The Mathematics Syllabus ............................................... 27
Lecture 4: Instructional Objectives ................................................... 41
Lecture 5: Teaching Strategies .......................................................... 51
Lecture 6: Planning to Teach Mathematics ....................................... 61
Lecture 7: Teaching Some Selected Topics ....................................... 71
Lecture 8: Testing Pupils' Learning ................................................... 81
Lecture 9: Instructional Materials for Teaching Mathematics ............ 91
Lecture 10: Mathematics Teaching: Then, Now and in Future .......... 101

Taken from College of Education and External Studies,

The courses in these programmes are conducted through distance education methods with print as the main medium of instruction. In addition, there are organised student support services that include tutoring and counselling, regional study centres, audio and visual materials as well as library services - all of which comprise the "learning package." The science programme includes basic experiment kits as part of the learning package prepared with assistance from SEPU. For more sophisticated experiments requiring the use of laboratories, the existing facilities in teacher training colleges and senior secondary schools throughout the country are utilised by the external degree candidates.

It is worth noting here that the B.Ed. degree course materials from Nairobi have recently been transferred to Makerere University in Uganda, with the assistance of COL, for the launching of a similar external degree programme aimed at secondary school teachers in Uganda. At the same time, COL is assisting in the training of Ugandans in the skills of writing, editing and producing their own course materials to fill the gaps left by the Nairobi courses. This is the kind of South-South cooperation that COL wishes to facilitate and strengthen among Commonwealth institutions.

ZIMBABWE SCIENCE PROGRAMME (ZIMSCI)

The Zimbabwe Science Programme (ZIMSCI) provides one of the success stories in the use of practical experiment kits in the classroom to teach science. The ZIMSCI package includes self-study materials, guides, assignments and experiment kits for carrying out practical work in the classroom. Separate packages have been developed for lower and upper secondary classes where there are not enough qualified science teachers. In such cases, the class teachers act as guides and supervisors, not as teachers. The contents of a sample kit for the upper secondary class ('O' level) are shown in Box 3.
Box 3: Zimbabwe Science Programme (ZIMSCI)

<table>
<thead>
<tr>
<th>Specialised Items and Structures Kit</th>
<th>Chemical Kit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alloys kits</td>
<td>Albustix (packet) 1</td>
</tr>
<tr>
<td>Elastic 1 metre</td>
<td>Calcium 100 g 2</td>
</tr>
<tr>
<td>Galvanised iron wire 500 g</td>
<td>Carbon rods (packet) 1</td>
</tr>
<tr>
<td>Polariser/analyzer kit</td>
<td>Iron Oxide 100 g 1</td>
</tr>
<tr>
<td>Soldering iron</td>
<td>Potassium Nitrate 5 g 1</td>
</tr>
<tr>
<td>Solder roll</td>
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<td>Mirror planes</td>
<td>Nails (500 g) 1</td>
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<td></td>
<td>Scalpel blades 2</td>
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<td>Microscope slides 60</td>
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It is important to point out that science kits are not cheap. They require considerable investment of physical and human resources, as well as time in their design, development, production and distribution. There is merit, therefore, in establishing systems for the review of existing materials and, accordingly, for the exchange and transfer of appropriate materials between institutions. In certain cases, there will be need for assistance in the adaptation of materials or for training in the design and production of local materials to fill identified gaps. These constitute some of the key functions that have been assigned priority in COL’s strategic plan. The transfer of the ZIMSCI sample experiment kit to the Bahamas is one case in point.
CORRESPONDENCE AND OPEN
STUDIES INSTITUTE (COSIT), NIGERIA

The Correspondence and Open Studies Institute (COSIT) was established at the University of Lagos, Nigeria, in 1975. Since then, it has conducted degree programmes in Science Education, Business Administration and Accounting as well as a diploma programme in Education and a preparatory programme in Science Education. The main purpose of introducing the B.Sc. (Ed.) degree programme was to train secondary school science teachers.

At COSIT, the following courses are taught at a distance: Physics, Chemistry, Biology and Mathematics. The University decided right from its inception that the multimode approach consisting of printed course texts, broadcasting and face-to-face tutoring would be used. Broadcasting was phased out within the first few years. Printed course texts thus became the main delivery mode supplemented by face-to-face tutoring. As a result of the introduction of a new unit course programme and failure on the part of the Institute to keep up with updating and rewriting the course texts, face-to-face tutoring (which was to account for only 20% of the total teaching component) became the main component of the programme. Even though the unit course programme was finally adopted by COSIT in the 1986-87 session six years after it was introduced into the full-time mode, serious efforts to write appropriate course texts were not begun until June, 1989. Many of the courses have now been written or are being rewritten. There is every reason to believe that all of these course texts will be completed by the middle of 1993.

From the inception of the programme, efforts were made to create study centres in other universities and polytechnics. Science practicals were to be undertaken by science students in these various centres, and COSIT would pay for the use of the laboratories as well as the classrooms at these centres. Practicals are also undertaken during the compulsory residential programmes held at the University of Lagos every year.

Even though the situation is not perfect, sufficient progress has been made to guarantee successful continuation of the programme. Efforts would need to be redoubled to identify more centres for practicals, so that students would not have to go too far from their stations in order to undertake practicals. The Institute is also planning to build large laboratories that could handle up to 250 students at a time in order to be able to accommodate more students for longer periods during the residential programme. This expectation may become a reality in the second phase of COSIT’s building programme. The first phase is expected to be completed by May, 1993.

Teaching Practice

Until 1989, students were sought out by teaching practice supervisors and observed while teaching in their own schools. This practice had become so expensive that in many cases, the Institute paid out more to teaching practice supervisors than it collected from students in fees for the session. Since 1990, the practice sessions have been concentrated in a few schools within the students’ study centre zones, and teaching practice supervisors converge at three or four schools in the same area and have been able to monitor their trainees more effectively at a lower cost to the Institute. It has also become possible for surprise visits to be made from Lagos to evaluate the closeness of interaction between the trainees and their supervisors, since designated schools are now easier to reach by one person, whereas in the past, it was not cost-effective to pay surprise visits to single schools in remote areas of the country.
In the larger centres, staff members from Lagos are able to spend up to a week at a time and participate in the supervision exercise. Nevertheless, the rising cost of transportation has made it more difficult to conduct the supervision exercise on a regular basis.

WHAT REMAINS TO BE DONE

The examples quoted earlier have pointed to a number of possible growth opportunities in the training of teachers for science and mathematics. It is in the area of teacher training that distance education has found its widest application in Africa. It should now be expanded to include the training of teachers for science and mathematics in order to solve the pressing problems of quantitative expansion of education for all people, the qualitative improvement of education at all levels, and the contingent issues of the rising costs of education.

The preparation and training of science teachers is not simply a question of producing the numbers necessary to meet projected educational goals of a country. Rather, it should be seen as an integral part of a continuous developmental effort toward a comprehensive national policy on science and technology.

There are several ways in which distance education can contribute to the improvement in the quality of the science and mathematics teachers and, therefore, of education generally. First, the use of centrally produced science teaching materials that can be updated quickly and distributed widely ensures that all science teachers receive the same standard materials. This is particularly important in improving the general academic background of the teachers by providing them with a broad scientific knowledge base. Further, the strengthening of the general scientific background and the improvement of subject matter competence of the teachers ensures that they have the capacity to perform well during training, in the classroom and in the laboratory.

Second, the application of distance teaching techniques in teacher training helps to equip the prospective teachers with a wide repertoire of learning and teaching processes, such as analysis, classification, deduction, hypothesis, experimentation, interpretation, formulation and synthesis, which are important skills in science. Through the use of well-structured study guides, experiment kits and written assignments, the teachers are put into a situation in which they have to practise these skills. It would seem, therefore, that one way of introducing process approaches to the teaching of science in schools would be to have the teachers themselves gain the experience and the confidence in using similar approaches during training.

Third, if most of the academic theory and content could be taught through distance education, it would give the teachers more time to emphasise pedagogic skill development and practice teaching. This is where face-to-face teaching becomes an essential component of distance education. It provides the teachers with an opportunity to reason about the content of instruction, to organise and manage learning processes, and to evaluate and motivate learners in a manner that promotes self-reliance. Teachers who have themselves undertaken distance education courses are likely to be more familiar with these learning activities than those who have not and, therefore, more confident in recommending those learning skills in which they have had first-hand practical experience.

It must be emphasised, however, that the task of training teachers for science and mathematics is only a first step toward the improvement in quality of education as a
whole. By themselves, the newly trained teachers will not be able to bring about the needed change in mathematics and science education, unless efforts are made to reform the related aspects of curriculum, examinations and supervision. Educational change implies change in the concepts, attitudes and behaviours of those inside as well as outside the educational system. The second emphasis, therefore, points to the need for incorporating curricular changes in science and supporting subjects such as mathematics within the teacher-training programme, so that the teachers can find direct classroom application of knowledge and skills gained during their training. For example, a teacher who finds that a new approach to science has direct application or relevance to the classroom situation is more likely to take keen interest in learning it and seeking more information than a teacher who learns it just for the sake of satisfying the examiner.

The third point to emphasise is the need to provide all mathematics and science teachers, particularly the newly qualified, with professional support and management on a continuing basis in order to improve their quality and morale. For this to happen, there has to be an efficient system of personnel management. This presupposes that there are, within the system, adequate and up-to-date records of information on all specialist teachers in the service for use in the planning of teacher demand and supply, and for deployment and promotion of individual teachers. It also presupposes that those expected to provide support and guidance are themselves well equipped to perform these tasks.

It is suggested, therefore, that distance education methods could be used to impart the latest information about curricular changes, teaching methods, and educational policies in mathematics and science to all inspectors and supervisors, in addition to the practising teachers, so that both the administrators and the educators can be on an equal footing on the long road to educational reform.

