Teacher Training for Science and Technology Education Reform
Regional Workshop on Teacher Training for Science and Technology Education Reform, 3-14 December 1990


- 79 p (Asia and the Pacific Programme of Educational Innovation for Development)

Teacher Training
for Science
and Technology
Education
Reform
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Preface

This resource book is a product of a Regional Workshop on "Teacher Training for Science and Technology Education Reform." It was participated in by ten science educators and science teacher-trainers from India, Indonesia, Iran (2), Malaysia, Maldives, Pakistan, Philippines, Sri Lanka and Thailand; five resource persons, one from India and four from SEAMEO-RECSAM, and eight observers.

The Regional Workshop was convened by the UNESCO Principal Regional Office for Asia and the Pacific (PROAP) and was jointly organized by its Asian Centre of Educational Innovation for Development (ACEID), and the SEAMEO Regional Centre for Education in Science and Mathematics (RECSAM), Penang, Malaysia, 3-14 December 1990.

The designations employed and the presentations of materials throughout the publication do not imply the expression of any opinion, whatsoever, on the part of UNESCO concerning the legal states of any country, territory, city, or area of its authorities, or concerning its frontiers or boundaries.
INTRODUCTION

This source book is compiled from the proceeding of the Regional Workshop on "Teacher Training for Science and Technology Education Reform" held in Penang, Malaysia 3-14 December 1990. It was jointly organized by SEAMEO-RECSAM and UNESCO/ACEID. This activity was part of UNESCO-APEID's 1990 Programme of Activities in Science and Technology Education, supported by the Government of Australia's Voluntary Cash Contribution to APEID. The list of participants, resource persons, observers and office bearers is found in Annex 1.

The Workshop developed exemplar training materials for science and technology education at the middle school level with emphasis on new competencies and skills required of science teachers, i.e. science process skills and its application to real life situations.

Based on the stated objective the workshop gave emphasis to:

(a) the new role of science teachers linked to the development processes in the Asian countries and towards meeting the comprehensive demands of learning and life.

(b) competencies and skills which must be learnt and practised by science teachers.

(c) changes in science teacher preparation programmes in the light of new role specifications and towards developing necessary teacher competencies.

(d) "evaluation" of science learning which takes into account both cognitive and affective domains effectively.

The Workshop was inaugurated by the Chairman of RECSAM's Governing Board, Tuan Hj. Nik Musa bin Nik Abdullah. In his speech he recognised the role of science and technology developments in the improvement of the quality of life, and that of a well-informed society in enhancing its own progress. He found the objective of this regional Workshop commendable for its relevance in this rapidly changing society. The sharing of country experiences and cross-fertilisation of ideas in the Workshop are certain to influence the direction of change and reform in science education in a large part of the world. He challenged the key educators present in this regional workshop to ensure that these changes and reform in science education are carried out in the countries they represent.

The welcome remarks was given by RECSAM's Director, Tuan Hj. Mohd. Khairuddin bin Hj. Mohd. Ashaari. In his remarks he welcomed all workshop participants to the UNESCO/APEID Workshop hosted by SEAMEO-RECSAM. He reiterated the commitment of SEAMEO-RECSAM to promote regional cooperation through education, science, and culture. The Centre has now come to be regarded as a viable development organisation worth considering as a model for regional co-operation and solidarity.

He looks forward to a continued and closer collaboration and co-operation between UNESCO/ACEID and RECSAM in the years ahead.

This source book is composed of four chapters. Chapter One is on country experiences. The innovations and efforts made in the preparation of teachers have been spelt out by the participants from the member countries. The major emphasis of their presentations are based on the four areas as stated in the workshop objectives. The end of the chapter presents a synthesis of the country experiences. The synthesis formed the basis for the development of chapters two, three and four of this book.
Chapter Two presents the trends and issues pertaining to teacher training for science and technology education reform.

Chapter Three presents the preparation of materials for the training of science teachers. Some exemplars developed are included in this Chapter.

Chapter four discusses the strategies for Evaluation of Teacher Competencies and Skills.

This source book is intended for use of science educators/science teacher-trainers in developing programmes emphasizing the new roles/responsibilities of science and technology teachers.
CHAPTER ONE

COUNTRY EXPERIENCES

The innovations and efforts made in the preparation of teachers have been spelled out in this Chapter by participants from member countries. Major emphases of their presentations are based on four areas namely:

(a) the new role of science teachers linked to the development processes in the Asian countries and towards meeting the comprehensive demands of learning and life;
(b) competencies and skills which must be learnt and practised by science teachers;
(c) changes in science teachers' preparation programmes in the light of new role specifications and towards developing necessary teacher competencies;
(d) "evaluation" of science learning which takes into account both cognitive and affective domains effectively.

INDIA

The New Role of Teachers of Science

(a) Shift to child-centred education in science which would help develop in the child, the scientific attitude and temper, technological competence and skills, self reliance, use of traditional skills and capabilities and making them enterprising, etc.
(b) Finding out the existing science talent and nurturing the talent.
(c) Involving the students in constructive project works.
(d) Exposing the students to real life situation, highlighting the effects of environmental degradation and imbalance.
(e) Emphasising the universal nature of science and hence including the component of international understanding and harmony.
(f) Involving the child in out-of-school, scientific activities like visiting science exhibitions, science-club activities.

Competencies and Skills Practised

(a) Encouraging participatory learning/teaching process in the classroom.
(b) Drawing illustrations from immediate environment, community.
(c) Actual demonstration of some activities - therefore, skill in designing and performing experiments - with locally available materials.
(d) Using and improvising teaching aids which facilitate the teaching-learning process.
(e) Designing activities for classroom teaching.
(f) Effective utilization of laboratory.
(g) Competence in plugging in the gaps (in the instructional materials) - for the continuous learning of the students.
Teacher Training for Science and Technology Education Reform

Teacher Preparation

(1) **Pre-service training**

Pre-service training at primary/elementary level is conducted by Basic Training Institutions, several of which have not been converted into District Institutes of Education and Training (DIET). This often is a two-year programme after Higher Secondary. For secondary schools, one-year pre-service training courses are conducted by colleges of education in the states, or four year degree-course after 12-years of schooling, organised by the 4 Regional Colleges of Education of National Council of Education Research and Training (NCERT). These lead to first degree in Education.

At the pre-service training stage, besides giving training in the methodology of teaching, the actual interaction with teaching situations is also imparted.

In actual training practices, the following are emphasised:

(a) Classroom practice teaching,

(b) Training for the education of handicaps (physically as well as mentally handicaps),

(c) Training in relation to community interaction and actual life situation - for example going to the villages; slums; hospitals; delinquent houses, and

(d) Use of ETV programmes for some abstract concepts.

(2) **In-service training**

In-service training, i.e. the updating of practicing teachers both in content as well as in methods of teaching is imparted through State Agencies.

A 3-tier mode of transaction is practised.

(a) Key Persons Orientation

(b) Resource Persons Training

(c) Teachers' Training

State Level Agencies are State Council of Educational Research and Training (SCERT), State Institute of Science Education (SISE) and State Institute of Education (SIE). The District Level Agencies like DIET (District Institute of Education and Training) - around 260 in number at present - co-ordinate the work of in-service training. Now at the district level, District Science Resource Centres (DSRC) are also coming up. These Centres are operating under district level educational institutes (including semi-government or non-government) and helping in the in-service teachers' training programmes. DSRC is engaged, in general, in science improvement programmes.

**Evaluation**

As a policy decision, comprehensive continuous evaluation has been recommended up to lower secondary stage. However, the final decisions are taken up by State Governments and as such, depending upon their preparedness, the same is being implemented up to different grade levels. Generally speaking, practically all states have adopted it at primary stage, though in some cases at the end of the fifth year in school, a terminal examination is conducted with some internality. In grades VI, VII and VIII, normally schools conduct their own examination. They also practise comprehensive continuous evaluation throughout the year and it forms a part of annual examination.
This aspect is being given serious consideration and the National Council of Educational Research and Training, (NCERT), is preparing experts at State Level who in turn will organise their multi-layer teachers' training/orientation in Comprehensive Continuous Evaluation programmes.

INDONESIA

A new science curriculum was implemented in 1986 in all primary and secondary schools. To improve the quality of teaching/learning, innovations such as student active learning and development of process skills were also implemented.

The science curriculum is intended to make the contents and topics relate to students' real-life needs, capabilities and environment. From class I to VI a separate subject, General Science, is taught in primary schools. General Science is an integrated subject consisting of physics, biology, earth and space, health education and environmental studies. At lower secondary level, science is separated into Physical Sciences and Biological Sciences.

The New Roles of Teachers of Science

- Providing a variety of learning.
- Using a variety of learning.
- Encouraging students as active participants in the learning.
- Encouraging students to be creative, discovering something by themselves, solving problems, deciding what to do.
- Improving better verbal interaction in classroom.
- Providing for individual differences.
- Using a variety of resources.
- Using the environment as resources for learning.
- Creating an attractive classroom that leads to students' active learning.
- Providing useful feedback.
- Assessing students' work in many ways.

Competencies and Skills Practised

The key teacher competencies related to activity-based learning have been identified. These are to:

(a) plan and manage the time available for learning more effectively;
(b) recognise and understand objectives relating to processes of thinking as well as concepts;
(c) recognise and provide for individual differences among learners, including children who are gifted, as well as children who are weak;
(d) organise and manage teaching and learning through a combination of class, group and individual activities appropriate to the needs of learners, the level of study, and the nature of the subject matter to provide a stimulating and effective environment for learning;
(e) use the environment and the children's direct experience as a resource for learning;

(f) use stimulating teaching and learning techniques (including questioning techniques) based on the use of process skills and leading towards more active and problem-centred approach to teaching and learning in science;

(g) provide better feedback to the learner and also to stimulate peer-group learning;

(h) evaluate the result of learning through the careful setting, monitoring, and assessment of children's output, not only through the work produced daily by the children in class but also through the attitudinal changes observed from time to time.

Active learning will be carried out successfully if supported with science-process skills. These skills are being developed in primary schools, such as:

- Observing objects or events.
- Raising questions.
- Making a hypothesis which is a tentative answer to their question, and which they can test in a scientific way.
- Planning and carrying out an experiment to test whether the predictions from this hypothesis are correct or not.
- Observing experiments, interpreting the data collected and using them to decide whether or not their hypothesis was correct.
- Selecting the most appropriate way to communicate their findings to other people. It can be verbal, that is, using language in written and spoken form, as well as non-verbal by using conventional symbols, pictures, drawings, diagrams, tables and graphs.

Teacher Preparation

In-service teacher training programmes are available in Indonesia. For primary science teachers, nation-wide training, utilising the "multiplier effect" concept has been instituted in connection with the new curriculum. Key persons are trained in content as well as methodology of teaching science at the national level, who in turn, train teachers at the regional level, who conduct the training at the district level.

Since July 1990, for increasing the qualification of teachers who graduated from Teacher Training Senior Secondary School, a modular instructional system was provided. This programme is conducted by the Open University. At the same time pre-service teacher training for the primary school teachers is provided at the tertiary level by the Institute of Teacher Training and Education Services and Teacher Training Programme within universities. In-service teacher training for lower secondary teachers is being developed nation-wide. This includes the establishment of district level SANGGAR which develops materials to support the teachers' curriculum development efforts. Curriculum leaflets, distributed to the schools, contain the broad curricular objectives, and instructional objectives.

Evaluation

To evaluate concept and knowledge, currently the government made a decision to stress the test on analytical thinking. Different types of tests are being prepared by Centre for Development Examination systems. Observation sheets have also been developed to evaluate the affective domain.
IRAN

(A) New Role of Teachers of Science

The present society needs science as related to other areas of human activity. The science teachers must also keep in mind that:

(a) society needs economic and cultural upliftment through education for better life.
(b) they must assess community needs and demands.