Clearly, the use of conventional methods to meet the varying and growing needs of education will be slow and expensive. It has been suggested in this paper that distance education might be one of the most practical and effective ways of generating the idea of continuing teacher education for science and mathematics, as rapidly and as widely as possible.
CHAPTER 16

TRAINING TEACHERS FOR MATHEMATICS, SCIENCE AND TECHNICAL/VOCATIONAL SUBJECTS IN DEVELOPING COUNTRIES: THE NIGERIAN EXPERIENCE

Grace A. Williams

INTRODUCTION

Formal western education was introduced to Nigeria by the Christian missionaries in 1842, while the first Teacher Training College was established in 1859. Before this institutionalisation of education, there was, of course, informal education in vocational/technical disciplines, and perhaps in rudimentary science and mathematics laced in the cultural milieu of African society. Unfortunately, due to the nature of the colonial superstructure, the emphasis of western education was on literary subjects (the Classics), which represented elitism. The African tradition of a reverence for utility in every aspect of life was relegated to the background, while this liberal western education (which was only useful for the work of clerical jobs in the colonial administration) was sought out and acquired by the African “elite.” Government thus became the major employer of labour. Mention must also be made of some training in western types of skilled jobs, which likewise originated in the colonial government’s need for technicians. These jobs were mainly in the areas of minor technicians required in the railway services, marine services and the public works department. From colonial times until very recent times, jobs in these fields generated interest in technical education. The clerk and interpreter worked with British officers in clean offices where decisions made affected the lives of Nigerians. Technicians in the railway, marine public works (or utilities) services worked with their hands and commanded little respect. Similarly, a technician earned less than a clerk and usually became apprenticed because he could not even pass the Standard VI examinations. Thus a technician earned less than a clerk. A skilled “native technician,” farmer, etc. earned even less than a British-trained technician. Consequently, right from colonial times the stigma of working with the hands rather than being a clerk was introduced to Nigerian society.

In the 1960s, however, emerging African countries realised that they were not developing satisfactorily (especially economically) and research found that graduates of the literary schools could not meet the country’s economic needs. It was seen that the university-developed literary education in the humanities could not produce persons with the technical knowledge very much needed in the young countries. Similarly, the paucity of science schools and the low output of science graduates resulted in problems with training technicans and technologists. Even in the 70s, it was clear that more
students in science and technology had to be produced in schools. As a result, colleges of technology and polytechnics were established, universities of technology as well as Colleges of Education (Technical) multiplied in Nigeria. It was in this light that Nigerians met in 1969 to work out a philosophy of education, which over a decade later became the Nigeria National Policy on Education. The need for and problems associated with technical and vocational education were major issues. Even more important was the issue of producing teachers to teach the many newly introduced subjects in technical education. The emphasis on technical and vocational education in Nigeria can be appreciated from the fact that not only were subjects in technical and vocational education introduced at both primary and secondary levels, but even the structure of the school system was affected. This emphasis gave rise to the famous 6–3–3–4 educational system in which much work is introduced at the secondary 3–3 levels to validate the emphasis on technical/vocational education and direct many secondary school pupils toward science and technical education.

I will now address the issue of teacher education in Nigeria (which approximates that of most developing nations) with respect to science, mathematics and technical/vocational subjects. A rationale for this presentation is that teacher education in these areas is a fundamental prerequisite for training students who can be effective launching pads for science and technological development, especially in Third World countries where development is relatively low. The production of teachers in these areas would help to eliminate apparent stagnation, which is one of the major problems affecting development and is the antithesis of science and technology. It is also necessary to ensure that teachers imbibe appropriate cultures in mathematics, science and technical/vocational endeavours such as in the areas of objective reasoning, logic and empiricism.

Integrating culture with mathematics, science and technical education requires a merging of school and society, especially where the social and cultural values plus a technological orientation are absorbed into the school system. Developed countries in Europe have built this technical orientation and culture into their societies over centuries. The spilling over of this attitude into the school system has been gradual, but even in European countries the schools cannot teach all that the young student must learn in technical and vocational education. Even though the mathematical and scientific principles are mastered, only basic technical and vocational skills can be taught. Development of technical and vocational skills takes place in industry. Although government and industry in developing countries recognise the importance of such experience and their shortfall in development of skills, it is still necessary for these countries to introduce measures and changes in the school system in order to increase their pace of technological development. In this regard, the Nigerian government signed an agreement with the United States for the training of technical teachers. Furthermore, in addition to the two existing Colleges of Education devoted exclusively to the training of science, mathematics and technical/vocational teachers, six more were established. Despite these efforts made by the federal government to rectify the shortage of teachers in the sciences compared to the glut in humanities and the arts, several problems still exist. I will identify these problems and advance strategies to solve them.

Problems associated with developing technical and vocational education in African countries include:

1. Lack of political will
2. Misinterpretation of the national policy on education
3. High cost of operating technical programmes
4. Shortage of mathematics, science and technical teachers
5. Low quality of students admitted into technical schools
6. Lack of interest and poor conditions of service for technical/vocational teachers
7. Lack of cooperation between staff in Faculties of Education and staff in Faculties of Engineering and other such professions.

PROBLEMS AND THEIR SOLUTIONS

1. Lack of political will. Different governments usually have varying priorities. For instance, a military government is more likely to allocate the major portion of its budget to defence rather than education. In the case of a democratically elected civilian government, promises made for free education at all levels usually mean that education gets a sizeable share of the budget. However, given the grandiosity of offering free education at all levels, the funds allocated are usually unrealistic. As mentioned, technical and vocational education has been very low on the priority list in education from colonial times. This colonial heritage is still with us; even though it has become apparent that technical education can earn more for a worker than education in the humanities, the social and political will of the nation is not yet directed away from education in the humanities. One major reason may be the tacit belief that education in the humanities is still more likely to lead an individual toward acquiring and assuming power in the social polity. In other words, a lawyer rather than an engineer, an historian or political scientist rather than a doctor is more likely to wield political influence and power in the society. The role model for aspiring young children with average or above average intellectual ability is, therefore, deflected from technical and vocational education.

Furthermore, with the emphasis on free education as conceptualised and practised in many African countries, there has not been in place a clearly delineated programme for meeting the expenditure of our so-called “free” education, nor has there been enough examination in terms of prioritising the three levels of education: elementary, secondary and tertiary. Further prioritisation of the various units within each of the levels has not shown the proper emphasis with regard to available funds for technical education. While it is fine for governments to talk about “free” education, the expenditure on education vis-à-vis other competing claims for funds in the country has not been well articulated in favour of education.

Strategies for remediation. It is clearly necessary to re-examine the idea of free education and to define “free” in the context of who pays for what and from what sources: students, parents, communities, local governments, states, regions, federal or central governments. Moreover, it would be necessary to re-examine the policy and practice of education in terms of bringing together educational institutions and industry in order to ensure relevant and useful technical education necessary for the advancement of any developing country.

Lastly, it will be imperative to examine the structure of salaries, emoluments and other conditions of service with respect to teachers, vis-à-vis other sectors of the economy.

2. Misinterpretation of the national policy on education. Some clauses in the National Policy on Education describing the mission, scope and status of vocational/technical education are not clear. It is stated that vocational/technical education should aim at providing a trained workforce in applied science, technology and commerce, particularly at sub-professional grades. This is taken to mean that this type of education is limited to the preparation of low- and mid-level wage earners only. Those implementing the government’s policy do not understand its content or scope and are, therefore, unable to stimulate support for the programmes. Given the presence of
indigenous technology and the various stages of its development. Attempts should be made to incorporate it within the programme and encourage initiative in teaching indigenous technology, thereby improving the quality of technical education introduced into the schools and making it relevant to the various regions of the country.

Strategies for remediation. In formulating policies and allocating funds, government should enlist the services of professionals who would examine educational needs and make recommendations accordingly. In addition, workshops, seminars and conferences should be organised to enlighten teacher trainers, educators and the general public as to the need for trained teachers in science, mathematics and technical/vocational disciplines, both at sub-professional and professional levels. Representatives from various sectors of the economy should also have the opportunity to participate in the formulation and implementation of national policies on education, insofar as their respective areas are affected.

There is also a need for compiling types of indigenous technology in various parts of the country and streamlining these with a view to improving the quality of their practice, as well as standardising materials and methodology.

3. High cost of operating technical programmes. Teacher training in the sciences and technical/vocational disciplines requires the use of laboratories and workshops furnished with special equipment and machinery. All of this costs large sums of money, which the federal and state governments are not prepared to meet in view of other more pressing needs, according to their perceived priorities. Governments often prefer building schools to provide general education, for instance, in the humanities. These need only lecture halls. This issue also boils down to the political will of policy leaders. Apart from Kaduna Polytechnic, no other institution claiming to prepare technical/vocational teachers in Nigeria has the good fortune of direct funding by the federal government. Initiative must be brought to bear on how to use well-placed technical and vocational schools optimally, since technical and vocational disciplines require expensive machines that must not be allowed to lie fallow. Such equipment must be used at least twelve hours every day of every week all year round. This may mean redesigning timetables and schedules for teachers and students, in order to ensure that many more persons have access to such equipment.

Recognising the high cost of some of this equipment, new initiatives must be undertaken in terms of using this equipment partly for teaching and partly for economic activities.

Strategies for remediation. Government ought to show commitment in practical terms by releasing special funds for the above purpose to institutions concerned. On their part, institutions should consult the business sector regarding its concerns in order to generate funds.

Local industries should be encouraged to manufacture scientific/technical equipment at reduced cost and also to provide maintenance for the machinery. More opportunities for research should be made available in order to encourage the development of simple tools and equipment rather than sophisticated equipment that might be able to do work at faster rates. Governments should try to acquire obsolescent equipment from developed countries with a view to studying such equipment and manufacturing parts that will make it work. Finally, more emphasis should be placed on proper maintenance of any machinery in any of the higher institutions in the country.

4. Shortage of mathematics, science and technical teachers. The federal government of Nigeria has terminated its agreement with the United States under the Technical Teacher Training Programme (TTTP), which was designed for the production of
teachers with bachelor and master degrees, since this programme did not encourage the preparation of teacher trainers within the country. Currently, the programme is being offered in four Nigerian universities, but this number is inadequate to prepare the required number of teachers for the various programme areas.

As for mathematics, many students shy away from this subject. They see it as difficult, since there is no room for memorisation and regurgitation of facts. The 1979 West African School Certificate examination results show that only about 4% had five credits including English language, mathematics and science subjects.

**Strategies for remediation.** To ensure basic training in technical and vocational education, the government must commence with the education of much needed teachers. More universities should immediately be authorised to run advanced degree programmes in technical/vocational education. Such programmes could be in the form of short courses, part-time or full-time leadership courses.