The teacher prepares the students for needs/requirements of the society/community. The development of science and technology in Iran is very important in relation to society. It is necessary for science teacher to know the strategy of economy, industry and agriculture, as linked to science and technology. The effort is to achieve self-reliance in industry, health and agriculture. They must also appreciate fully the technological learning needs of children in order to fulfill their country's needs.

(B) Competencies and Skills

Competencies

(a) Teacher provides motivation and drive for the students – that science is important for the progress of a country.
(b) Students know about themselves and the environment. Science information must be updated by the teacher (latest knowledge). The students must be made to realise that science is a progressive subject and the latest ideas be taught.

Skills

(a) The teacher should learn and exercise skill of logical thinking; "what, why, how" problem-solving skills.
(b) Observing, collecting data, classifying and comparing,

Explanation skills

Making theories, concepts.

Students should be able to quantify the quality of environment, set examples, give estimates of distances without having to really measure perfectly.
(c) Problem-solving.

(C) Changes in Science Teachers Preparation Programmes

At present, the education system of Iran consists of:

(a) 5 years elementary school (6-10 year old)
(b) 3 years secondary preparatory school (11-13 year old)
(c) 4 years high school (14-17 year old)
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In the teacher training programme, the teachers trained for elementary school, undergo two years of training for all subjects and some areas covered in science. Those trained for the secondary preparatory school undergo two years of training either in the Arts or Science subjects. While the teachers trained for teaching in the high school must be graduates and study four years in the University. These high school science teachers are specialised in one field only either Biology, Chemistry, Physics or Geology.

Suggested changes for science teacher training programmes:

1. Improve the programme.
2. During teacher training, trainees should be shown good examples of teacher teaching techniques and patterns.
3. Emphasis on using educational technologies. There are at present teachers who do not have the skills to use scientific technologies and material and also others who do know but do not use/apply the same.
4. The teacher-training programmes should be changed from theoretical approaches only to one that is practical and activity-oriented.
5. Latest technology in science development, medicine, industry and agriculture in advanced countries should be adopted and adapted in the teacher-training programmes so that the teachers can disseminate these technologies in their school students.
6. Organise workshops, conferences, seminars about teaching science to the teacher trainees.
7. The teacher-training programme should include in-service training for trained teachers who can undergo training while still working, for example, the teacher teaches in the morning and undergoes training in the evening.
8. The programme should include an exchange of ideas and methods in teacher-training programmes from other countries either through country visits, conferences or educational magazines.
9. The trainees should be taught how to make their own teaching aids from inexpensive materials.
10. The trainees who have become trained teachers should be allowed to undergo continuous training or follow-up training to realise the progress in science; some trained teachers should also be allowed to further their studies to masters and doctorate degrees.

Evaluation

At present, the evaluation programmes consist of evaluating the cognitive and knowledge parts only. What needs to be included in evaluation is the affective skills and attitudes. This can be done through interviews, practical tests (for skills) and written tests.

The evaluation of school students performance is through a common central examination. The teachers should be trained to evaluate their students efficiently themselves and have the central examination system replaced. Evaluation should be a continuous process throughout the school life of the students and not be made once a year at the end of the year.
MALAYSIA

In 1983, a new primary school curriculum was introduced called the KBSR. It emphasizes the basic 3 R’s, communication skills, man and his environment as well as individual development. The KBSR stresses learning through group activities and introduces enrichment and remedial programmes.

The New Role of Teachers of Science

(1) **Teacher as facilitator**

In the KBSR, the learning process is no longer restricted to "teacher tells, students accept". The teacher has to create an atmosphere whereby the students can investigate, question, discuss and seek guidance to come to a correct conclusion.

(2) **Teacher as designer and maker of teaching aids**

In carrying out the KBSR, science teachers have to equip themselves with a lot of teaching aids in order to succeed with the programme. In the training colleges, the trainees are trained not only in content and methodology, but also on various ways and means of creating their very own innovative teaching aids out of inexpensive materials.

Competencies and Skills Practised

(1) Creative in designing and producing teaching aids directly related to subject matter as well as being of inexpensive and lasting material.

(2) Skilled in creating an environment rich with potentials for students to investigate scientific phenomena/concepts easily, with minimal guidance from the teacher.

(3) Skilled in applying science knowledge/facts taught in schools to everyday life, whenever possible.

Teacher Preparation

The following are suggested changes in preparation of science teachers in view of the new role specifications:

(1) Change in attitudes - the attitudes of trainees must be changed to that of being fully committed to their vocation.

(2) The training colleges must be able to produce teachers who throughout their careers will be willing to experiment and explore in search of better methods and techniques.

(3) Before communication skills can be developed between the teacher and his primary school students, these skills must first be developed and practised between teacher trainer and trainee in order for the trainee to emulate and further enhance these skills when he becomes a teacher.

(4) Lecturers have to be continually updated on the latest development in teaching requirements, strategies and skills before they can impart these to the trainees.

Evaluation

Evaluation in the cognitive domain is well known to all teachers but it is in the affective domain where the problem crops up. In Malaysia, trainees have to include dissemination of good values during
a lesson. Wherever possible, the values should be directly related to the subject concerned. Evaluation of the affective domain can therefore only be qualitative.

MALDIVES

Science and technology play an important role in assisting national development goals. Taking into account the present-day trends and in view of training Maldivians for the 21st century, developing science and technology is vital. The national educational goals emphasise the provision of science education which is relevant to the local environment.

Competencies and Roles of Science Teachers

Three key factors are kept in mind in developing effective training programmes for Maldivians. These are:

(1) Familiarising with upgraded content and the ability to acquire more knowledge.
(2) Grasp of educational methods.
(3) Practising of acquired skills.

Competencies in the teaching of 'Environmental Science' includes understanding of ecological principles, economic theories, national and international resources, study of man and his biosphere, awareness and implementation of public environmental policy and the role of every citizen in the process.

Educational competencies include the acquisition and use of information for behaviour and attitude formation; an understanding of the social relations of the school, trends and problems in education.

Skills required are mainly environmental problem-solving, handling of values and controversial issues, use of materials and the local environment.

Competency in methods require an understanding of its aims and objectives, identification and use of resources, understanding of assessment and feedback, identification and solution of environmental problems.

The teacher plays a multiple-role in the classroom. These are:

(1) as a model.
(2) as a psychological weather-maker in determining the social climate of the classroom.
(3) as a question-poser to stimulate thinking and interest.

Teacher Preparation

Pre-service programme

Teacher training courses in the field of pre-service education contains a methodology course and content up-grading course.

Methodology course is designed to equip teachers with the required skills and methods of teaching environmental studies in primary grades. The study and application of the scientific method is stressed in the course. Time allotted is 70 hours.
Content up-grading course is designed at improving their science background knowledge, thus giving them more confidence in teaching the content effectively. Time allotted is 60 hours.

At middle school stage, teaching is mostly conducted by expatriate teachers and local teachers trained abroad.

In-service programme

In-service training courses in science and other subjects are presently carried out for trained and untrained teachers. These are mainly face to face training - either the trainees being brought to a particular location or the trainer moving to a particular location. The training period for such programmes is mainly two weeks. On-site teacher training is now in practice with a teacher educator being posted at a particular location for a longer period.

The changes in the curriculum, the varying patterns of science education and the national development goals together have determined the nature and scope of the science teaching programme. The revised curriculum for use in teacher training emphasising scientific skills, attitudes and values has been implemented from 1989. Furthermore, this curriculum would be reviewed in early 1991 in light of the problems and shortcomings experienced.

Other changes in the aspect of teacher education includes further training for science teacher educators, developing teacher education texts, strengthening of information network in science and technology and the realization of the urgent need for training of middle school teachers.

Evaluation

Evaluation in primary schools is mainly done through continuous assessment. However, in Grades 4 and 5 cognitive objective type tests are given in addition to it. Rating scales are prepared, having in mind both the cognitive and affective domains.

No particular instrument is yet formulated in middle school to evaluate pupil achievement in the affective domain. The instruments used at present are mostly cognitive.

PAKISTAN

Science Education is the most important area among the factors that influences the growth and development of every country.

In Pakistani schools, Science is taught in two stages:

(1) Primary and Middle Level (I-V and VI-VIII): Science is taught in an integrated form.

(2) Secondary Level (IX-X): Science is taught independently in 4 subjects.

Science education reform is carried out through:

(1) continuous training of teachers in a phased manner through refresher courses for 4 to 6 weeks, with emphasis on:

(i) Developing an understanding of professional knowledge.

(ii) Developing an understanding of educational theory to help in professional judgement and actions.
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(iii) Developing a knowledge of relationship between educational and psychological aspects of learning.

(iv) Developing technical skills through training and practical experiences.

(v) Developing an ability to make best use of community resources.

(2) Popularisation of science and technology through science museums, science clubs, science fairs, science poster contests, computer based science instruction scheme, audio-cassette textbooks.

(3) Provision of optimum physical facilities and manpower resources.

(4) Implementation of modified curricula, textbooks, and instructional materials.

(5) Development of teaching-learning strategies.

(6) Development of feedback mechanisms for effective evaluation of training programmes.

New Roles of Teachers of Science

In view of these reforms in science education, some of the science teachers' roles have been recast and modified, others have been reinforced, while new ones have evolved:

(1) a professional who continues to improve his knowledge;

(2) an educational theorist who exercises professional judgement and actions about science education and its reform;

(3) a technologist whose technical skills are most needed for teaching aids and equipment improvisation;

(4) an educational psychologist with an in-depth knowledge of the relationship between educational and psychological aspects of learning;

(5) an active member of the community who makes best use of community resources;

(6) a campaigner/advertiser who popularises science and technology through science museums, clubs, fairs, camps, computer-based instruction, and audio cassette textbooks;

(7) a nurturer of science talent who guides the science talented students to higher levels of accomplishment;

(8) an evaluator who continually seeks effective evaluation.

Competencies and Skills Needed by Science Teachers to Efficiently Perform Their Roles

(1) Learning skills - to process and learn new knowledge.

(2) Technical skills - to productively use technological equipment and apparatus in constructing/improvising teaching aids and devices.

(3) Organising skills needed for organising in-school and out-of-school science activities.

(4) Competence in using knowledge in curriculum work, instruction, evaluation, developing strategies.

(5) Pedagogical skills needed for teaching practice and use of instructional materials.
Country Experiences

(6) evaluating skills needed to evaluate science learning, identify the science talented, evaluate science programmes and projects.

Teacher Preparation

(1) Pre-Service Training

It is managed before the teacher enters the department as a regular teacher and provides a basic knowledge of teaching. The courses offered are:

- Primary Teaching Course (PTC) - to teach at the Primary School Level (Classes 1-5)
- Certificate of Teaching (CT) - to teach at the Middle Level (Classes 6-8)
- Bachelor of Science (B.Sc.) or/and Bachelor of Education (B.Ed.) to teach at the Secondary School Level. The teacher receives training either through a 14+1 model to get a one-year degree; a 12+3 model to acquire a B.Ed. after 3 years. The teacher seeks specialisation in 2-subject combinations: (a) Physics-Chemistry, (b) Physics-Mathematics, (c) Chemistry-Biology. At the end of the training course, the pre-service trainees is required to give at least 2 practice teaching lessons, 1 in each subject of specialisation.

No new programmes have been instituted lately.

(2) In-Service Training

Training is provided to teachers in service to update their knowledge of content, methods of teaching, and new developments in curriculum.

In-service training courses ranging from 1-4 weeks, or with a crash programme or yearly plan basis are offered both by the Federal and Provincial Governments, subject to the availability of funds.

The newly established Institute for Promotion of Science Education and Training (IPSET) arranges special seminars, conferences, workshops for teachers, students, parents and the general public.

Evaluation

New techniques of identifying and evaluating the science talented students have developed through the out-of-school science activities (e.g. science fair, science camp, science contest, etc.).

The IPSET has taken, as one of its objectives, the development of new assessment procedures including aptitude tests, achievement tests, and attitude tests.

The in-service training is a means of providing feedback on the quality and scope of the pre-service training.

PHILIPPINES

Emerging Roles and Competencies of Science Teachers

The educational reform and current national goals are envisioned to recast the Philippine educational system more qualitatively than structurally, resulting in the emergence of new roles for teachers, particularly science teachers.
Teacher Training for Science and Technology Education Reform

The new roles of the science teacher require him/her to become:

(1) Updated and competent in:
* facilitating the growth of scientific literacy among the general populace, which should, in turn, hasten modernization and economic progress;
* nurturing science talent for development into future manpower for science and technology.

(2) A socially-oriented teacher, who:
* works for social equity, justice, and peace through scientific development;
* strives to develop in students, participatory and decision-making skills needed for the solution of public issues and problems.

(3) An environmentally-oriented science teacher, knowledgeable and skillful in:
* tying up science concepts to real-life local and global conditions;
* devising/selecting appropriate within-school activities that facilitate comprehension of more complex and higher-level ecological concepts;
* developing values and attitudes that are strongly pro-conservation and contribute to the enhancement of the environment;
* promoting participation and public action against the environmentally harmful applications of science and technology.

(4) A science teacher, knowledgeable in the psychology of learning and the intricacies of interpersonal relationships in the classroom, so as to competently:
* create an enjoyable learning atmosphere;
* inspire students to give forth their best and to develop their full potential.

(5) An ingenious and resourceful lesson planner and organizer, who:
* matches content with appropriate strategy;
* employs motivation schemes that catch and hold the interest of students;
* designs and improvises devices and equipment out of available materials.

(6) An articulate and efficient lesson presentor, who:
* by appropriate selection of language and teaching devices, facilitates learning;
* makes the lesson appear easy and enjoyable;
* accomplishes the objectives of the lesson.

(7) A perceptive evaluator, who:
* constructs test items to evaluate comprehension of science content and science methodology, laboratory skills, and development of the students' affect (feelings, interests, concerns, sense of responsibility, attitudes and values).
* is capable of translating scores and other forms of evaluation into grades.
Teacher Preparation

For admission into the teaching service at the elementary school a Bachelor of Science in Elementary Education and, in the secondary school, a Bachelor of Science in Education (B.S.Ed.) degree is required. A qualified science teacher is one who has majored in Physics, Chemistry, Biology, or Integrated (General) Science for which at least 36 units of credit have been completed.

A workshop sponsored by the Bureau of Higher Education has recommended the installation of new courses, such as Environmental Science, Earth Science, and Science and Society; the updating of textbooks and other resource materials; and the increase of hour-credits for such courses as Botany, Zoology, Chemistry and Physics for some teacher-training institutions.

Alternative strategies to increase the number of science majors in the Bachelor of Science in Education (B.S.Ed) programme are presently under consideration. One strategy is to make available for science majors a number of government scholarships. Another strategy is to organize consortia of proximally located teacher-training institutions which offer science majors programmes, with each unit offering the course as is best capable to the programme.

Evaluation

The past decade saw a great deal of improvement in test construction and test administration in science teaching. It is common place now to end a science lesson with a 3-item or 5-item quiz to find out roughly how well the students have learned the lesson. This practice compels the teacher to focus the teaching-learning transaction on the objectives of the lesson. The end result is increased effectiveness and efficiency. However, the evaluation has concentration on the cognitive domain.

It is only lately that some inroads have been made into the evaluation of the affective domain. This has come about in the form of a few workshops on test item construction such as that conducted by the National Educational Research and Testing Center (NERTC), and a more recent one conducted by the University of the Philippines, Institute for Science and Mathematics Education Department (UP ISMED). On the whole, however, paper-and-pencil testing of the affective domain of science teaching is not a common classroom practice as yet. More commonly, the science teacher makes intuitive and qualitative assessments of the students' interests, concerns, attitudes and values in science. These are written by the teacher in the students' report cards.

SRI LANKA

Science is compulsory at Junior and Senior secondary levels. It is a "science for all" and a "science for citizens". The emphasis of the learning process of science is to learn science scientifically. The objectives of science education at this stage, in terms of learning by pupils, are to:

1. Understand the methods and procedures followed by scientists in solving problems, and using them where necessary.
2. Develop the scientific knowledge, skills and attitudes necessary for day to day life.
3. Develop the knowledge, skills and attitudes required for a good personal health as well as good public health.
4. Recognise local resources and acquire the scientific knowledge, skills, and attitudes to use them efficiently.
(5) Understand the problems and dangers arising due to new technological developments, and appreciate the importance in selecting a suitable technology for Sri Lanka.

(6) Understand the impact of mankind on the environment and appreciate the importance of the equilibrium of nature.

(7) Appreciate the service of scientific institutes in developing the country and get the assistance of those institutions where necessary.

(8) Develop competence in assessing critically the information given by communication media.

(9) Develop creativity and originality.

(10) Use science efficiently in hobbies.

(11) Understand concepts and patterns in the integration of science.

(12) Build up educational foundation for further education in life.

But what is taught in school is directly linked with the examinations, which test only the knowledge component. Teacher education is one aspect where changes are possible.

The Competencies and Skills

The following need to be developed by science teachers:

(1) Understanding and appreciation of the importance of science education in building up an inquiring mind.

(2) Understanding the nature, process and procedures of science.

(3) Acquiring scientific skills and attitudes by means of activities within the laboratory and outside.

(4) Knowing the content and the objectives of grades (6-11) science syllabus and familiarising with the handbooks, teacher guides, etc.

(5) Acquiring knowledge, developing skills and building attitudes to teach grades (6-11) syllabus and to fulfill given objectives.

(6) Using necessary psychological principles in teaching.

(7) Constructing teaching aids and improvising apparatus using low cost resources from the environment.

(8) Recognising and using the resources available in Sri Lanka relevant to grades (6-11) syllabus and using them as required.

(9) Acquiring the skill to handle the laboratory equipment and instruments properly, efficiently and carefully.

(10) Using the environment and resources without damaging them and appreciating their conservation.
Teacher Preparation

The institutes which prepare and implement the teacher education programmes are:

(1) **Teacher Colleges**

There are two teacher colleges out of the seven colleges in the country. Trainees are selected from non-graduates with the qualification G.C.E. O/L and A/L with teaching experience. The training period is 2 years.

(2) **Colleges of Education**

Colleges of Education were started in 1985 as pre-service education institutes. The trainees are selected from G.C.E. A/L. The training consist of two-year residential and one-year internship periods.

(3) **Institute of Teacher Education**

The Institute of Teacher Education (ITE), under the National Institute of Education, conducts teacher-in-service training separately for trained teachers and untrained teachers.

In 1985 a new teacher education curriculum was prepared for colleges of education which emphasised the improvement of skills and attitudes of the teachers in science. In this new curriculum.

(1) more time is given for laboratory and field work.

(2) a new subject area called "Education Practice" was introduced.

**Evaluation**

The evaluation process consists of continuous and terminal assessments. Observations, interviews and assignments are the bases of the continuous assessments.

Fifty percent weightage is given to manipulative skills in science practicals.

**THAILAND**

**New Role of Teachers of Science**

Thailand has emphasized the utilization of science and technology as the key factor for the social and economic development of the country. Thailand placed emphasis on 3 areas:

(1) Genetics Engineering and Biological Technology.

(2) Electronics and Computers.

(3) Material Science.

With the intention of becoming a semi/newly industrialized country, with development plans in accordance with natural resources, Thailand needs qualified manpower. The general populace needs to possess minimal skills and knowledge that will enable them to lead quality life. Then decision-makers need to have basic knowledge and understanding of science and technology and comments to the search for more information in order to make wise decision. Finally a certain percentage of high calibre manpower is needed to produce and invent technological products so that the country will be able to be self-sufficient.
In response to the country's needs, the Ministry of Education will implement the revised curricular structure nationwide in May 1991. The structure calls for more emphasis on the learning process at all levels. Also, at the secondary level, more time is allocated for elective courses. In addition, an expansion of 3 more years of education in primary schools is now being tried out in certain pilot schools.

Science teachers, the key factors to successful manpower development, need to change their roles to be more dynamic, flexible and more global.

The science teacher's expected roles are as follows:

1. Facilitator: facilitating development of science process skills, scientific attitudes and ethics in science;
2. Innovator: being innovative in choosing things available and putting them together and promoting scientific message using real life situation/problems;
3. Curriculum developer/implementor: develops teaching-learning materials/activities that are relevant to local development;
4. Stimulator/inspirator: stimulate students and bring about their potentials;
5. Evaluator: needs to evaluate students progress in all aspects and provide feedback to them and ownself;
6. Leader: in promoting critical thinking and decision making among students and community especially in the issues concerning local/national development that might have adverse effect on people;
7. Learner: willing to learn about changes taking place around and attempt to interpret and utilise these.

**Competencies and Skills to be Learned and Practised**

"Open competence" first put forward by the "Study Group Meeting on Science Curriculum and Instructional Materials Development" (UNESCO, Bangkok, November 1981) need to be acquired by/should be required for science teachers. This includes: science process skills (13 skills illustrated by SAPA) Knowledge: Ideas/concepts and applications of science and technology Way(s) of thinking: analytical, synthetical, divergent, imaginative and creative scientific attitudes ethics and values in science decision making.

**Teacher Preparation**

1. **Pre-service training programmes**

Presently there are 2 degree programmes being offered.

1.1 A 4-year education programme for high school graduates whether from universities or teachers' colleges. The programme varies from place to place. There have been no major changes in terms of the programme structure. Nevertheless, when implementation of new science curriculum occurs, time is allocated for training the student teachers before they complete the programme. More time should be allocated for:

- courses in ethics in science where its effects on human beings and their environment are heavily discussed.
- discussions and looking into development plans at the national as well as local levels.
(1.2) A 2-year education programme for diploma graduates offered by teachers' colleges.

(2) In-service training programmes

Occasional in-service training programmes are conducted in various forms:

(2.1) Face-to-face training programmes done at the institution/cluster/school-based, in response to the teachers' needs and administrators' needs.

(2.2) Distance-training programmes

These are conducted formally and informally through televised educational programmes of the open universities; newspapers; radio; television; resource books/materials, such as programmed instruction materials, videotapes. In the near future, the Institute for the Promotion of Science Teaching (IPST), in co-operation with the office of Primary Education Commission, Universities, and Teachers' College will set up a scheme for in-service training programmes for primary teachers who are mostly untrained in science teaching.

Evaluation

At present most of the evaluation is conducted internally. Science teachers at secondary level are required to assess students' behaviour in affective domain and record the assessment in a report card. Science process skills, unfortunately, are seldom assessed at both levels although efforts are being made to make sure that these skills are emphasized in the curriculum objectives as well as in the teaching-learning materials.

However, with the implementation of new curricular structure which provides opportunities for students to take more elective science courses, there is a trend that assessment will emphasize more on science process skills and scientific attitudes. This is due to the nature of the elective courses developed by IPST which calls for development of science process skills and scientific attitudes in students.

(Examples of these elective courses are: Various scientific toys, Mechanical and electrical toys, Science and problem-solving, Let's begin with science project, Fun with electronics, Science projects and quality of life).

SYNTHESIS OF COUNTRY EXPERIENCES

The discussions following each presentation of country experiences and the summaries presented by the participants from the member countries provided the basis for coming up with the following syntheses.

Scientific and technological developments and the aspirations of people for their further growth and influence on industrialisation efforts have led to reform in science education, in most countries in Southeast Asia. Reciprocally, a reformed science and technology education plays an important role in achieving national development goals. The reform consisted in changes in approaches, strategies, and points of emphasis in the science curriculum of the elementary and secondary schools which resulted in new roles and competencies/skills demanded of science teachers, changes in science teacher education programmes, and laid emphasis on evaluation in science teaching at all levels.
New Roles of Teachers of Science

Science education reform demands that science teachers perform new roles. The science teachers' roles have increased in number and complexity. The new roles listed below have been drawn from papers on the subject submitted by the eight participating countries in this workshop.