The pattern and curriculum for work in all nursery schools as well as the lower half of primary school must be on manipulating objects, and making and building objects. Reading, writing and arithmetic should be developed as ways of communicating among children what they have been taught.

5. **Low quality of students admitted into technical schools.** It is surprising to note that entry requirements into Colleges of Education are very low (three credits at two sittings). This means that those attending Colleges of Education are usually people who were rejected by the universities and polytechnics for not obtaining the requisite 5/4 credits, respectively. These are students who will later become teachers and proceed to teach other would-be teachers who are as educationally incompetent as they are. This practice has a long-term effect of lowering educational standards in schools and colleges.

Perhaps less emphasis could be paid to the number of credits acquired at the secondary school and more emphasis should be placed on students’ ability to reason. Also, new types of evaluation texts could be designed and integrated within the system.

A problem related to that highlighted above is the proliferation of Sandwich Teacher Education Programmes. These programmes are usually very hectic, and participants hardly have time to comprehend what they are taught before they must sit the examinations. In fact, lectures end the night before examinations commence. In the case of mathematics, science and technical education of teachers, there is not enough time for practical work in the laboratories and workshops. This crash programme can only produce many “half-baked” teachers rather than quality teachers.

**Strategies for remediation.** High entry requirements should be maintained in order to ensure that only the best students are admitted into teacher training programmes. This is necessary as teacher educators ought to have a profound background in their areas of specialisation.

Also, a proper system for monitoring and simplifying the various teacher programmes multiplying throughout the country should be set up.

6. **Lack of interest in and poor conditions of service for technical/vocational teachers.** The dearth of teachers in the fields of mathematics, science and technical/vocational education compared to other areas is due to the fact that teachers feel neglected. Student teachers do not receive any allowance during their training and are even expected to pay fees to support expenses incurred while being supervised.
during teaching practices. Also, training supervisors usually complain of inadequate allowances and non-insurance of their lives during trips to trainees; they cannot, therefore, be relied upon to do their best during the supervision exercise.

The economic recession, which has created massive unemployment, has not improved matters, especially since many teachers graduate from the programmes without securing job placement. This can kill whatever enthusiasm they may have had before and during training. When they finally secure jobs, technical teacher educators are paid ridiculously low salaries. Financial incentives once given by government to encourage the study of mathematics, science and technical/vocational subjects were stopped long ago. Consequently, teachers either opt for more financially rewarding jobs in industry or emigrate to industrialised nations.

Strategies for remediation. The Federal Teachers’ Bursary Scheme should receive a boost in funding, so that allowances can be given to student teachers and their supervisors during teaching practice.

There should also be a concerted effort by governments to retain and encourage teachers in the areas of mathematics, science and technical/vocational teacher education by offering them the same conditions of service as those in industry and also paying their entitlements as and when due.

7. Lack of cooperation between staff in Faculties of Education and staff in Faculties of Engineering and other such professions. Some university faculties and departments in Nigeria bear parallel relationships with some teacher education programmes, for example, Engineering and Technical Education. Whereas engineering programmes are geared toward designs, technical education programmes deal with customary production and service. This delicate demarcation is misunderstood, however, since both programmes derive their subject matter from the industry; although technical teacher education has the added professional education competency. Engineering faculties of universities scramble to run technical education programmes rather than leaving them to the faculties of education, which are better equipped to train teachers. This issue of non-clarification has hindered the effective management and operation of technical/vocational education in the universities.

Most education faculties have fairly large numbers of staff who do not take sufficient interest in the vocational, science or mathematics areas of competence. The syllabi open to their students in education is quite often left to be designed by their counterparts in mathematics, science, engineering or business. As a result, such syllabi are designed not for education students or students who intend ultimately to teach, but for their colleagues who are professionals in those areas. An obvious implication to this situation is that education teachers are inferior in the subject matter to be taught. This should not be allowed to continue.

Education teachers must be capable of designing courses in the teaching area that are not inferior or pale reflections of courses taken by professionals in the field. Education teachers must not only know enough of the teaching subject in their own subject area or discipline, but also be broad enough in their grasp of the subject to enable them to design, especially at the university level, teaching subject areas for students in education. For example, a vocational teacher who teaches and intends to produce teachers who can produce students in civil and mechanical areas of engineering should be competent and able to teach civil and mechanical students in engineering in any faculty of engineering. This is perhaps a sine qua non for ensuring respect and cooperation between teachers in education and those in the professional field.
Strategies for remediation. There should be a school of Vocational Teacher Education in the universities with departments and a Provost at the head for smooth management and effective programme implementation. The practice of grouping all the occupational areas under one department should be discontinued, since it stanches growth in the respective areas.

These measures would also put an end to the uncertainty and confusion that has plagued teacher education in mathematics, technical and vocational training.

SUMMARY AND CONCLUSION

This paper has addressed some of the issues and identified problems that adversely affect the training of sufficient numbers of teachers for mathematics, science and technical/vocational teacher education in a developing country like Nigeria. Some strategies were also advanced as ways of solving these problems.

Teachers minister to the intellectual, mental and physical needs of learners; their training goes a long way in ensuring their success and ability to meet these needs. A sound, well-balanced teacher education package prevents teachers who are ineffective, disilluminated, indifferent, apologetic or worse still, drop-outs.

Concerned governments need to demonstrate their seriousness about policy statements by taking immediate steps to put into action the recommendations made to them by agencies and committees set up by them. To have adequate information, however, these agencies and committees should include experts in the areas of mathematics, science and technical/vocational education, as well as professional educators in other subject areas.

If Third World countries are to advance technologically, their governments must carefully examine their priorities and select them in terms of what is good for the country. It is necessary to give optimal training to all levels of potential teachers from the pre-school age to the university level in order to obtain the best results. Scholarships should be available for brilliant students who would be potential mathematics, science and applied science teachers. In addition, the package of emolument for teachers must be sufficient to encourage them to remain in the teaching profession. Opportunities for retraining and expansion of knowledge for educators must also be available so that standardised methodologies of imparting knowledge to student teachers can be maintained. Infrastructures for the educational system consisting of laboratories, workshops, repair and rejuvenation centres must be created within states to facilitate local production and maintenance of tools and machinery. These need not be new physical structures; they could be existing institutions. Additionally, more formal and informal meetings must be encouraged and established in which the problems of teacher education and the industry would be carefully and continuously examined.

Developing nations should follow in the footsteps of technologically advanced countries, which have cherished cultural values that make for progress. The Industrial Revolution in Europe coupled with the capitalist spirit changed the people's outlook. The human energy released for changing and directing the environment, when channelled to good use, effected major changes in the world. Since technology means change, we must change our outlook and attitude. Nigeria, and indeed all Third World countries, need a new orientation in order to master their environments and exert better control over their economies, with a view to enhancing technological advancement.
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CHAPTER 17

THE TRAINING OF TEACHERS FOR SCIENCE, MATHEMATICS, TECHNICAL AND VOCATIONAL SUBJECTS

S.T. Bajah

Abstract

Very few countries of the world are known to have trained and retained in their school systems sufficient numbers of teachers for science, mathematics, technical and vocational subjects. Although the reasons for the insufficiency vary from one educational system to another, it does appear that the issues, problems and solutions are similar though not necessarily the same. This paper argues that there is a continuous need to seek pragmatic and feasible solutions; however, the methods and style of executing the activities will take different forms according to the specific needs of each country.

INTRODUCTION

The objectives of this Round Table have been well defined:

- to identify the key issues and problems in the training of teachers for science, mathematics and technical/vocational subjects
- to discuss and recommend strategies to resolve these problems, with illustrations from specific examples and case studies
- to develop a viable programme of activities for COL in teacher education and training
- to evolve approaches and strategies for effective cooperation among the various institutions, agencies and countries, and determine COL’s role in these processes.

For the most part, the Round Table intends to deal with staff development in the specific subjects. However, it is pertinent to draw attention to the fact that staff development needs will generally be addressed on at least five levels:

1. individual
2. institutional
3. local
4. national
5. regional
The precise methods and style of executing projects at the above levels, and the pattern and content of delivery will take different forms according to the specific needs of each country and region.

**RATIONALE: TEACHER TRAINING IN SPECIALISED SUBJECTS**

Mathematics, technical and vocational subjects are generally treated as specialised subjects at all levels of many educational systems. Because the subjects are regarded as specialised, they usually require special attention. At the primary level, due to inadequate initial training and modernisation of the curriculum, primary school teachers need special additional training to enable them to effectively teach the subjects. The question is, Should primary school teachers be specialists?

At the secondary level, the variety of subjects grouped under specialised subjects is so enormous that the teachers need to specialise. Specialisation seems to be easily accepted at this level. What is perhaps lacking is the bringing of trained teachers to the frontiers of their subjects. (See Table 1.)

### Table 1

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<tr>
<td></td>
<td>Maths (Arithmetic)</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>Elementary Maths</td>
<td>P+S</td>
</tr>
<tr>
<td></td>
<td>Advanced Maths</td>
<td>S</td>
</tr>
<tr>
<td></td>
<td>Logic</td>
<td>S</td>
</tr>
<tr>
<td></td>
<td><strong>Tech/Voc Subjects</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technical Drawing</td>
<td>S</td>
</tr>
<tr>
<td></td>
<td>Building</td>
<td>S</td>
</tr>
<tr>
<td></td>
<td>Metalwork</td>
<td>S</td>
</tr>
<tr>
<td></td>
<td>Woodwork</td>
<td>S+PS</td>
</tr>
<tr>
<td></td>
<td>Canework</td>
<td>S+PS</td>
</tr>
<tr>
<td></td>
<td>Secretarial Studies</td>
<td>S+PS</td>
</tr>
<tr>
<td></td>
<td>Catering</td>
<td>S+PS</td>
</tr>
</tbody>
</table>

* Level

P – Primary
S – Secondary (Post-Primary)
P – Post-Secondary
In many developing countries, the education budget is stretched to its limits because of the salary bill of the large number of teachers, both primary and secondary, required in the school systems. To reduce this cost, many educational systems opt for primary school teachers who are generalists in order to avoid the additional cost of providing for specialist primary school teachers. At this point, however, I am not able to provide empirical information for comparative teacher effectiveness of specialist versus generalist teachers of science, mathematics, technical and vocational subjects.