The new roles of science teachers are as follows:

1. Life-long learner - continuously strives to learn science and technology developments, educational and psychological developments, and local/global issues and events;

2. Innovator - sees familiar things, events in new ways; acts as change agent in school and community; is convinced of the need to change if the quality of education and of life is to be improved; must be able to adapt materials and methodologies to the local situation;

3. Implementor/developer of curriculum - interprets curriculum and translates it into student learning activities; draws ideas from the physical/biological/cultural environment for use in interactive learning of students;

4. Perceiver of children's needs/development - is concerned with the growth and development of children; considers their needs when planning lessons;

5. Planner - plans the sequence and emphasis of the lesson;

6. Resource manager - selects and mobilises locally available teaching materials, equipment and facilities; identifies and mobilises human resources to enhance student learning;

7. Facilitator of learning - facilitates growth of scientific literacy through the development of science process skills and the acquisition of scientific literacy;

8. Interpreter and communicator - interprets and communicates to students the concepts, processes, and the philosophy of science as stated in the curriculum; interprets and communicates to the general public the goals and activities of science education;

9. Supervisor of children's growth and development - supervises activities and tasks that provide opportunities for intellectual and physical growth of children;

10. Developer/promoter of values, attitudes, feelings, and social responsibility - develops scientific values and attitudes; must be skillful in developing the value not to abuse science so that it is harmonious with society and the value of environmental conservation;

11. Evaluator of learning outcomes - assesses the cognitive, affective, and psychomotor learnings of students in science; constructs test items; devises instruments and procedures for evaluating the affective domain and psychomotor domain;

12. Effective member in community development - initiates/participates in projects that develop and improve the community; links science and school to the community; possesses the commitment to improve the quality of life in the community.
Competencies/Skills Required of Science Teachers

The proper performance of the science teachers' new roles requires the acquisition of certain competencies and skills. Competencies and skills needed for effective teaching cut across several roles that teachers perform. These competencies and skills are listed below:

(1) science-process skills
(2) instructional skills
(3) information-processing skills
(4) decision-making skills (ethics and values in sciences)
(5) managerial skills
(6) creativity
(7) evaluating skills
(8) scientific values and attitude development skills

Changes in Science Teacher Training Programmes

Science and technology education plays an important role in assisting national development efforts. Taking into account the present day trends, the communication patterns of science education, and national developmental goals together have helped determine the nature and scope of the science teacher training programmes. With the effort to produce a need-based and culture-based science curriculum, the elementary school science curriculum has resulted in major revision. Science-kits have been introduced to be used in implementing the curriculum. With major changes in the curriculum, the need for curriculum renewal in teacher education programmes at in-service level has become an immediate and urgent need.

In general, pre-service teacher training programmes include students with 12 years of schooling, who undergo one to two years of teacher training. In some cases, it is further supplemented by one year of internship programme. Few exceptional cases are of countries having to accept 7 to 10 years of schooling, supplemented by two years and one year of teacher training respectively. This is in the case of an urgent need for teachers to fill in the role of expatriate teachers and untrained teachers.

Earlier, the trend in teacher training in science has included training in methods of teaching only, whereas the present, day training includes training in content and methods of science education. Mastering only in methods has not helped in effective transfer, due to lack of confidence in teachers themselves. Hence, content up-grading in science has been realised as an urgent need for effective teaching of science. Emphasis is greatly laid on learner-centred and activity-based approaches. Hence, laboratory practices, classroom demonstration, active participation by the students whenever possible, and field interactions have become major components of the course.

Present-day education stresses on giving equal opportunities to all students - slow learners, gifted and handicapped.

Pre-service training has a component of community interaction. That is, the would-be-teachers go to the actual situations such as mentally-retarded children's homes/schools; slum; factories; mines; etc. to access the need for the special-education in all such cases.

Technology education plays an important role in meeting the demands of learning and life.
Teacher Training for Science and Technology Education Reform

Familiarisation of tools and improvisation of tools, providing field level experiences, developing new technological materials have become important components of teacher training.

Science cannot be learnt in isolation of the environment. An understanding of the environment and ecological principles, conservation are areas included.

New institutions, either in the form of organisations or resources centres, have further supplemented training programmes. These have been established at National, Provincial or District level, depending on the numbers of teachers.

Utilisation of available resources in all fields help to enrich the on-going programme in science education and provide it with more meaningful, in relation to daily life.

The above changes in science training makes it evident that students are more sensitive to the environment and to the community.

In-service training is imparted in a number of ways. It includes summer classes which is planned to coincide with school holidays. This can be one of the methods of face-to-face training. The other type of face-to-face training is, instead of removing teachers from their attached schools, teacher educator/trainer are being sent over for a fixed period to provide training.

Distance education has proved one of the most effective ways in imparting in-service education in countries especially where transportation is difficult due to geographical locations.

In case of in-service training involving large number of trainees, this has resulted in weak results or dilution of what was imparted initially, so direct training is always more fruitful than using a mediator.

It is virtually impossible to give training to an exceptionally large number of practising teachers by one organisation. This not only faces the constraints of the resources but also it is unmanageable.

Therefore, help of different institutions are sought fast. Most commonly the 3-tier in-service programme is in practice: Orientation of Key Persons or Master Trainers; Training of Resource Persons, and Training of Teachers.

Attempts have been made to provide locally relevant materials for use in teacher training. Materials printed in local language would serve as useful teaching materials in enriching their knowledge.

Evaluation

Changes in curriculum often receive a setback due to the rigid examination systems. Essay type of test has led on to objective type tests with no change in the level of testing, still leading to testing of knowledge at the cognitive level.

Several countries seem to accept continuous evaluation. But this, too, has proved difficult to implement due to teacher unwillingness or unpreparedness. The most important reason is pupil/teacher ratio being very high, multi-grade teaching catering to a large number of different abilities and age groups, and also teachers having to teach in more than one shift.
Societal perception has also to be considered in finalising a method of evaluation. Parents' and societies' concern for students to do well in school is almost common everywhere. Hence, their expectation and an understanding of the method of evaluation is necessary. Any sort of evaluation tool prepared, need to be well understood and perceived by the society.

Abolition of annual examinations, contrary to expectations, had a decrease in achievement level of students. These examinations have acted as motivators to learning on the part of the students' and the teachers' efforts input in the teaching-learning process being greater to get the desired outcome from the evaluation.

Changes in the curriculum can be further supplemented with improvements brought about in the methods of teaching and for effective results, the evaluation methods for implementation need to be improved upon further.
CHAPTER TWO

TEACHER TRAINING FOR SCIENCE AND TECHNOLOGY
EDUCATION REFORM: TRENDS AND ISSUES

Introduction

National development in third world countries is closely dependent on the availability of literate and capable manpower. Development is no longer perceived in isolation to scientific and technological process. Consequently, elementary education is no longer viewed as mere learning 3R’s or obtaining a certificate from an institution. These nations need a broad base of talents nurtured in a rational and scientific climate and environment. The pace of development is closely linked to the extent of assimilation of scientific and technological developments, growth of scientific temper and national capabilities to develop appropriate indigenous technologies. Towards this, a basic understanding of specific developmental needs is to be appreciated. It is now appreciated that no growth model can just be transplanted from some developed countries into a developing country, and more importantly, only higher level technological and scientific personnel alone are not sufficient for universal distribution of the benefits of scientific and technological developments. It is these realisations which prompted the third world countries to consider seriously the need for providing science education to all children up to elementary/secondary level. This has been a very bold and positive development in the context of the countries which were and several still are, struggling to universalise basic education itself. These nations are still facing obstacles in terms of resource crunch, including economic, social and cultural handicaps.

It may appear intriguing to recall at this stage that just a few years ago, girls were not expected to study mathematics and science even in elementary classes. There were situations when boys were compulsorily required to study mathematics but the same was optional for girls. This illustrates the path traversed by the present-day science education, now being remodeled as science and technology education. The perceptions of science have changed amongst the teachers and the perceptions of science from the community are also now very different. Science is no more for the elites; it is for all. It no longer prepares pupils for next higher class or grade, but for life. And once this is accepted, science can no longer be a distant and difficult jargon of laws, rules and hypotheses only, but of everyday assistance in improving the quality of life through judicious understanding and appropriate utilisation. Science and technology education has now to be oriented, reshaped and linked to comprehensive national development goals. Content of science and technology is to be determined by a large variety of expectations that the society has from it. Each country has to ensure availability of trained manpower, develop self-reliance in science and technology capability, encourage innovations in basic science as well as relevant technologies appropriate to national socio-economic objectives and needs. They have to prepare a much wider base of people equipped with basic appreciation of scientific approach, scientific temper and enhanced creativity. This could be achieved by science for all, technology being accepted, adopted, adapted and utilised by all. In developing countries, the demand on and from science and technology is essentially of amelioration of human conditions, as a necessary ingredient to enable all people to contribute to national development.

A. The New Role of Teachers of Science Linked to the Development Processes in the Member Countries and Towards Meeting Its Comprehensive Demands of Life and Learning

Consequences of rapid developments in science and technology and their impact in socio-cultural life may include considerable impacts on the human approach to life itself.
Trends and Issues

before each one of us in the future would be how to make gainful use of these developments. We can certainly visualise the exploitation of knowledge, its management, universalisation and transfer of the relevant and useful developments to the next generation. The last one obviously is largely the prerogative of the teacher and for valid reasons of the science teacher. He has to handle new inputs in curriculum, larger numbers of pupils in the classrooms and meagre resources to manage these. Even within these constraints, he has to nurture the potential of his pupils towards their all-round development. He 'teaches' to enable the young ones

- to react to changing environment with rationality and scientific temper;
- to foresee the future environment, newer technologies and their impact, and identify such elements as are likely to contribute to it significantly; and
- to anticipate such contributions on their own part, as would influence the future environment in a positive direction.

This obviously cannot be achieved by teachers, so long as the mere transfer of knowledge is taken by them as their major professional obligation. There is no dearth of such learned individuals who opine and see a neck-to-neck race between the present-day education and catastrophe. The only way to salvation instead of catastrophe is again geared to the above mentioned objectives.

Practically, every nation has attempted revision in teacher education programmes, particularly in science teacher preparation during the last few decades. These changes in teacher education are part of the comprehensive changes in educational structures, curriculum revision/renewal, strengthening of institutions, including training institutions and other efforts in professional development of teachers. As the curriculum development is a continuous process in all stages of education, so is the process of curriculum renewal in the teacher education programmes at pre-service as well as at in-service stages. Probably, the changes in teacher training require greater insight and in-depth appreciation of all other changes, to make these programmes more effective. If the teacher is not fully equipped and trained to handle the new curricula, the curriculum transaction would be weak and, consequently, the learning in schools inadequate. Teacher education institutions have to continuously update their understanding of the curriculum-renewal processes as well as the demands and expectations from the community on the educational system. The training strategies have to be governed by both these considerations. The science teacher is, however, no longer a mere transactor of curriculum in the classroom, but much more than that.

Science teaching was conceptually replaced by learning science, learning by doing, activity methods, child-centred approach and others. All these were attempts in the right direction and could be considered as the outcome of past experiences in science teaching and appreciation of the current learning needs of children. As indicated above, the science teacher prepares children to face real life situations and not only for getting good grades or marks in annual examination. He is preparing the child for an adult life which is closely and intimately related to the changes taking place in his immediate environment. Further, he has to be prepared to receive continuously such changes, developments and their impacts in his adult life in the future. Scientific and technological developments are not divorced from social, cultural and behavioural aspects. Consequently, skills and competencies like making a point in conversation, making adjustments, information-processing, communication, group behaviour and management are crucial to teaching and learning of science and consequentially for the science teacher.