ISSUES AND PROBLEMS

Six issues that relate to the training of teachers for the various levels have been identified in this paper:

1. time
2. quality of initial training
3. the dynamic curriculum
4. cost
5. the socio-cultural environment
6. quantity of available teachers

Several problems are associated with these issues, for example, inadequacy, insufficiency, ineffectiveness, etc. as specified in Table 2. A major constraint in tackling the two global issues of quantity and delivery is usually cost. It has now been shown that in many countries, the cost of providing further training for the existing workforce of teachers in science, mathematics, technical and vocational subjects can be reduced by the introduction of training through distance education, which allows teachers to remain in their jobs during training. In Nigeria, the Institute of Education, University of Ibadan, has successfully executed such a programme for the primary school level (Associatehip Certificate in Education – ACE Programme).
Table 2: Key Issues and Problems in the Training of Teachers for Science, Mathematics and Technical/Vocational Subjects

<table>
<thead>
<tr>
<th>Issues</th>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>• Not enough</td>
</tr>
<tr>
<td></td>
<td>• Too much in a hurry</td>
</tr>
<tr>
<td>Initial Training (Quality)</td>
<td>• Inadequate</td>
</tr>
<tr>
<td></td>
<td>• Crash programme</td>
</tr>
<tr>
<td></td>
<td>• One-off</td>
</tr>
<tr>
<td>Dynamic Curriculum</td>
<td>• Modernisation</td>
</tr>
<tr>
<td></td>
<td>• Tendency toward national curriculum</td>
</tr>
<tr>
<td></td>
<td>• Need for localisation</td>
</tr>
<tr>
<td></td>
<td>- print materials</td>
</tr>
<tr>
<td></td>
<td>- A.V. materials</td>
</tr>
<tr>
<td>Facilities (Cost)</td>
<td>• Inadequate</td>
</tr>
<tr>
<td></td>
<td>• Insufficient</td>
</tr>
<tr>
<td></td>
<td>• Laboratories poor</td>
</tr>
<tr>
<td></td>
<td>• Workshops ineffective</td>
</tr>
<tr>
<td>Socio-Cultural Environment</td>
<td>• Science versus cultural belief</td>
</tr>
<tr>
<td></td>
<td>• Science and superstition</td>
</tr>
<tr>
<td></td>
<td>• Science and religion</td>
</tr>
<tr>
<td>Sexist Factor (Quality)</td>
<td>• Attitudes of girls and women toward subjects</td>
</tr>
<tr>
<td></td>
<td>• Bias in available textbooks</td>
</tr>
</tbody>
</table>
SOLUTIONS AND STRATEGIES

Table 3 provides in summary form some of the identified problems and recommended strategies to resolve them.

Table 3: **Recommended Strategies to Resolve Identified Problems in the Training of Teachers for Science, Mathematics and Technical/Vocational Subjects**

<table>
<thead>
<tr>
<th>Identified Problems</th>
<th>Recommended Strategies to Resolve Them</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>Regrouping of subjects offered in training institutions instead of notoriously unwieldy fragmentation (from 14 subjects to 6 subjects), e.g., in Nigeria: Pre-NCE/NCE (i) Local Language (ii) English (iii) Mathematics (iv) Integrated Science (v) Social Science (vi) Craft</td>
</tr>
<tr>
<td>Quality of Teachers</td>
<td>Emphasis on the two well-known areas in a balanced way: content, process. Retraining the Trainer of Trainers (TOT) through: • distance education (e.g. NTI) • intensive regional/national workshops (STAN) Introducing innovative ways of teaching the subjects</td>
</tr>
<tr>
<td>Quantity of Teachers</td>
<td>Offer bursary to science teachers-in-training and special science teachers’ allowance (Nigeria) Enticing more girls/women into science – special campaign, e.g., Roadshow (COMSEC) Enhancing the status of science teachers by establishing awards for “Excellence in Science, Maths and Tech/Voc Teaching” (STAN) Need to recruit and retain women science teachers</td>
</tr>
<tr>
<td>Cost of Training</td>
<td>Budget more money for training teachers Involvement of industries in training of science teachers and giving a percentage of profit to training institutions involved with science, mathematics and technical/vocational teachers</td>
</tr>
<tr>
<td>The Environment</td>
<td>Public understanding of science Explaining local superstitions instead of dismissing them Teaching science for the environment – global issues</td>
</tr>
</tbody>
</table>

At the primary school level, there are two options open to any country. Either train the teachers as generalists who teach all subjects or also train specialist teachers of the identified subjects to complement the generalist teachers. My experience has indicated that specialist subject teachers are more confident teaching the special subjects than are the generalist teachers. The main source of fear is non-familiarity with the content of the specialised subjects.
Until countries can afford to accommodate within the education budget the cost of additional specialist teachers, the following strategies could be adopted:

- Include in the curriculum of primary school, pre-service teachers’ aspects of the specialised subject and make it a core subject compulsory for all trainees.
- Improve the academic level, especially in the content area, of the teacher trainers in the specialised subjects through distance education, while they continue to teach.

At the secondary school level, the general practice of having specialist teachers should continue. However, there is a need to familiarise the teachers with the latest thinking in their subject discipline through continuous distance education and introduce them to current communication technologies. Laboratory work and workshop practice can be arranged during the face-to-face phase of a distance education programme for the teachers of specialised subjects. There should be no substitute for interactive, hands-on activities for teachers.

RECOMMENDATIONS AND SUGGESTIONS

Table 4 summarises some of the recommendations and suggestions, drawing attention wherever possible to the special role that COL can play. The seven activities suggested at this Round Table can provide worthwhile topics for constructive discussion.

There is a need to draw attention to the fact that in Nigeria the professional association, Science Teachers Association of Nigeria (STAN), has developed innovative strategies through subject panel workshops all over the country. It has contributed a lot to curriculum reawakening and continuous further training of teachers in science, mathematics and technical subjects at both the primary and secondary school levels. COL may find in STAN a ready ally in carrying forward programmes and activities to train specialist teachers in science, mathematics, technical and vocational subjects.

The Commonwealth Secretariat through programmes in the Education Programme (EDP), the Commonwealth Science Council (CSC), and the Commonwealth Association of Science, Technology and Mathematics Educators (CASTME) will be very willing to work with COL to improve the quality of the delivery of science, mathematics, technical and vocational subjects throughout the Commonwealth countries.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification of issues and problems</td>
<td>Arrange regional meetings of TOTs drawn from teacher training institutions, institutes and faculties of education in universities. Publish analysed information and distribute widely.</td>
</tr>
<tr>
<td>Development of a series of 10-minute video programmes aimed at exploring science through observations and demonstrations</td>
<td>Make contacts with reputable companies* to develop programmes. Look for funds to support their production. *EDUCATIONAL BROADCASTING SERVICES TRUST – LONDON</td>
</tr>
<tr>
<td>Support for and participation in activities of professional associations COL excellence in teaching award at: • Regional • Primary • Secondary Levels Cooperation with CASTME awards</td>
<td>COL to design its certificate – Excellence in Teaching a subject. Professional Associations with regional base to organise, screen and recommend a name to COL. Both certificate and COL’s exemplar materials to be given to candidates and the institution. International recognition of primary school science teachers will help to boost their status.</td>
</tr>
<tr>
<td>Regular newsletter on classroom teaching of subjects</td>
<td>New and practical experiences to be disseminated widely. COL may incorporate into existing newsletter or launch a new one to appear quarterly.</td>
</tr>
<tr>
<td>Support for national efforts in teacher training through distance education in science, mathematics and tech/voc subjects</td>
<td>Support consultants to national distance education programme during the face-to-face contact phase of programme. Supply COL’s available exemplar materials to teacher training institutions.</td>
</tr>
<tr>
<td>Training primary school teachers of science, mathematics and tech/voc subjects in specific skills</td>
<td>Support consultants to national and regional workshops with the specific task of introducing and using materials developed by COL.</td>
</tr>
</tbody>
</table>
CHAPTER 18

IDENTIFYING THE RATIONALE, KEY ISSUES AND PROBLEMS IN SCIENCE, MATHEMATICS AND TECHNICAL/VOCATIONAL TEACHER EDUCATION

Andrew J. Salisbury

I have compiled a list of some issues facing teacher educators in teacher education institutions. The list is not exhaustive, but gives an indication of the types of issues that arise in teacher education. I will use the terms “tutor” for the teacher educator, “teacher” for the teacher in school, “student” for the person training to teach, and “child” for the young learner, probably in school.

IDENTIFYING KEY ISSUES AND PROBLEMS IN TEACHER EDUCATION

Key Issues in Teacher Education Institutions

Professional development
Students learning to become teachers must start on the first rung. It is to be expected that they will make mistakes and “learn on the job.” Nevertheless, it is important that children not suffer unduly from the students’ initial lack of experience and ability.

Changing the “irresponsible” student into a “responsible” teacher and extending the individual student’s narrow view of education and schooling
It takes some students time to adjust to new and rather unexpected professional responsibilities.

Tutor use of procedural principles: “teach them as we wish them to teach”
If students are asked to employ a variety of techniques and teaching strategies in their classrooms and laboratories, then tutors should attempt to use the same techniques and strategies in their dealings with students.

Developing in students the confidence to teach subject knowledge and application for science, mathematics and technical/vocational subjects
Students may lack the confidence to teach. They may think that they have little to offer. Placing them initially with small groups to teach can give them the break they need. On the other hand, many student teachers will have a good grasp of their subject, yet be quite unaware of the learning difficulties children may have. Small group teaching may be of value to these students for different reasons.
Relating learning science, mathematics and technical/vocational subjects to learning about educational issues
Education theory, education in a subject and practice in schools are often seen as three distinct and separate activities. Connecting these and emphasising their inter-relationships is a prime concern of tutors.

Making students aware of the aims of education
It is false to assume that the aims of education are implicitly known and agreed upon by all. On the contrary, students need to formulate their aims and be able to communicate their ideals and educational philosophies.

The incomplete nature of the teacher education course
Teacher education does not cease at the end of the pre-service training period. It must be regarded as a continuing, in-service education.

Developing reflective and evaluative approaches in the student teacher
Self-evaluation is essential for teachers and should be encouraged. It is difficult to ensure, however, that each student will do this effectively.

Developing a desire for further study
This should be a prime goal of any teacher education course.

Liaison and partnership with schools and school administrations
An effective tutor makes this a high priority. Tutor teaching in school and requesting good teachers to contribute to a teacher education programme, including joint interviewing of candidates for teaching, are useful strategies.