Teachers' Own Initiative

Without going into the technicalities, let us attempt to perceive steps which the teachers of science and technology can initiate themselves without much external assistance.
Some of these probably could be listed as:

- The teacher must observe his own way of work and analyse the same to incorporate such changes he considers expedient.
- The teacher must be convinced of the need to change; his approach, style, habits, and even personality.
- Teachers must appreciate the necessity of not only teaching but also 'talking' to his pupils and effectively listening to them. Listening could be a positive reinforcement in the style and approach of the teacher.
- The activities involving a pupil's attitude require extra effort. Resource mobilisation and its appropriate utilisation also depend upon this willingness.
- A basic understanding of the behaviour and background of the pupil is as necessary in science teaching as in any other discipline. In imparting instruction in science at the elementary stage, one has to break several barriers.
- No one else can give the teacher a methodology suitable in all aspects to handle a particular topic, particular group of pupils or specific situations; he himself has to evolve the same. He must be prepared for modifications at each stage and through every source.
- Science teaching and technological skill development has to be interesting, understandable and human. No approach, style or methodology can afford to neglect this aspect. Efforts are to be made to link it to the individual's life and his environment.
- The science and technology teacher must understand and appreciate the role of the appropriate language in his effort. Ability to communicate in a language within the reach of the child is a must.
- The teacher must guard against becoming a weak teacher as he grows in years and experience. He has to remain open to new experiences and learning situations to re-equip himself with all available sources.
- The science teacher has a distinct role and he has to know about this himself as well as make others realise the same.

**Identification of Teachers' Specific Role**

Identification of the roles of a teacher could be viewed from different angles. There is no dearth of those who are sincerely convinced that their job is to teach (only). On the other end are those who find it hard to single out positive attributes which a teacher could safely avoid. The list of expectations from teachers becomes alarmingly long, often probably beyond the reach of individual human beings.

As we examine the role of a teacher in developing countries, several of them still struggling to universalise elementary education, we find justification in a much broader and wider role expectation of the teachers by communities and learners. Where else is the other resource? We discuss some of the more pronounced roles of teachers.

(i) **Curriculum developer**

From a centrally prescribed curriculum, usually available in term of textbooks and official instructions, this is a revolutionary change. Not only are teachers being involved in the process of centralised curriculum development, they are being provided the opportunity
and responsibility to develop their own curriculum, relate it to real life situations, design locally-relevant activities, utilise local resources and encourage children to bring in their life experiences and relate them to the curriculum. The teacher is the designer of activities himself. He is not only the implementor of the curriculum but its developer as well. He organises activities, arranges community expertise available to school, improvises wherever necessary and organises the entire activity.

(ii) **Motivator**

The teacher is often in situations where resources are inadequate and need to be mobilised. No innovative teaching-learning situation could be conceived unless the teacher is keen to innovate. Once he has thought of requisite resources and designed an innovative situation, his job gets confined to motivating the target group. What better method could be to motivate than to motivate by example. He could visualise interesting and rewarding learning situations, expose children to materials that would generate curiosity, explain natural phenomenon and provoke children to discover more. There could be no limits if the children are motivated to know things around them, observe them, analyse and bring their own interpretation and learning to the teacher. The teacher could also be a partner in such investigations.

Only a motivated teacher could be a motivator of students or of a community. To provide motivation to others, he himself has to be an investigator and explorer.

(iii) **Teacher as Learner**

A teacher is a life long 'student'. Teaching is one profession which could literally be enjoyed by the practitioners as they have practically all decisions regarding methods, strategies, techniques of curriculum transaction to be decided by themselves individually. With his pupils, a teacher is totally and completely autonomous. It is his latent potentialities which could convert the learning process into really enjoyable and interesting, burden-free situation for the children and for himself also. Naturally this requires much homework on the part of the teacher. He has to constantly update himself, learn from all possible sources available to him. He has to keep his eyes and ears open. The best learning that comes to a teacher is from his pupils. Pupils' reactions, questions, interventions, degree of interest and rapport with the teacher could be converted into potential instruments of evaluation of the teacher's own learning. A sensitive teacher, fully conscious of his responsibilities is bound to make all efforts to learn more and more. The situations now are such that without willingness to learn, no teacher can remain even at 'average' performance level and is destined to become a weak teacher. The system has to provide necessary motivation and opportunities for all teachers to continuously become more equipped teachers.

(iv) **Community collaborator**

This reflects best the changing demands on the teacher and the widening of his roles and responsibilities. He is the resource person for the community, and the parents as well. They know he shapes the future of their children. They go to him to help them find solutions to their own problems as well as to interpret for them the new changes that are affecting their lives. To perform this role, the teacher needs to understand himself, the existing socio-economic and cultural scenario, perceive the possible impacts of technological changes and prepare the community to accept only those which would not only provide short-term gains but would be of lasting benefit. Several of these situations would require a good number of precautions to be taken. Only the teacher could explain, demonstrate and convince regarding its necessity.
Here is a chance for the teacher to establish a close working relationship with the school and the community. This would mean mutual accountability, which in turn, would really contribute in the effective functioning of the school.

(v) **Evaluator**

Evaluation no longer remains a simple routine activity. It requires in-depth understanding and adequate preparedness. The objectives of evaluation are no longer confined to testing of cognitive attainments; it includes cognitive and equally importantly, the affective domain. In view of the drastic change in the very objectives of curriculum transactions, the learning in affective domain has become very prominent as the majority of learners are not going for higher education but are being prepared for life. As such, it is implicit to evaluate their interest, attitudes, values and ability in decision-making. On the psychomotor side, the manipulative and laboratory skills are to be developed and consequently evaluated.

In majority of the situations, the teachers are to conduct formative evaluation which provides diagnostic feedback to the teacher himself. The summative evaluation could be conducted the same as it has been in practice for long, though its techniques and procedures would be different now. However, it is the formative evaluation which requires the teacher to be ready to investigate, pose his own questions; identify and select situations and problems; design activities; and finally, make decisions to enable him to assess what he, in fact, desires to assess. It is this continuous evaluation of pupil achievement which could help teacher in decision-making at various stages to improve learning.

**B. Competencies and Skills which must be Learnt and Practised by Science Teachers**

The new role expectations demand new skills and competencies of science teachers as they are, in addition to their curriculum oriented roles, supposed to be the guides of the community in terms of new developments taking place in the fields of agriculture, medicine, communication, household technological gadgets, and others. This implies that they need competencies and skills that with equip them to meet the demands of the community which is striving everywhere to improve their quality of life. While individual teachers have played such roles on their own initiative, the sheer pace of transformation makes it implicit on teacher-education programmes to equip all teachers with such skills that would enable them to meet the comprehensive demands of learning and life. Initially, when science became part of school curriculum, it was perceived as something meant only for a select few; those who would go for higher education and become scientists. This is no longer the case now. It is fully realised that science has to be 'science for all' and as such its content, methodology, and objectives need a thorough re-definition. This has been attempted or is being attempted. At present we have gone at least one step ahead and it is now not only 'science for all' but 'science and technology for all.' From universalisation of elementary education, we have moved to universalisation of science education.

In terms of the science teaching competencies, it would be desirable to specifically identify the requisite skills for each stage/area, as no one particular set of the same, may be universally applicable everywhere. Wherever a curriculum development, or renewal process is taking place, the requisite competencies have to be identified and classified. This in fact, helps in the renewal of teaching-learning material for teachers and teacher-educators. This would include self-learning material for teacher-educators, hands-on experience and also for developing analytical process skills among the teacher-trainees. Genuine problem-solving situations are rarely visualised in such training programmes. While theoretically we might have brought it in textbooks, it is rare to find exercises where teacher-educator and teacher-trainees work together to find solutions to the problems for which solutions are genuinely not known to both; as otherwise, the exercise often
becomes a routine repeat performance to the teacher. The teacher-trainees are to be given an opportunity which would allow full play of divergent thinking required to anticipate the problem situations, and identify alternative strategies to find different solutions. There is indeed an intense need to develop this aspect of teacher-training process, in the context of which the question of competencies has been often discussed. In the Study Group Meeting on Science Curriculum and Instructional Materials Development in 1981, it was observed that "... in order to adapt to the rapidly changing and progressing age and to contribute to the socio-economic progress, it is important for all the students to acquire certain competencies and attitudes to solve problems, processing appropriately fast expanding information and to think creatively. For education to assist in this, school science education programmes will have to provide for teaching-learning experiences through a variety of methods which will help develop concepts and skills which are flexible and applicable to a wide variety of situations rather than limited in scope." The requisite competencies and attitudes were subsumed under four major processes, namely:

- Information-processing
- Problem-solving
- Creativity
- Decision-making.

These and a few other alternative formulations were discussed by the group in detail. It was agreed upon that it would be rather artificial to attempt separate classification of skills and competencies. While these could be technically distinguished, none could overlook the wide extent of overlap in each case. The group then proceeded to discuss some of these skills/competencies considered essential for the lower secondary stage.

(i) Information processing and utilisation

The textbook or the teachers guide/manual are no longer sufficient to equip the teacher of science. So much more is available, changing and affecting the learners; which just can no longer be ignored. The developmental sectors are producing materials relevant to the community and hence to the teacher. The mass media is influencing not only the technological front but also the social and cultural fronts. The situation before the teacher is manifold. First, he is supposed to identify and locate sources of information, establish necessary channels to procure these and then proceed to sieve out the relevant and useful components.

The primary sources often do not provide information within the comprehension of the target group. The teacher here becomes the interpreter of the same to the groups of his concern. Most of these would pertain to the fields of medicine, agriculture, industry, energy, nutrition, health and these could expectedly change the quality of life of the children as well as adults. The salient and relevant aspects of these newer technologies will have to be internalised by the teacher as only then can he do justice to his efforts.

In their actual lives, opportunities for school teachers in access to information include first hand evidence in real situations, e.g. school surroundings, problems in the community, information from secondary sources such as newspapers, magazine, radio programmes, T.V. programmes, etc. and information from tertiary sources such as data centres, information centres. It is essential that teachers' skills be developed in effectively selecting appropriate information to be used in their teachings.
(ii) Creativity

All children are endowed with this natural gift. The objective in developing this skill would provide situations which would nurture creativity. These would be the settings that provide full opportunity to develop the inherent creative talents of children. When a young child visits a sea shore for the first time, his imagination, resulting out of his observations, immediately proceeds to establish concrete relationships, find solutions and explanations. Even the list of observations alone would be unending. The teacher could in turn, always keep a list of such creativity-promoting settings.

A bullock cart, horse driven carriage, makes noise. Greasing or oiling are the solutions. What is beyond that? Could everyone afford it? Is it readily available? Identification of such unsolved problems which have multiple solutions and are linked to community needs is one right approach for the teachers. In the curriculum context it could provide themes for discussion of multi-disciplinary nature within the classroom as well. Accepting new challenges, (problems help in this approach) also prepares children to handle 'risky' situations and problems.

It is implicit that in creativity nurturing activities, probing, analytical and open-ended questions could not only lead to solutions but also permit full scope for the children to formulate alternative solutions.

The technological developments, reaching every habitation and community, provide ample scope for identifying creativity-promoting settings. Episodes from history of science, particularly the way scientists work, could infuse new enthusiasm. This could also exploit the idealism and desire to do something "big" which is inherently present among all children.

One major point which deserves serious attention on the part of the teachers is his assessment of pupils' response. As an example, consider a child who comes forward with few alternative solutions patterned similarly while another, after a thoughtful consideration, comes forward with only one solution. The child's solution is away from routine thinking and establishes new connections. Needless to say, the child has provided much pronounced evidence of creativity than the other. The distinction is to be utilised by the teacher to determine his inputs.

(iii) Managerial skills

More often than not an elementary teacher works under constraints and handicaps, such as lack of resources and teaching/learning materials. On his own professional side, opportunities for updating himself with new development, techniques and technologies rarely make an appearance before him in terms of in-service education or orientation programmes. For children, the teacher is a 'Mr/Miss Know All' and mobiliser of all resources apart from being a fountain-head of knowledge and must answer to their curiosities and questions. How could this situation be managed effectively?