Imparting information about legal, contractual and administrative responsibilities of teachers
These aspects of teaching are very important.

Viewing teaching as a political activity
Teaching and teacher education are political activities and should be regarded as such. The dangers of being overly or overtly political should be minimised.

Acquiring a socio-economic view of science, mathematics and technical/vocational subjects in society and the development of business sense
These issues are of increasing concern in our global environment. There is a present need in society for the promotion of enterprising and entrepreneurial approaches to living in the 21st Century.

Education for work and unemployment
Education must be made relevant to life outside the classroom.

Having a cross-curriculum approach to science, mathematics and technical/vocational subjects
These subjects cannot be taught in isolation. Comprehension of their inter-relationships is as vital as mastering them individually.

Developing teaching skills
Students need to learn more than subject content; they must cultivate the ability to motivate children, be aware of their learning difficulties and know how to overcome them.
Acquiring essential knowledge, skills and techniques
There is a danger that tutors may emphasise subject knowledge to the exclusion of other important aspects of teaching and learning.

Acquiring a variety of teaching strategies and styles
The following inter-related skills are complex and require considerable practice:

- using question-and-answer techniques
- promoting classroom discussion
- explaining clearly
- using visual aids, especially the blackboard
- making drill and rote learning motivating and meaningful
- sorting out misconceptions
- developing skills to motivate children

The conceptual gap between “knowing about” and understanding something
There is a need for classroom discussion and co-operative classroom ventures as well as pure exposition. Students need to be aware of the need for promoting language skills and dialogue among children in order to facilitate understanding.

Informal education out of school in museums, fairs, home, shops and workplace
School should not be seen as the only place to learn. Distance education has its place, as do extra-curricular activities.

Professional contact with parents
It is easy for this aspect of teaching to be ignored in teacher education. The value of using parents as a resource for learning both in formal and informal education should not be underestimated.

Key Issues in Schools and Society

Class size and resources
These two are perennial problems!

Dealing with the differentiated curriculum and understanding children’s individual characteristics
It is sometimes hard for a tutor to persuade a student that not all children learn at the same rate or by the same processes.

Dealing with children who have special needs
This task requires particular expertise. Some teacher education institutions have decided that special needs is an in-service concern rather than one of initial teacher education.

Extending the very able child
There is considerable literature on the issue of whether to “accelerate” the gifted child or “enrich the learning environment.” In most cases, a teacher must do both, although many find the very able child poses a challenge.

Teacher competencies
A good appraisal scheme covers the majority of teacher competencies.
The ability to construct learning schemes and lesson plans
These are not usually acquired through instruction. They are learned through a mixture of practice and theory.

School administration and organisation
These come in a variety of forms, and it may be difficult for a student to come to terms with an organisation and rationale with which they are unfamiliar.

Curriculum responsibilities
The following list gives some indication of teachers’ concerns:

- **Knowledge**
  - rote learning
  - algorithmic/routine
  - investigative/discovery

- **Skills**
  - drill
  - repetition
  - explanation

- **Understanding**
  - philosophy of science, mathematics and technical/vocational subjects education
  - instrumental
  - relational
  - logical thinking

- **Attitudes**
  - usefulness
  - value to individual
  - value to society
  - cultural value
  - mind training
  - immediate value and future value
  - enjoyment
  - satisfaction

- **Management of human resources**
  - sociology of science, mathematics and technical/vocational subjects
  - role as leader
  - role as fount of knowledge
  - co-operative agent
  - motivation and rewards
  - control of pupils’ behaviour
  - the cultivation of self-control

Management of science, mathematics and technical/vocational classrooms and laboratories

- **Organising the primary classroom**
  - for storing apparatus
  - for display pictorial representation
  - using excellent pieces of work for “permanent” display or for immediate display
  - use of radio, television and video recordings
  - use of information technology
- **Classroom management skills**
  managing the whole class
  developing viable group work
  dealing with the individual

- **Management of children's responses**
  psychology of learning science, mathematics and technical/vocational subjects
  managing the curriculum
  assessment
  planning
  setting tests and examinations
  record keeping
  interpreting results
  negotiation of relevant student studies
  producing profiles
  maintaining standards
  justifying science, mathematics and technical/vocational subjects on the curriculum

- **Giving attention to children's activities**
  making things happen
  solving large and small problems
  tidiness
  accuracy
  recall of factual information (e.g., multiplication tables, chemical symbols, names of parts of animals and plants, units in physics)
  speed (with or without 100% accuracy)
  diagrams
  spatial awareness
  artistic

**Key Issues in School/Teacher Education Institution Liaisons**

Schools are generally concerned with children's progress; whereas institutions have other concerns. Liaison between the two requires awareness of each other's immediate as well as long-term needs and concerns. Responsibilities and expertise must be shared in the following areas:

- Resources: human and material
- Qualifications: namely, the lack of suitably qualified teachers
- Communication among interested parties
- In-service education
- Non-formal education
CHAPTER 19

TRAINING OF TEACHERS
OF SCIENCE, MATHEMATICS AND
TECHNICAL/VOCATIONAL SUBJECTS

John D. Turner

In this paper I intend to concentrate on the training of teachers of science, though
most of what I have to say would be equally applicable to teachers of mathematics and
technical/vocational subjects.

The shortage of adequately trained teachers of science is a world-wide phenomenon,
almost as common in richer countries as it is in the poorer ones. This shortage can be
attributed to a number of factors:

1. Science teaching in schools tends to be weak and an inadequate basis for more
   advanced programmes. An additional consequence of poor teaching is that the
   subject itself becomes unattractive and often appears more difficult than it really is.

2. The teaching of science is an area where there are major sex differentials. The
   teaching of science in single-sex girls' schools is notoriously poor, while in many
   countries (most?) the assumption is that science is a predominantly male-oriented
   subject in which girls are not, and perhaps even should not be, interested.
   Consequently, women are grossly underrepresented in undergraduate science
   programmes.

3. Since science has gained this reputation of being a difficult and unattractive subject,
   few prospective university/polytechnic students are interested in applying for
   science courses, even though in most countries it is easier to gain entry to such
   courses than to courses in more popular subjects such as law, accountancy, social
   and economic studies, and arts. Moreover, much university science teaching is
   notoriously reactionary, which leads to above average failure rates. Students do not
   wish to take a science programme in a university if other options are available.

4. Since these factors lead to an overall shortage of scientists for whom there is an
   increasing demand, not primarily from education but from commerce and industry,
   it becomes extremely difficult to retain qualified scientists within the educational
   system. Industry is quite prepared to buy specialists by paying very substantially
   higher salaries and also, if necessary, by "buying out" the funding arrangements
   that are intended to tie scientists to the teaching profession for a number of years.
These factors lead to a gross undersupply of specialist science teachers. The demand for science teachers, however, is continuing to rise at an alarming rate for the following reasons:

- the continued increase in the birth rate in most developing countries
- a growing perception of the importance of science in a good general education, leading to
- the general move toward incorporating more science and technology in the primary school
- the demand from industry and commerce for an increasing number of well-trained specialist scientists
- a substantial backlog of needs that must be satisfied before one begins to meet the increasing demand. This is as true of education as of other sectors of the economy. For example, a country I recently visited has 24,000 secondary school teachers; of these, only 4,000 in all subjects are graduates and half of the remainder are totally untrained. It could be argued that the training of the non-graduate 20,000 should be regarded as a priority need before embarking on the training of entirely new members of the profession.

The demand for basic education for all enunciated by the Jomtien Conference underlines the urgent need for teachers in all sectors, a need which is most pronounced in the fields where greatest shortages currently exist. Mathematics, science and technology must all play an important role in a good basic education, and that education will itself continue to stimulate an increased demand for secondary education. If the teacher supply situation is bad now, it will surely deteriorate rapidly.

So far, we have looked at the shortage of qualified science teachers. We must also be aware, however, that preparation for science teaching is not a once-in-a-lifetime activity. Rather, as the scope and depth of science knowledge increases, it becomes essential to engage in a continuous process of in-service education of science teachers. This is necessary in all subjects, but is particularly urgent in the case of science.

Taking into account the extreme magnitude of the problem, one is driven to the conclusion that the needs cannot be met by traditional teaching methods. An entirely new approach has to be adopted for the teaching of science. The only feasible available methodology is distance learning; however, our knowledge of the techniques of distance learning is currently inadequate for our needs.

Moreover, the number of specialists in distance learning methodology currently available is tiny in proportion to demand. The number who have had experience in producing and directing successful programmes is even smaller. Consequently, the main difficulty in the great majority of countries that are most dependent upon distance learning solutions is the acute shortage of skilled personnel. It is one thing to be able to talk about strategies in distance learning. It is quite another thing to be able to sit down and give the extremely detailed assistance required to enable subject specialists to convey their expertise in an appropriate form.

Another major problem relates to the most desirable media for specific courses. Commercial correspondence courses have relied, for the most part, on the printed word coupled with an efficient postal service and skilled, in-house tutors. The British Open University model, which is an example of a highly successful programme with relatively small drop-out rates and a high success rate, has accustomed us to think of multimedia programmes including not only printed work and distant tutors, but also support through radio and television and their accompanying recorded equivalents. These programmes are also supported by residential courses, some of which, such as certain
science programmes, are compulsory for all students. These techniques have been adopted by a number of other programmes that have also used satellite technology in order to increase the market. New media are also becoming available with an apparently unlimited potential for distance education, for example, CD ROM, computer-assisted learning and interactive video programmes.

The fact remains, however, that for most of the potential users of distance education, advanced technologies are virtually inapplicable. Even in those countries that have used them, questions arise as to whether the money would not be better spent on increasing the users of the system, rather than on providing high-cost resources for a small fraction of those who need to learn. This implies that the solutions we are seeking should depend on low-cost-techniques as much as possible and especially, on printed materials. Indeed, even within printed materials, choices may have to be made between varieties of programmes with different costs. An inevitable trade-off has to be made between spreading distance learning packages of lower quality around a much greater market and making programmes with a high success rate and a high cost available to a smaller proportion of the population. Such decisions may vary according to the nature of the audience and whether it is indeed a mass audience to which particular programmes are directed. We must also discriminate between different legitimate purposes for distance learning. The one that tends to be uppermost in our minds is the purpose of making education available to students for whom there are insufficient teachers, or for whom teachers cannot be afforded under a traditional system. A second purpose is to provide additional tools to teachers who are inadequately trained and who cannot teach at the required standard. A third is to extend the provision of learning to a very much larger number of people who are not registered students, but who “overhear” the studies provided for others. With some programmes, such as those in primary health care, the existence of the larger audience could make audio or video programme transmissions cost-effective, while they would not be cost-effective if they were provided only for registered students. Similarly, the provision of written or cassette-recorded materials to schools for class use by inadequately trained teachers may make the production of such materials financially viable, although that would not be the case if one were only costing the provision of totally distance education programmes. It is necessary, therefore, in considering distance education in any particular situation to provide an overall strategy whenever possible, rather than a partial, narrowly focused one.

We also need to look at the problems and opportunities of the students themselves. Indeed, students provide the most reliable evaluation of programmes. A recent small-scale survey, for example, indicated quite clearly that in one institution, the mathematics programmes were regarded as being of the highest quality, whereas the programmes in statistics were specifically excluded from this commendation. Whether this would have been equally apparent to professional and highly skilled evaluators is at least in doubt.

What students appreciate about distance learning programmes in helping them to learn successfully are:

1. Regular assignments that are rapidly marked and returned to the student help to maintain commitment, allow students to diagnose and monitor their own progress, and take some pressure off the final examination. The continuous assessment element is regarded by most students as of the utmost importance.

2. Support from locally based tutors is also greatly valued where this can be organised. This support, of course, can be a costly benefit unless a substantial number of students are grouped together.
3. Residential schools are regarded as being of great importance. These need not be of great length and should be directed where necessary to those aspects of the programme that are difficult to undertake at home. In science, this would clearly be practical laboratory and workshop practice. Residential courses at the beginning of each unit are of particular value.

4. Student self-help groups can also be of great assistance. It is difficult to organise these, however, without central support, since individual students are unlikely to know which other individuals near them are undertaking the same studies in the same subjects at the same time. Such groups, however, are very highly motivating and are a low-cost means of providing remedial help. Central assistance may also be required to locate suitable premises for self-help groups, if no homes of the participants are suitable for informal meetings.

The main drawbacks of learning science through distance education as reported by students are:

1. The limited opportunities for practical work are a major problem. Even when, as in the case of the British Open University, experimental kits are provided, these are found to be only of limited use compared with full access to a laboratory. This places a greater emphasis on the use of residential courses for hands-on laboratory experience.

2. Another problem for most scientists is the limited access to computers that distance education students have. There are very few students in developing countries who could afford a private computer or who would have access to a public one, though this would be available to some civil servants. The best that could be managed for most people would be a hand-held calculator, though some remarkably comprehensive ones can be obtained at low cost.

3. Another problem often referred to is that some students are admitted to courses in chemistry or physics, although they do not have sufficient mathematics to take full advantage of the programmes provided. This indicates a need for appropriate prerequisites or, in some cases, the use of mathematics modules specifically tailored to the needs of the sciences, rather than the needs of potential professional mathematicians. It has often been found that trying to describe in words matters that would normally and better be described in figures causes the modules to be much too "wordy."

4. It is often helpful to have a textbook with a different perspective on the course materials from that provided by the programmed learning materials. Recommendations should be made for such books and opportunities to be made available for purchase.

5. It is important that the subject experts who provide the material for courses should be able to recognise which parts of the programme cause genuine difficulties to students. It is often reported that there is a temptation to belabour straightforward parts of the programme, then skim over the more difficult parts.

6. Students may have different experiences of the course, depending on which tutor is assigned to them. The programmes lay a great responsibility on tutors for the speedy return of assignments, as well as for the careful and helpful treatment of error. Where this is not adequate, the students are at a gross disadvantage.
In addressing these problems, a methodical approach is necessary. I would propose the following guidelines:

1. Even where there is abundant access to the media and sufficient technical assistance to maintain the equipment required, a minimalist approach should nevertheless be maintained. Only those media that are absolutely essential for the success of a programme should be used. There is no country so rich that it can afford to waste scarce resources. Where a very large increment of cost is necessary to provide a very small increment of knowledge or skill, the necessity of that increment should be closely studied.

2. There should be a realistic attempt to evaluate the existing resources of the country in terms of the technical infrastructure. If the postal system is totally unreliable, alternative means must be found for distributing course materials. If radio transmission is poor, it is impossible to rely on audio assistance as an integral part of the programmes, though it may be used for purposes of enrichment. The same is true a fortiori for the visual media.

3. If it proves necessary to use audio cassettes as part of the programme, the repair facilities must be realistically surveyed. It may well prove necessary in some countries to provide a central servicing facility as part of the distance learning infrastructure.

4. It is wasteful of effort if teachers and lecturers, however highly skilled, are asked to write distance learning materials, if they have not been specifically trained to understand the distinction between textbooks, lecture notes and distance learning materials. A high priority should, therefore, be given to the employment of distance learning specialists who can both train and work with subject specialists as they undertake their work.

5. There is no point in producing materials de novo if materials already exist and can be used without adaptation. There is no point in even adapting materials that are already completely adequate for the job. Similarly, it is counter-productive to write materials de novo if existing materials in another country can be effectively adapted. Different subject areas and indeed different topics within subjects have highly differentiated cultural loading, and it is necessary to diagnose carefully the needs of each module. This is an area where a good deal of central guidance can be made available to national workshops.

6. The feasibility and helpfulness of using science kits should be carefully investigated at each level. The same principle of avoiding unnecessary complication should be used throughout distance learning provision. Kits should be tailored specifically to individual teaching points and where feasible, the kits should be small and made available as each topic is covered rather than made available in large kit form, much of which will be used months or even years after delivery. Most students will not have the facilities for storing such kits, and there is a danger of them being broken or deteriorating before the time has come when they can be effectively used.

7. Proper attention should be paid to the learning needs specific to the job for which the students are being prepared. In particular, where the courses are part of a teacher training or upgrading programme, only those aspects of the subject that are essential for the teachers to do their work should be taught. The principle of selectivity in subject matter is important in every subject in every country; too little attention is paid to the principles of such selectivity. What is relevant and what is irrelevant must be clearly distinguished from each other.
The guidelines just mentioned are by no means subject specific, though they appear in their present form related to science. There are, however, general organisational criteria, which must be met whatever the subject, level and purpose of the teaching may be. Among these criteria are, for example:

1. Political will, that is to say, if the politicians, who for many jobs represent the employers, believe that distance education is an inferior form of learning, it is unlikely either that adequate financial provision will be made or that the motivation for securing sound learning exists.

2. The availability of recurrent resources is of the greatest importance. Nothing is more dismal than for students to embark on a course that cannot be continued due to lack of financing. This implies that self-sustainability should be built into the programme, so that it does not present a constant drain on the education budget.

3. Immaculate administration is an essential prerequisite of success in distance learning. Great care must be taken in the design of headquarters and regional offices, and in the choice of hard- and software needs.

4. Training of all those involved in the distance education programme is absolutely essential. Even those who are well prepared in distance education technology (few such people exist in most countries) will still need specific training in the aims and administrative patterns of each specific course that is established.

5. All part-time tutors, most of whom will also be full-time teachers or lecturers, should be adequately remunerated for the extra effort they put into the programme. Without this remuneration, the programme will fail.

6. Quality assurance mechanisms must be built into the system. The work of every tutor/marker must be regularly and randomly evaluated, as should all other aspects of the programme, such as the continued writing of new materials and the efficiency of record maintenance.

The role of The Commonwealth of Learning in teacher education in science, mathematics and technical subjects seems to me to be the same as that in its relationship with other areas. These can be summarised as advice, training, evaluation and research, cataloguing and coordination.

Advice. The advisory function of COL is to field appropriate teams of specialists to advise Commonwealth nations on the possibility and logistical arrangements for meeting specified educational needs by distance learning. A database of such specialists in the Commonwealth is already being prepared.

Training. It is a matter for dispute whether the Commonwealth of Learning should itself undertake training. It was not established as a training institution, and it seems more appropriate for the training function to be undertaken by advising, on the basis of its own database, on the availability of existing distance education trainers for in-country training. It should also provide finance for training in the early stages of COL-backed and partially resourced programmes.

Evaluation and Research. It would be helpful for COL to maintain its own small group of specialist evaluators, who might work with local counterparts in a training capacity to ensure the professional integrity of the evaluations that must be an integral part of all distance learning projects. Whether it does this by having its own corps of evaluation specialists or by maintaining a database of such specialists is a matter for determination.
What is absolutely clear, however, is that the Commonwealth of Learning must maintain a collection of evaluations of different distance education projects in the Commonwealth and elsewhere, which would be available to member states for comparative study when comparable programmes are under consideration.

Cataloguing. This is one of the most important functions of the Commonwealth of Learning. It must have a fully developed database of all distance education learning materials available from public sources in the Commonwealth. The database should contain detailed, module-by-module descriptions of the material, the purposes for which it was devised, a history of the use of the materials including evaluations, not only for the purposes for which it was originally written but also in cases where it has been used either in existing or in modified form in other nations. It should also contain information about copyright and the fees that might be expected to be charged for unaltered and altered use. To be effective, this database would need to be detailed and able to be accessed by a large number of different key words depending on the purpose of access. It should be possible, for example, for a Ministry of Education to be able to find out by return of FAX which courses are available in, for instance, the training of initial teachers in the teaching of reading to learners of English as a second language in Class I of the primary school. The list would include materials available in a variety of languages in each subject. There are many highly suitable television programmes, for example, in the teaching of different aspects of science which could be made available virtually without modification as enrichment learning for serving teachers. In other cases, such material may need to be dubbed. The precise aims, content and accompanying materials for individual programmes should be almost immediately accessible to the enquirer.

Coordination. The coordination heading also embraces negotiation. This will not primarily be a matter of discussing training needs with governments, which would be a part of the advisory function, but rather negotiating with the copyright holders of existing materials the lowest possible prices at which different types of usage of their materials might be made. The possession of such information, which will have to be updated on an annual basis, is absolutely essential if governments are going to be able to decide whether it is more economical to adapt already existing materials or to put the same amount of resource into providing their own.