The school education systems mostly attempt to play a supervisory role, collect certain data or utilise teachers for performing other roles, as in elections, census, etc. These systems rarely provide professional support, and consequently, the teachers are left to fend for themselves. Only he can help himself. His role as a resource mobiliser comes into play at this stage. He needs to utilise community support, expertise and skills available with others to be utilised for the benefit of the children. A visit to a small industrial establishment could provide much more insight and education than what could be achieved over weeks in classroom situations. To anticipate learning in such situation, to arrange for the same by co-
ordinating with different agencies and individuals require a well-developed skill of persuading people to utilise their inherent tendency to help children and contribute as a societal obligation.

The other aspect would be to organise learning materials, tools, science kits, often from the school education system itself. Subsequent replacements, improvisations would need particular attention. This phenomenon has been observed in several countries when the limited enthusiasm towards activities dies down to 'wear and tear'.

A very major role in the total management of the school is played by teachers. However, the head of the school, his commitment, rapport with other teachers and willingness to apply himself to the tasks ahead plays the most vital role. He must be fully conversant with the needs of science teachers and the demands on or expectation from them.

(iv) Decision-making

The developmental activities and their consequences have brought in sharp focus the need for critical level decision-making from local level to international level. The degradation of environment is one case in point that indicates the damage resulting out of decisions aimed at short-term gains which were fated to result in long-term damages. Use of insecticides, pesticides, chemical fertilisers, location of industries and numerous others require a sharp decision-making preparedness of the young persons. It is a need, not only for the individual's own situations, but may also help in initiating or participating in people's actions and community decisions.

The first skill required towards decision making is that of information processing, judging to ensure accurate and adequate information and recognising the consequences of the alternative possibilities that may exist in a certain situation. The objective assessment of short-term or long-term consequences will not often be easy to assess and may call for collective decision-making. The teacher may be the person to present objectively, the information, possibilities and alternatives before the community. His intervention would carry weight and hence enhance his responsibility further. His communication skills would also be brought into action in these situations. He has to have a basic understanding of group behaviour, particularly in societies which do not find consonance among traditions, beliefs and technological impacts. Social sensitivities make objective decision-making complex. Mature and sensitive handling becomes expedient.

What a teacher does in the classroom situation is the preparation for the above. He may not be handling 'mature' individuals but he is amongst dynamic, creative, free-from-prejudice minds which could definitely be much more objective in individual and collective decision-making. Once prepared to do so, they may give better evidence of objective decision-making in the future.

(v) Science process skills

One of the aims of science teaching and learning is to develop within the learners the scientific capabilities of which science process skills may be the most explicit components.

Science process skills, as prescribed by the AAAS comprise the basic skills and the integrated skills, to be presented by pupils.

The pupils learn to develop their basic skills in:

- Observing
Using space/time relationship

Classifying

Using numbers

Measuring

Communicating

Predicting

Inferring

The integrated skills make use of the basic skills in the development of more sophisticated processes of:

- Formulating hypothesis
- Controlling variables
- Interpreting data
- Defining operationally
- Experimenting

Behaviourally, pupils should be able to perform the following to demonstrate their science process skills:

a. Basic skills

- Observing - "Identify and name/find out properties of an object or situation by using their senses."
- Using space/time relationships - "Construct drawings of common 3-dimensional shapes."
- Classifying - "Identify and name observable properties of objects which could be used to classify the objects."
- Using numbers - "State and apply rules for expressing the mean of a set of numbers, rates as ratios, and the decimal equivalents (or approximations) of ratios."
- Measuring - "Demonstrate the use of simple measuring instruments to measure length, mass, and time."
- Communicating - "Describe the properties of an object in sufficient detail so that another person can identify it."
- Predicting - "State predictions by interpolating between observed events or extrapolating beyond the range of observed events."
- Inferring - "Identify inferences that should be accepted, rejected or modified on the basis of additional observations."

b. Integrated skills

- Formulating hypothesis - "Construct a hypothesis that is a generalisation of observations or of inferences."
- Controlling variables - "Identify and name variables which were not held constant in the description of an investigation, although they varied in the same way in all treatments or were randomised."
**Trends and Issues**

- **Interpreting data** - "Describe certain kinds of data, using the mean, median, and range; construct predictions, inferences, or hypotheses from this information."

- **Defining operationally** - "Construct an operational definition which adequately describes a procedure, concept, object, or property of an object in the context in which it is used."

- **Experimenting** - "Construct a question to be answered, construct a test that will provide data to answer the question, identify variables to be controlled, construct operational definitions, demonstrate the test, and collect and interpret data from a given set of observations. Construct a report of the experiment."

It is essential that science teachers also acquire and be able to demonstrate science-process skills. Moreover, they must have a clear and systematic view of how scientific capabilities may be developed. They must also have a clear cut and systematic view of teaching competence in conducting activities for the development of these skills.

**C. Changes in Science Teacher Preparation Programmes in the Light of New Role Specifications and Towards Developing Necessary Competencies**

**Programme Objectives**

The curriculum changes and renewals in member countries have also resulted in perceptible changes in the objectives, structure and contents of science teacher preparation programmes. A broad overview would indicate that, generally speaking, the following are included in the objectives of teacher preparation programmes:

- develop an understanding of the nature of science and take a holistic view of science.
- acquire sound scientific literacy and appreciation of social and ethical aspects of science and technology.
- analyse the content in terms of concepts, activities and applications.
- plan suitable activities, mobilise appropriate resources, and organise activities.
- design, identify and implement strategies aimed at developing science process skills.
- relate learning experiences and learning activities to the developmental stage and the age of the learner.
- design and organise activities to help children with specific needs, i.e. slow learners, gifted, physically and mentally handicapped.
- encourage learner-centred and activity-based approaches.
- utilise learning experiences from life and immediate environment of the learners.
- develop suitable outlines, procedures and methods of evaluation and provide feedback for remedial action.
- identify real-life situations, solutions of 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 experiences and environment joyful.
- appreciate the use of educational technology and also encourage the children to utilise the same.
- familiarise himself with the curricular changes taking place.
- equip himself to act as interpreter of new ideas and technologies to the community.
- find out the relationships of science and technology with health, agriculture, industry, nutrition and other aspects of living.
- use the scientific knowledge in correcting false beliefs, prejudices and practices.
- develop decision-making and problem-solving skills and utilise these in daily life situations.

Programme Structures

Structures of programmes vary in member countries depending upon several factors. Eleven or twelve years of school education followed by one, or two or four years of pre-service education summarises the different programmes and trends. In some cases this includes internship of varying durations. There are instances when two years of teacher education is followed by another year of supervised teaching in actual school situations.

There is another very significant aspect of teacher preparation programmes which concerns teaching of science in remote and far flung areas and also to children of deprived, depressed and underserved people. These numbers are not small. Teachers who are trained in pre-service programmes are unwilling to serve in these areas. Even if rarely some of them agree, they find themselves alien in the social and cultural climate and as such their stay is cut short by circumstance if not by unwillingness.

Certain bold decisions have been taken to cater to the needs of these groups. Minimum entrance qualification has been reduced to ten years from twelve years. Young children from the concerned areas are given preference at the time of entrance to elementary teacher-training institutions. Certain incentives are also provided to them. To look after the girls education, which deserves top priority in view of their abysmally low literacy rate, certain short term strategies have been evolved. Girls from these communities are encouraged to complete eight/nine years of education and then provided intensive orientation and upgradation by the state to enable them to serve their own communities and provide education to the children. They are encouraged to enhance their qualifications through correspondence enrichment programmes and also by being provided with opportunities to join regular schools.

The importance and need for in-service education for teachers, who joined schools after receiving pre-service teachers training, is now fully realised and infrastructures have been set up to cater to this aspect. The programmes normally focus on teaching methods and approaches, educational technology, child-centred and activity orientation of curriculum transaction strategies, development of vocational skills, improvisation and design of low cost equipment, community interactions and others. Wherever numbers are large, a multiple tier strategy in terms of training of master trainers, resource persons, and finally the teachers is adopted.

Institutional Infrastructure

Countries have developed national level institutions catering to the changing needs of practically all aspects of school education. Those with larger population have corresponding institutions at state level and also at district level. It is increasingly being realised that there is a need to have comprehensive elementary level teacher training institutions for such a viable area or number of teachers, which could be easily accessible to them and meet the demands of pre-service as well as in-service education of these teachers. Such an institution could perform the following illustrative functions:
1. Training and orientation of the following target groups:

- Elementary school teachers (both pre-service and in-service education)
- Head masters, Heads of clusters schools, and Officers of Education Department dealing with elementary education.
- Instructors and supervisors of non-formal, part-time education (induction level and continuing education).
- Members of education committees at various levels in the area, community leaders, youth and other volunteers.
- Resource persons who will conduct suitable programmes for the target groups mentioned above.

2. Academic and resource support to the elementary education system in the district in other ways, e.g. by:

- extension activities and interaction with the field,
- provision of services of a resource and learning centre for teachers and instructors,
- development of locally relevant materials, teaching aids, evaluation tools, etc. and
- serving as an evaluation centre for elementary schools and programmes of non-formal and part-time education.

3. Action research and experimentation to deal with specific problems of the area in achieving the objectives in the areas of elementary education. Assessment studies in community needs, attitudes, environmental changes, and external influences.

Such an institution needs to be provided with well-equipped laboratories and well trained staff. Its unit-wise structure could be on the following suggestive patterns.

- Pre-service Teacher Education Branch – consisting of faculty members in the "Foundations" area as well as in various school subjects (excluding work experience).
- Work Experience Branch, including technological skills training.
- Area Resource Unit for Part-time and Non-formal Education.
- In-service Programmes, Field Interaction and Innovation Coordination Branch.
- Curriculum, Material Development and Evaluation Branch.
- Educational Technology Branch.
- Planning and Management Branch.

To be really functioning and dynamic, basic essential facilities need to be provided for. Some of these could be listed as follows:

- Library and documentation.
- Methods laboratories for Physical and Life Sciences.
- A work-shed and garden/farm for work experience activities.
- Equipment for Education in Visual & Performing Arts.
Teacher Training for Science and Technology Education Reform

- Playgrounds and equipment for Physical Education and Sports.
- Audio-visual aids.
- Computer Room.
- Equipment for education of the handicapped.
- Special materials and equipment relevant for Part-time and Non-formal Education.

These institutions will run regular programmes of pre-service, in-service and the staff would be fully acquainted with the local area-level situations, the community needs and would relate the learning to local resources and needs. The trainees would be familiarised with changes taking place in the quality of life, both positive and negative, and shall be helped to prepare for 'life.'

Specific Strategies for Training of Science Teachers

An institution like the one suggested above would be fully equipped to look after the training needs of all elementary teachers including science teachers. However, it may be worthwhile to discuss in some detail as to how the stage to train the teachers of science ought to be arrived at. The development of curriculum, science kit and tool kit, and training of teachers are to be viewed comprehensively and attempted sequentially. A core co-ordination group could start the process of curriculum renewal through an academic group including curriculum developers, subject teachers, teacher educators and practising teachers. Simultaneously, the other group consisting of technical experts, skilled persons as well, may begin the exercise of identifying technical and manipulative components. The two groups could interact regularly. While the first one would proceed to develop textbooks, teachers guides and supplementary materials, the second would be ready with a science kit and tool kit, along with production details. Both outputs could be tried out in schools simultaneously and the tryout would lead to comprehensive co-ordinated revision on both sides, resulting in their being ready for use in teacher training, likewise the textual materials and also the kits. Training programmes must precede the use of the materials and kits in schools. At the same time, there is always a need to ensure that adequate number of such materials are available in schools by the time the teacher is back from the orientation.