While these may be the "classical" roles of the Commonwealth of Learning, there may also be more specific needs in the teaching of science and the training of science teachers. These needs relate specifically to the practical nature of the knowledge and skills to be conveyed, the integration of residential programmes into the courses and the use of kits, to which reference has already been made.

At the beginning of this paper, the conviction was expressed that for many students, there will be no alternative to distance education if the aims of Jomtien are to be realised. This gives a special urgency to the solution of the many problems in the training of teachers in scientific subjects throughout both the poorer and richer countries of the Commonwealth and demands cooperation of the whole family of Commonwealth nations in this urgent task.
CHAPTER 20

TRAINING OF TEACHERS FOR SCIENCE: MATERIALS, METHODS AND MEDIA

Emmanuel Apea

Introduction

Despite the Universal Declaration of Human Rights made over forty years ago that "everyone has a right to education," the World Conference on Education for All (WCEFA) held in Jomtien, Thailand, drew attention to the following startling statistics:

- More than 100 million children, including at least 60 million girls, have no access to primary schooling.
- More than 100 million children...fail to complete basic education programmes.... (WCEFA, 1990)

Addressing the issue of basic education, the Conference emphasised that education is more than an end in itself. "It is the foundation for lifelong learning and human development on which countries may build systematically, further levels and types of education and training." This basic education, however defined, was seen to include a science and technology education component, as the Conference noted the urgent need for "a world community of scientifically and technologically literate citizens" (WCEFA, 1990).

That governments worldwide recognise the importance of science teaching and learning cannot be overemphasised. Formal school syllabi of most countries officially exhibit science as an item even in the primary curriculum. However, apart from such problems as shortage of teachers, lack of teaching materials, inadequate classroom accommodation, inadequate libraries and poor laboratories, teaching itself leaves much to be desired at all levels of the school system.

Teachers are a key factor in the educational enterprise. They are recognised as the single major determinant of the quality of education (Department of Education and Science, 1983, p. 1). Today, there are about 30 million teachers in schools; about 60% live in developing countries, where primary school teachers outnumber secondary school teachers by two to one. In the developed countries, teachers are about the same in numbers at the primary and secondary levels (UNESCO Statistical Yearbook, 1990). There are no reliable figures given anywhere that indicate how many of these teachers actually teach science and technology. However, since in general every primary school teacher may be assumed to have responsibility for science, in whatever form it appears
in the curriculum, one could estimate that globally about 18 million teachers in primary and one million teachers in secondary schools might be teaching science and technology (Layton, 1992, p. 9).

This paper is concerned with the training and support that ought to be given to science teachers, especially in the developing world. It provides a rationale for training science teachers, identifies some of the key issues and problems involved in their training, suggests strategies for resolving some of these problems, and recommends areas of science teacher training in which the Commonwealth of Learning could usefully and effectively be involved.

**RATIONALE FOR TRAINING SCIENCE TEACHERS**

Science is an experimental subject; learning it is of most value when students are involved in the process of scientific investigations, namely, identifying a problem, hypothesising a solution, collecting information, analysing experimental results or observations, and drawing conclusions to test the hypothesis. For effective learning, students should spend part of their time carrying out independent investigations or working in small groups where each person involved has a good share of the responsibility and autonomy in what is being done. This has been the philosophy of a number of modern programmes like the East African Science Project, Nigerian Integrated Science Project, Ghana Junior Science Project, Nuffield Science Project and the American Chemistry Study, to name but a few (Apea, 1980, p. 1). It is also the philosophy underlying the process-based approach to science teaching and learning in which a teacher’s role involves, among other things:

- ensuring that the children have real things to observe, handle and investigate, thereby having access to evidence against which to test their ideas
- finding out about children’s existing ideas and taking these seriously as the starting point for learning
- making available access to a range of ideas from others: other pupils, books, media, visitors, visits, etc.
- discussing with children ways of improving their testing of ideas and their use of evidence
- ensuring that the children reflect upon and communicate their results in a variety of appropriate ways (Harlen, 1987, p. 7).

The type of student learning implied in the role of teachers described above requires motivated, skilled and knowledgeable teachers. Regrettably, many teachers involved in science teaching in primary and junior secondary schools, especially in the Third World, are ill-prepared initially, at least (Harlen, 1987, p. 1). Some have no basic teacher training, and thus have no knowledge of the nature of science, neither are they familiar with schools and children. Others are compelled to teach at levels for which they have not been prepared. The situation in Zambia illustrates both phenomena quite well.

In Zambia, three groups of teachers are employed in primary and junior secondary schools. First, there are some untrained teachers, with or without a Grade 12 level of education, who may teach up to Grade 7, usually in rural areas. These teachers are employed by district administrations as a temporary measure only and are replaced as soon as trained teachers become available. Many of them tend to opt for training when they succeed in gaining admission to a pre-service teacher-training college.
Second, there are teachers who have been trained for two years to teach all subjects including science in primary schools from Grades 1 to 7, but they may sometimes be asked by the Ministry of General Education, Youth and Sport to teach up to Grade 9.

Third, there are holders of diplomas who are trained in teacher-training colleges that offer courses for teaching Grades 7 to 9. They are trained in two types of institutions: secondary teacher-training colleges, where trainees can specialise in science, and the National In-Service Training College (NISTCOL), which offers one-year courses to trained primary school teachers with five GCE ‘O’ Level passes and a minimum of three years of post-training teaching experience. Diplomates of these institutions often find themselves teaching Grades 10 to 12 (by British standards, Overseas GCE ‘A’ Level) (Report of UNESCO/UNDP Programming Mission, 1990).

Even when teachers are known to have undergone initial training, many are found to have a weak academic background and, consequently, lack the confidence to teach effectively.

Initial (pre-service) training is necessary for teacher trainees to acquire basic knowledge about the subject, and the teaching and learning processes. It is also recognised as necessary for trainees to develop appropriate attitudes and commitment to teaching, to achieve competence with appropriate teaching strategies, to acquire the ability to communicate and select, modify and design curricula. However, no matter how good the pre-service training programme may be, it can never fully prepare its graduates for all the tasks and problems that occur in the range of teaching contexts encountered in their careers. The rate of change in development in science and technology with the consequent pace of change in teaching and the need to maintain the relevance of curriculum to children’s everyday lives call for continuing in-service education aimed at helping teachers to master new roles and responsibilities, as well as refining their techniques in teaching. This was confirmed by the Commonwealth Secretariat, which pointed out that the "areas of concern in teacher training cluster around two broad headings: the supply and training of teachers at pre-service level; the provision of adequate, in-service support" (Commonwealth Secretariat, 1990).

ISSUES AND POSSIBLE STRATEGIES IN SCIENCE TEACHER TRAINING

Commonwealth countries are faced with the challenge of providing science for all the increasingly large numbers of young children entering schools. Already, there is an acute shortage of science teachers for the small numbers of students currently pursuing science subjects. If efforts are to be made to train increased numbers of teachers while maintaining the quality of such teachers, several questions, including the following, should be considered:

- How does science teaching compete with other careers open to science graduates?
- How are teacher trainers to be selected?
- How can science teachers be trained to have understanding, appreciation and enthusiasm for science and thus the confidence to teach it effectively?
- How can they be equipped to teach children who must be flexible enough to adapt to changes in the future?
- What is it that these teachers ought to know?
- How can teachers be motivated to keep up-to-date in content and methods of teaching?
- Who trains the teacher trainers?
Why do most students opt for arts courses rather than science disciplines?

How should the special issue of girls’ low participation in science courses be addressed?

What provision, in terms of materials, should be made for science teaching?

How can new ideas and methods be used to improve the quality of effectiveness of science education?

Some of the above issues are discussed below.

Selection

Improving the quality of teaching demands that a number of factors be taken into consideration. One of these factors is that the right person, namely, people committed to the teaching profession, be admitted to teacher-training institutions. Unfortunately, “too many lows” have been allowed to enter and successfully exit professional training programmes (Lamier and Little, 1986). In the special case of science teaching, requirements from institutions are not demanding enough. For instance, in a developed country like Australia, no institution requires a full secondary school education in science as a prerequisite for entry into an elementary school teacher education programme. Many teacher trainees are found to be those who have dropped science early in their schooling (Owen et al., 1985, p. 285). Owen and others note further that whereas the school science background and attitudes of entrants to secondary school science teacher education programmes tend to be less of a problem, the pool for recruitment is not as wide as it ought to be, and instruments for selection are not well developed. But, how does one enlarge the recruitment pool and filter out those unlikely to succeed? According to Colin Power, evidence suggests that self-selection should be the rule during the course, supplemented by assessment based on performance. Such self-selection and assessment procedures require teacher education courses designed so that a teacher trainee is involved in typical professional activities; they also require adequate measures of the competencies to be developed in pre-service programmes, and the progressive weeding out of students with low levels of academic performance, commitment and competence in teaching. He points out that a strategy for improving the selection and counselling process has been developed at the University of New Hampshire (Power, 1988).

Developing Confidence in Science Teachers

Lack of confidence, especially in primary science teachers, is a major handicap militating against effective teaching. Confidence in teaching requires five aspects of knowledge, which Wynne Harlen and others distinguish as follows:

1. **How-is-it-called-knowledge.** Relates mainly to the formulation of factual information, the right name, the appropriate word. It helps to show that you know what you are talking about, yet does not guarantee it. Learning by rote tends to lead to this form of knowledge.

2. **How-it-appears-to-be-knowledge.** Refers to direct experience. It is knowledge emerging from interaction between an observer and the object under observation. It embodies properties or observable behaviour of real objects and their possible or actual interactions with other objects, or with the observer/learner. It is verifiable knowledge, based on experience, observation, experimentation, research and induction. This knowledge makes prediction possible.
3. **How-does-it-relate-knowledge.** This conception signifies a higher order of abstraction in which relationships between concepts become evident: generalisations, conclusions and patterns inferred from repetitive experiences or experiments. It may also be deduced from pure thought processes in which existing concepts, at various degrees of abstraction, are related to each other, or are recognised as related to each other. Even reflecting on such thought processes may form new knowledge that, in the sense here elaborated, comes close to being identical with "insight" or "understanding."

4. **How-it-should-be-done-knowledge.** Comes close to the ability to do things. However, it goes beyond the physical ability or skill insofar as it incorporates not only the remembered sequence of operations, but also the foresight to create, invent, lay out and plan a succession of processes or operations in order to compose things, put things together, calculate, compute, programme, experiment or run an investigation. One could call this "technical knowledge," but in a more than purely mechanical sense. Above the levels of imitating and the grasping of procedures one needs insight and inventiveness in order to be able to organise an experiment or an investigation.

5. Finally, there is **How-to-find-your-way-about-knowledge**, which makes a person resourceful enough to tackle any problem in the most effective way possible. It consists of a knowledge of resources and their accessibility. It is the knowledge of how to make use of any level of existing knowledge within oneself, coupled with the knowledge of where to look and obtain the new information, advice or resources one needs. One knows where to look for things, situations, people, books, scripts, charts, maps, archives, tables, computer ware and whatever other modes of storing information may be useful. This is the knowledge that leads directly to self-reliance in searching and in learning (Helen, in press).

Based on all these aspects of knowledge, Wynne Harlen continues to describe a tripartite interactive pattern of education that teachers of primary science ought to be good and confident in their teaching:

- The child interacts with the "subject matter" at hand (e.g., germinating seeds, darkness-seeking woodlice, an isosceles triangle or some quantity to be divided). At the same time, the child interacts with the teacher, who through word, deed or other intervention (or, indeed, by just leaving the child quietly alone) assists in the learning process.

- The "subject matter" (which, broadly taken, comprises the "stuff to be learned," the things to be handled, the sources being tapped and the problem situations into which the children are placed) interacts both with the children to whom it presents a challenge and with the teacher to whom it once was, or may now still be, a challenge.

- The teacher, in turn, interacts with the inquiring children as well as with the object of their inquiry, namely, the "subject matter" at hand.

A special programme for developing confidence in primary school teachers who teach science and technology is described by Hubert Dyasi. The Workshop Centre at the State University of New York, at which this programme takes place, and its programmes are described in Layton, (1992). Dyasi states:

Our elementary school teacher programmes have enabled us to see the possibility for cultivating positive teachers' perceptions of themselves
and of the school children they teach; they have enabled us to establish and maintain vital connections between the university and the schools. Most of all, they have imbued all those involved with renewed confidence in teachers’ capacity to conduct science and technology classes.

Whereas the above quotation applies mostly to primary science teachers, teaching at the secondary level also requires that teachers be helped to be enthusiastic in their own learning and in their own formation of knowledge. At the moment, many science teachers in senior secondary schools tend to have a science degree (obtained after three to four years’ training) in one or more major disciplines and one year of professional teacher training. The short duration and dominance of separate methods (chemistry, physics, etc.) in most end-on programmes mean that they provide inadequate training for such teachers. Often this means that teachers are unable to function effectively as part of an interdisciplinary team.

In order to be confident, both primary and secondary science teachers need an awareness of having a distinct view of science, in addition to the necessary subject knowledge.

Is science an accumulation of facts to be conquered by gathering factual knowledge? Or is science a way of learning: the operative skill of acquiring knowledge by the intellectual processes of observing, questioning, hypothesising, experimenting and reasoning? The answers teachers give to these questions determine their view of science and influence their style of teaching.

In-Service Science Teacher Training

Since one cannot achieve all of the aims of training through an initial course, a balance needs to be drawn between what ought to be taught in pre-service institutions and what should be provided through in-service courses. Wynne Harlen and others have presented proposals for core opportunities to be provided through initial training courses, as well as additional opportunities that may be provided through in-service programmes (Harlen, in press).

In-service training has taken various forms: workshops, regional meetings and conferences sponsored by science and science teachers’ associations, tertiary institutions, ministries of education and organisations such as UNESCO, the Commonwealth Secretariat, RECSAM (the Regional Centre for Education in Science and Mathematics). In order to encourage practical (laboratory) work in science in schools, these organisations have run courses for teachers and teacher trainers in improvisation of equipment, production of equipment, and handling (use), maintenance and storage of equipment (Commonwealth Secretariat, 1976, 1977, 1979). These courses are supplemented with comprehensive manuals and guides aimed at acquainting teachers with new equipment.

In reaching a larger number of teachers in some countries, much emphasis has been placed on “low-tech,” audio-visual and printed materials, and short, one-off in-service days organised by central authorities. Regrettably, short courses isolated from sustained support at school and system levels often do not lead to any significant changes in practice. The longer modules and mini-courses developed at Macquarie University, Sydney (which seek to update teachers’ understanding of assessment using a combination of tape/slide, resource material and microcomputer programmes) have made significant impact when used as part of a school-focused, professional development programme (Power, 1988, p. 291).
A successful strategy for updating the professional knowledge and competencies of teachers, especially those isolated by geography or family circumstances, is distance education. The success of the Open University of the United Kingdom has paved the way for many countries to experiment with the use of learning packages (study text, readers, practical work, audio or video cassettes, computer-assisted learning (CAL) packages for microcomputers and teleconferencing. In Zambia, a UNESCO initiative has been launched to double the output of primary science teachers at the National In-Service Training College (NISTCOL). The University of the West Indies Distance Teaching Experiment (UWIDITE) illustrates how new information technology may be used in the future to establish in-service science networks. The system links six widely separated island university campuses and extramural centres using the International Telecommunication Satellite Organization (INTELSAT) satellite, microwave, tropospheric scanner and ultra-high frequency (UHF).

The low participation of girls in science, particularly in physics and chemistry, is a concern of many educational authorities and governments. A number of reasons (biological, social and cultural) have been advanced to explain why few girls follow science courses in secondary and higher education. The male image of science and the emphasis on a teaching learning style (based on facts and principles, theories, theorems, and laws and "discoveries") often put off many students, especially girls. A process-based science teaching and learning, in which a person's whole environment becomes a science laboratory, is seen likely to project a more human view of science and thus appeal to all students, including girls. This way of learning through process skills requires pupils to have opportunity for:

- actively seeking evidence for themselves through their own senses
- testing their ideas against evidence and previous experience
- becoming aware of ideas other than their own
- seeking more effective ways of testing ideas.

Teacher trainees must be given opportunity to try out ideas and test them against evidence as much as children do. This is the basis of the workshop approach being used increasingly for training primary and lower-secondary school teachers (Harlen, 1987).

It must be noted that when all is said and done, in-service education programmes will not achieve their full purpose unless they are accompanied by appropriate career structures for science teachers. If teachers are to be motivated to increase their competence, then they must be "recognised and rewarded in terms of promotion, extra increments and professional recognition. Teachers need to feel that professional advancement will follow efforts that they themselves can make and is at least partially within their own control" (Commonwealth Secretariat, 1990).

Training the Teacher Trainers

There is concern that not much is being done to help teacher trainers develop professionally. Bell poses the following questions:

- What qualities, skills and knowledge do teacher educators bring to teacher education?
- What qualities, skills and knowledge are needed to meet the demands of teacher education today and in the future?
- How might the appropriate professional development be achieved both within institutions and the profession? (Australian Science Teachers Journal, 1991)
The requirements of teachers change as they go through their careers, so there must be provision for trainers to develop their skills and acquire new ones to meet the demands of providing effective in-service teacher training.

One thing that lends hope to this whole area of professional development, be it for teachers or trainers, is the increasing evidence of breaches in the insularity of these professionals and their engagement in supportive partnerships and alliances of many kinds. The World Declaration of Education for All (WDEA) shows the centrality of partnership in education when it states that "new and revitalized partnerships at all levels will be necessary" (WDEA, 1990). Already, such partnerships between non-governmental and governmental agencies, education and industry, as well as others are taking place. The Australian Science Teachers Journal reports:

New Zealand's traditional pattern of teacher education has been overthrown by the University of Auckland's innovative 4-year Bachelor of Science Education degree which incorporates a concurrent teacher training component and a period of industrial placement. The degree aims to produce a generation of teachers better equipped for the challenge of secondary school science education in the 1990s and beyond. A unique feature of the degree is that it is spread across three institutions: the University, the Auckland College of Education and the Auckland Institute of Technology. Thus it provides an interesting case study for those still struggling to establish co-operative ventures across department and faculty boundaries. (Australian Science Teachers Journal, 1991)

With regard to this innovation in teacher education, perhaps a note of caution is necessary. For, while innovative programmes are to be encouraged by international institutions like UNESCO and COL, it should be noted that an innovation could be counter-productive if the result is simply one more component of teacher training, but less concentration on the development of skills to teach the knowledge, attitudes and skills implied in the school curriculum.

SUGGESTIONS AND RECOMMENDATIONS TO THE COMMONWEALTH OF LEARNING (COL)

The functions and objectives for which COL was set up appear to be in line with the strategies indicated as solutions to some of the many problems and issues highlighted in this paper.

Partnership is a concept that COL is expected to promote in view of its function as "facilitating inter-institutional communication links." COL needs to form links not only with formal educational institutions, but also with non-governmental organisations such as the International Council of Associations for Science Education (ICASE), Technology and Mathematics Educators, and Girls and Science and Technology (GASAT). By working with these and similar organisations, COL would be able to influence educators and other persons concerned with training teachers at all levels of the educational system.

COL’s cooperation with its partners could take several forms. With GASAT, for instance, COL could assist in developing non-sex-stereotyped materials, which could be used in teacher training institutions and in in-service courses for preparing teachers to teach in a way that benefits both boys and girls. In the same way, COL could work with
UNESCO and other UN agencies; with ICASE and other non-governmental organisations; with the Commonwealth Secretariat and other governmental agencies in the implementation of Project 2000+. Project 2000+ is a three-phased project, which seeks to provide the science and technology education dimension to Basic Education For All. One of the areas of focus in this project is science and technology teacher training.

In line with its function in undertaking and supporting evaluation of applied research in distance education, COL must be involved in developing materials for science teacher training that build capacities of institutions to train effectively. An example of the type of research that could also be done would be a long-term, follow-up study of a cohort of newly qualified science teachers with a view to relating training experiences to subsequent experiences in teaching. COL should undertake case studies that aim to promote multidisciplinary teaching, especially between science and mathematics, and integrated sciences.

COL is well placed to promote the development of materials and related in-service education programmes for science teachers. It might be worthwhile for COL to explore (if it has not already done so) the possibility of linking COL-sponsored training courses to formal qualifications. UNESCO has experience in this area of qualifications and should, if requested, be ready to assist COL.

References


*World Declaration on Education for All.* Article 7, 1990.
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