Teacher Transformation

The teacher is the principal means for proper implementation of educational programmes and appropriate transaction of curricula within the classroom and outside the classroom. Expectations from teachers are very many. The changing times have enhanced their roles and responsibilities. It is, as such, imperative that the teacher preparation programmes take due cognisance of the changing scenario and provide such education and training to the trainees that will equip them to meet the new challenges. While pre-service programmes are very important, equally significant are the in-service programmes which can really update the teacher and keep him abreast with the new developments, particularly in the field of science and technology relevant to the community. The teacher has to remain 'aware and awake'. Apart from training programmes, this would also depend upon his own interest, aptitudes, and creative abilities. Rational and scientific thinking will definitely keep him dynamic and make him receiver of new ideas, techniques and technologies.

The structure and content of elementary level teacher education programmes, at pre-service stage and also at in-service stage need to be examined with respect to the components, contents and methods of science education, skill and technical training. There are still programmes at elementary education level which practically provide no training in science and skill components. Unless and until these are provided to all the teachers, they may not be in a position to develop requisite scientific approach, rational outlook, willingness to change and capacity to analyse, interpret and accept change.
TRAINING TEACHERS OF SCIENCE AND TECHNOLOGY

CORE GROUP

ACADEMIC GROUP
Curriculum Development
Textbook, Teachers guides supplementary material
Try out

TECHNICAL GROUP
Technical and Skill components identification
Identification of items of science kit and tool kit
Production; assembly
Try out

REVISION

Final textual material
Final science kit and tool kit

TRAINING STRATEGY
Training programmes

Resource person
Teachers

Key Person
Evaluation

FEEDBACK
In countries where the number of institutions and children are pretty large, mobilisation of community resources is a must. To achieve this, there is greater need for understanding the demands of the community by the school. Equally important is the need to prepare the community to provide for the needs of the school. This is a situation of mutual accountability of the learning systems and the community where the teacher becomes the prime mover on both sides. Towards this, it would be necessary to have well-equipped learning centres, school complexes, institutes of training, fully equipped to train in techniques, technical skills and technologies. These institutions should be willing to open their facilities to the community and accept their problems. These facilities need to be available to all the teachers on a regular basis. Further, it may be worthwhile to encourage individual teachers to take up innovative, experimental and action research projects which need to be assisted in various ways. This would generate self-confidence of teachers and achieve teacher transformation which is the basic aim of all teacher education programmes.

D. Evaluation in Science which Takes Into Account Both Cognitive and Affective Domains Effectively

The understanding of 'assessment' in schools has grown over the years, from the narrow knowledge of 'terminal examinations' to much broader area, evaluation of the pupils 'achievements'. These are then compared to expected achievements pertinent to the stage of the learner. At this stage, rather through this exercise, the teacher foresees and visualises remedial inputs, whenever considered necessary.

The most visible demonstration of assessment could be seen in any active and alert classroom situation. The way teacher responds to queries, questions or answers of a child indicates an 'evaluation' to the child. The child notices whether his intervention was liked, discouraged, used as an idea in developing the lesson, or simply ignored. These provides definite indicators to the learners. These could also be equally, if not more significantly, important to the teacher, who in fact 'sees' the levels of achievement of each individual learner. The situation could be termed as 'child referenced' and provides immediate feedback - both to the teacher and the learner. Situations where standardised tests are administered, the basis is the 'average' expected learning for the particular stage and the outcomes of such a test indicate relative achievements of the learners. This, unfortunately, is the most prevalent practice and is equally responsible for the negative image of evaluation; hence the need for multifarious efforts to improve upon the methods, practices and procedures of assessing the learning outcomes.

The Objectives

It is now universally accepted that the purpose of assessment is essentially to help learning. Once it is so, it ipso facto becomes a part of teaching-learning process, being carried within the school or outside the school. Learning does not take place in the presence of teachers only. However, they are in a much better situation to observe more closely and could provide feedback not only to the learners but also to parents and others interested in keeping themselves abreast of the progressive attainments of the learner. The concept of continuous comprehensive evaluation is a consequence of these considerations.

In practice, there are few success stories of continuous comprehensive evaluation. There are situations where terminal evaluation has been discarded in favour of continuous comprehensive evaluation which has not yet taken off. The learning of the children has obviously suffered in these situations. Without going into technical and theoretical aspects of evaluation, it may be worthwhile to discuss what actually can be 'ascertained' and 'obtained' by the teacher out of the regular teaching and learning situation in and outside the classroom. In an activity based learning situation, the following could help the teacher to know –

(i) how children proceed
(ii) how they progress at different stages
(iii) the way they derive inferences at various stages by interpreting situations
(iv) the initiatives for further activities that come from them
(v) the relevance of the activity to real life situations as perceived by the learner
(vi) concrete suggestions for changes and for applications.

This could only be a suggestive list. In fact, it is the teacher himself who is to determine the points of 'observations' and 'participation'. He 'knows' what to look for, how to get the requisite details, match it to the stage of progress of the child and finally to utilise it to help the child.

The Teacher Prepares

The teaching and learning of science in the present context has brought upon the teachers of science added roles and responsibilities. He has to be more equipped and better prepared before a learning interaction/activity takes place. The teachers need to ensure the following, as prior self-preparation:

- He is fully aware of the possible learning outcomes.
- Ensures availability of sufficient materials, equipment that are in a fit condition to be handled by learners.
- Know the points of intervention for himself particularly in group learning situations.
- Willing to learn from the children's ideas and ready to listen to them with patience.
- Talks only that much which is sufficient.
- Has equipped himself fully well in the area under study not confining only to textbooks or teachers guides but having consulted other resource material which may even have to be arranged.
- Has prepared his talking points in a language within the comprehension of the children.

The Child Proceeds

Before any particular activity is undertaken by the child and the teacher together, they normally interact at the initiative of the teacher. After this and before the actual activity begins the following may be relevant for the teacher to ensure that the child:

- is clear about what he is proceeding with
- has understood the teacher well
- knows the points which need further clarification
- knows why is he performing the activity.

While the activity is on, the teacher may like to observe the following:

(i) 'Peer' group interaction - its extent and quality of participation by each and individual learner

When children are in groups, those attempting to remain 'withdrawn' are to be encouraged for enhanced participation. This could be done by assigning specific tasks within the total activity to a particular individual - 'Rajan - why don't you record the temperature variation - you are such a keen observer'.

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(ii) Handling of equipment

There certainly would be children who would avoid handling equipment, particularly if it is delicate or breakable. The teacher is supposed to provide assurance and impress the need for every one to separately handle the equipment. It generates interest in the equipment.

(iii) Observation during experimentation

This requires alertness and skill of recording with precision. There are situations where help may be needed from others. The teachers' role is to encourage learner to be precise, cautious, accurate and follow a systematic approach in recording observations.

(iv) Measurements, if any

The way measurements are made indicate learning and development of proper attitudes and honesty of purpose. At this stage, children often come forward with the possible inaccuracies and deficiencies in their measurement. This is to be treated as normal expectation.

(v) Inferences, hypothesis

This, too, is a skill development exercise and prepares children to play a very significant role in adult life. Obviously, it could also play a major contributory part in case they go for higher levels of learning science.

(vi) Interpretations

Observations and results have a meaning if these lead to the development of analysis of situations and interpreting all that is evident through observations and data, and what could be derived out of it. In fact, so much is to be interpreted in future life!

(vii) Correlations, connections

Learning through activity-based science gains added importance if the learner could relate it to real life experiences and situations. The emphasis is now shifting towards developing curriculum from the experiences of the child. It is definitely going to be the in thing in years to come.

(viii) Applications

Every activity must lead to appreciation of its possible applications. The concepts learnt must be seen to be applicable in different situations. It would be preferable if these are easily identifiable.

(ix) Utility

This has to be viewed from the angle of science, technologies and societal acceptance of changes. It is not necessary that every activity should lead to utility. Some may indicate negative aspects as well. Use of pesticides, insecticides could be converted into several learning activities few, of which, may indicate negative effects.

Each one of the above indicates either the learners approach, attitude, interest, skill, competence or capacity. The extent of peer group interaction could communicate total dependence on others or capacity to work with others, share ideas and learn from others. Only the teacher's keen observation and involvement could make a distinction.
Classroom Situation

Imagine the change in the classroom interactions and consequent pleasure both to the teachers and their pupils when at the end of the lesson, they carry out different processes of thought on the same concept. Consider the following sample terms:

1. Analysing
2. Applying
3. Assembling
4. Checking
5. Collecting
6. Classifying
7. Discovering
8. Defining
9. Dismantling
10. Degeneralizing
11. Hypothesizing
12. Limiting
13. Locating
14. Mathematizing
15. Outlining
16. Quantifying
17. Reformulating
18. Selecting
19. Summarizing
20. Telling
21. Transferring
22. Validating
23. Verifying
24. Writing

Utilising Assessment Results

The way a teacher reacts to his own assessment of different aspects of the learning behaviour of the pupil is crucial. Let us take a few examples.

- The child has not proceeded in his/her activity as per the perceptions of the teacher. Now it is the turn of the teacher to understand the 'perception' of the learner and then analyse the way the child proceeded further. Here the teacher may like to analyse his own role while assigning the activity to the child and sieve out as to what were the weaknesses in the interaction. Language could be one.

- Understand the way children learn and develop their ideas. No idea need to be brushed aside without asking for, and understanding the way they arrived at it. Was there an alternative way possible?

- All achievements are to be discussed with learners in positive ways. However, in doing so, the teacher may also like to reinforce certain technique, approach or ability that would help the child next time.

- In group discussions, those who appear withdrawn need to be encouraged, if necessary, by providing sufficient provocation.

- Provide children a chance to test their own ideas. Let them be prepared to challenge assumptions and ideas whenever they differ with others.
Teacher Training for Science and Technology Education Reform

- Encourage him to go further. Whenever the child feels that a job is completed, he needs encouragement and also further motivation to find out alternative uses, utility and application of the job considered complete.

Comprehensive evaluation could become a practical idea only through the total involvement of the teacher and learner in the school situation. Prior to it, the complete and thorough understanding of evaluation needs by curriculum developers would be a prerequisite. Evaluation conducted in the right spirit could certainly help the learner in nurturing his talents, creativity and enterprise.

Teacher Evaluation

This has all along, been a neglected aspect. While one could readily identify efforts in examination reforms and evaluation procedures for children in practically all countries, one rarely comes across anything other than the terminal examinations at the end of pre-service teacher training courses; when it comes to evaluation of teachers. It is no doubt a sensitive issue but it no longer could be ignored. The need for professional updating of science teachers has been realised and as a consequence, different strategies for the same have been evolved. These include face-to-face interaction, correspondence education or a combination of both. However, there rarely is a built-in mechanism. In isolated cases wherever it has been attempted, teachers have either avoided participation or ignored returning the ‘response sheets’.

There is a need to study and analyse in-depth the evaluation needs of teacher education programmes. At pre-service, this analysis should concentrate in bringing about necessary changes, particularly in the affective domain. In case of in-service programmes, the need is to develop a pattern or a system which would be acceptable to participating teachers and would also bring forth the gaps that still need to be looked after by programme planners. This deserves serious consideration.

An Illustrative Case Study

In order to have a practical idea of roles performed by individual teachers, it was considered relevant to scrutinise a specific study presented before the group. The intention was to identify, on the basis of this scrutiny, the roles, skills and attitudes which could be attributed to the teacher concerned. The study is given below.

Teacher-Community Relationship

The teacher-community relationship has a long and healthy tradition. It is possible to locate teachers and communities with mutual concern and consideration in abundance. The teacher is also a guide, helper, interpreter of new technologies, apart from being a ‘teacher’. In times of need, the community looks toward the teacher. There are teachers who themselves identify the community needs and proceed to find solutions. Obviously, there are limitations of various types but these never deter enterprising individuals. Identification and dissemination of such stories may be undertaken by teacher preparation institutions. One such case is that of Shri Chandra Shekhar Lohumi, an elderly primary teacher from the northern hills of India. He had no formal training in science but developed a scientific outlook and concern for the community.

*Lantana camara* has been rated as one of the world’s ten worst weeds. It is an attractive member of Family Verbenaceae and is a native of South and Central America. It was introduced by the English to Indian gardens around 1809 as an ornamental plant. The English have left—but the gift they brought has resisted all efforts and forces of eviction. An aggressive invader, this problem weed is found almost in all the States of India but is more common in certain parts of Rajasthan, Punjab, Uttar Pradesh, Himachal Pradesh, Assam, Bihar, Kashmir and Delhi. It spreads to wider areas where cattle grazing is a major concern. It resists cutting, stumping,
burning and even spraying. The seeds are disseminated by birds and animals. It blooms throughout the year.

Lantana competes with the crops for space, food and water, overruns forest plantations and it also harbours injurious insects, including the malarial mosquito. The leaves and berries are toxic to animals and humans as it causes photosensitization due to hepatocellular damage.

Shri Chandra Shekhar Lohumi, a school teacher since 1932, when posted in the village Naukuchiyatal, was deeply touched by the plight of the village people, their cattle, their crops because of the overgrowing Lantana, locally called Kuri. He remembered having heard somewhere about a similar situation in Australia and recollected that they had introduced an insect to control cacti plantations. Ever since this thought occurred to him, he was on the lookout for such an insect which could be feeding on Lantana. He began his search by observing the bushes around his own house. He also discussed the problem with the local farmers. After a fruitless search of several days, he was once told by a fellow villager about a withering bush of Lantana which was a rare phenomenon. Although he was unable to discover any insect on that bush, he was very optimistic that he was close to his discovery. And finally he discovered some insects on Lantana leaves on 26th of December 1967. What followed was a systematic collection, observation of plants and the bugs, seasonally and regularly. He spread populations of bugs on Lantana and useful crop plants and studied the effects. He also observed that the population of the bug is affected by the extreme seasonal changes which were favourable for its growth. The adult insect is formed within 12 days from the egg. Its age is from 21 to 25 days. His study and record of the life cycle of the bug was found highly scientific, logical and rational by research scientists.

Shri Lohumi contacted the nearest Agricultural University in Nainital to ensure that the scientists there also were appraised of the problem and his solution. He was very particular to ascertain that there is no adverse effect of the spread of the bug on other useful crops. Only then Shri Lohumi started raising the insect population and distributed these to the local farmers, as well as the neighbouring villages and again made systematic observations. The discovery made by Shri Lohumi was researched by several scientists and his findings confirmed that this insect is an effective control for Lantana. He was given a special prize by the Indian Council of Agricultural Research in the year 1980.

Discussions

This is a typical case where a concerned teacher, proceeding systematically and rationally, arrives at a solution which helps the community. The teacher ensures that the solution arrived at is examined in its aspect, particularly concerning any other harmful effects. The following roles of the science teacher were identified, in addition to his normal classroom teaching.

(i) Innovator  
(ii) Helper  
(iii) Interpreter  
(iv) Problem identifier  
(v) Coordinator  
(vi) Researcher  
(vii) Observer  
(viii) Problem Solver
Skills were identified as

(i) Sensitivity (to situation)
(ii) Information processing
(iii) Communication with community
(iv) Commitment to change
(v) Decision making
(vi) Creativity

Essentially, it is the positive attitude to life that leads such an individual to perform his social and community obligations, dutifully at each stage of life.
CHAPTER THREE

PREPARATION OF MATERIALS
FOR THE TRAINING OF SCIENCE TEACHERS

Introduction

The influence of science and technology has been so pervasive that most aspects of life, even the realm of the abstract, and almost all sectors of society have in some ways been changed. A large part of the global population sees this influence and change as mostly beneficial, leading to a better quality of life. But society has to keep in step with Science and Technology while putting controls on it to prevent/minimise its abuse and misuse if it is to derive benefits from it. Reforms in science education are means to do so.

Science education reform should be evident in the class and classroom. We expect a classroom that is undergoing science education reform to have a display of updated illustrations, charts, maps and equipment. We should see tools, improvised equipment, and materials being used by children. We also expect much interactive learning taking place not only between teacher and students but also among students in an atmosphere of sharing. We should find the teacher eliciting and accepting questions, suggestions, and comments from students. The students' behaviour should be determined by self-discipline rather than teacher-control. Students should be eager to discover and learn by themselves, seeking confirmation of their school learning in the real world and bringing these experiences to the school. The lessons should include community problems thus extending the classroom into the community and availing of its resources.

Science education reform should make it possible for the students and community to benefit from each other at the instance of the teacher.

Teacher Training Materials

Pre-service Teacher Training Materials

Materials for use in pre-service training usually come in the form of textbooks, modules, and/or loose-leaf hand-outs. Textbooks and modules are often prescribed for specific courses by the instructors of the course. In general, they are authored by specialists and written for a discipline or a specialized branch of a discipline and NOT for a specific course. For example, "Teaching Science and Technology in the Secondary School" could be a published textbook that has been approved for use in a pre-service course entitled "Methods of Teaching Science in the Secondary School" in Teacher Training Institution A, but is titled "Strategies of Science Teaching, Secondary School" in Teacher Training Institution B. The author could be the instructor himself, or someone else, possibly not known to the instructor of the course. Loose-leaf handouts are usually culled from several sources or written by the instructor to supplement the content of the textbook or the module. They are usually given out a few pages at a time, throughout the term as needed for dicussion or task performance.

In-service Teacher Training Materials

In-service training materials are written for or reprinted as readings for specific training courses. They are intended to provide for specific identified needs of trainees. For instance, if in a needs assessment conducted by the in-service coordinators and lectures, the majority of teachers in a locality were found deficient on knowledge of local applications of science principles and ideas, then a training manual may be prefaced. The manual may include, among others, background information for teachers on local applications of science and technology.
In-service training manuals for science teachers are generally characterized by a curious mix of some or all of the following different kinds of content:

1. educational foundation topic which in the view of the trainers and coordinators would answer some expressed need of the trainees;
   
   Example: An educational psychology topic such as cognitive development of adolescents.

2. science/technology/mathematics topics for which the trainees have expressed a need for upgrading;

3. topics on strategies of teaching science which may be conducted along the micro-teaching demonstration-cum-post demonstration discussion;

4. exemplar lessons for teaching the students of trainees;

5. instructions on the production of trainee output which may take the form of:
   
   a) an action plan to conduct a project, echo a seminar, or a school-base training for other science teachers.
   
   b) a part of a curriculum material that may be used in the school of the trainee.
   
   c) an improvised equipment or teaching device.

6) instructions on the performance of a required task such as peer teaching, or full length lesson demonstration in a real class, or planning and carrying-out a scientific investigation to develop science process skills.

**Preparation of the Exemplar Lesson**

The exemplar lesson has become a major feature of many teacher training manuals. It functions as a guide to lesson preparation for classroom teaching and exemplifies in print the strategies and subject matter reflecting science education reform. A thorough presentation on the preparation of exemplar lessons is in the succeeding parts of this chapter.

**Lesson Preparation** - The foregoing is an exercise on lesson preparation

A major task of the science teacher is lesson preparation. A successful performance of this task demands the use of skills which the teacher is expected to learn.

In writing a lesson in science a teacher may go through the following steps:

- selecting a topic drawn from a real life situation
- stating objectives of the lesson
- selecting strategies and resources to use in teaching the lesson
- writing out a plan for a science lesson
- illustrating the selection of a topic drawn from a real life situation

1. Given a prescribed science curriculum objective "To identify environmental problems in the community", choose a topic drawn from a real-life situation that you can use to plan a science lesson that would enable students to attain the prescribed objective.

   Example: Utilisation of pesticides and fertilisers in farms and households.
2. Find out how suitable your selected topic is by answering the following questions.
   - Does your topic deal with a serious problem of the community?
   - Will the topic develop science learnings that are beneficial both to the students and the community?
   - If you answered YES to both questions, then you have chosen wisely. If one or both of your answers is NO, then look for another topic.

   A follow-up discussion should bring out the following points:
   - the seriousness with which the problem is regarded by the community.
   - using the topic as a means of teaching science concepts.
   - using the topic as a way of teaching environmental consciousness and social responsibility.
   - using the topic to teach several science ideas.
   - the applicability of the topic to both farming and urban communities.
   - the interest of the students on the topic.

3. Look up the list of teacher competencies/skills specified in Chapter Two. Which of them must you possess to successfully pursue a science lesson?

4. Look up the list of teacher roles (see Chapter Two). Which role do you perform in selecting this topic for teaching. Explain your answer.

   A discussion should bring out the following ideas:
   - teachers perform various roles as they do various tasks for and in teaching
   - the roles of the teacher have increased in number and complexity as science and technology education continues to develop
   - teacher skills are varied; they make various roles possible
   - awareness of the roles and skills improves performance.

**Stating Objectives of the lesson**

All lessons are likely to become effective if both teachers and students are aware of the objectives. The objectives of each lesson must be explicitly stated in terms of learning outcomes which would facilitate evaluation of the effectiveness of the lesson. The lesson objectives could be cognitive, affective, and/or psychomotor.

**Discussion**

- Cognitive objectives - those that aim for the development or refinement of knowledge; those that aim for the development or refinement of how to acquire knowledge.
  Example: To identify the various types of pesticides used by a community.

- Affective objectives - those that concern feelings, interests, appreciations, attitudes and values.
  Example: To develop a feeling of concern for the undesirable effects of pesticides.
Psychomotor objectives - those intended to develop and refine action, motion and behaviours.

Example: To collect different kinds of pests in a square meter of cropland.

The suggested steps in integrating the three objectives are as follows:

1. Write lesson objectives for the topic chosen.
2. Identify which objective or part of an objective is cognitive; which one is affective; which one is psychomotor.

Based on the given topic in Task #1, the following are examples of objectives:

- To state the problem brought about by the use of pesticides and fertilisers.
- To find out by a survey of a community (by asking parents, neighbours and farmers) what different kinds of pesticides and fertilisers are used, how they are used, and what are their effects.
- To set up an experiment to identify the most potent pesticide and fertiliser used by a community.
- To decide using role playing in a class if the sale and use of certain pesticides and fertilisers should be controlled or totally banned in a community.

Discussion - Bring out the following points:

- Lesson objectives give direction to the lesson; strategies, resources, and evaluation are based on it.
- Lesson objectives can be stated in terms of science process skills (e.g. observe, predict, hypothesise, infer, etc.)
- Lesson objectives can be stated in terms of knowledge to be learned (e.g. to gain understanding of ..., to clarify, to differentiate ...)
- Lesson objectives can be stated so as to include the teaching strategies (e.g. to design an experiment..., to conduct a survey...)

3. Identify the skills needed to write the lesson objectives of your topic. (See Chapter 3 for list of competencies and skills.)

Consider the needs of students in relation to the topic, the objectives, and the strategies.

Students as growing adolescents in a community have certain needs. These needs must be considered and provided for, if they are to benefit maximally from the lesson.

1. How did you make your strategies more suitable to your students' age level?
2. How did you provide for the development of verbal skills in your students?
3. How did you provide for the development of higher level thinking skills in your students?
4. How did you provide for attitude and value development of your students?
5. What skills do you need to do all of the above?
6. What role do you perform in taking into consideration numbers 1-4.
Selecting strategies and resources for the lesson

1. Based on your chosen topic, decide what strategies and resources you will use in teaching the lesson.

   Discussion

   - the strategies must fit the objectives and resources and vice versa.
   - whenever possible, focus on strategies that develop science process skills, values, and attitudes.

2. Are the strategies you have chosen for your lesson suitable? How can you tell?

3. Are the resources to be used with the strategies appropriate?

   Discussion

   - focus on resources available within a community.
   - resources should include teaching aids, equipment, instruments and references.
   - require students to improvise tools and equipment.

4. What skills are needed to choose the appropriate strategies and resources for your lesson?

5. What role is performed while selecting a particular strategy and a resource?

Writing out a lesson plan

1. Assemble the topic you have chosen, the objectives written, the strategy and resources identified and write out a lesson plan from them. Arrange them as follows with all their details:

   Topic:
   Objectives:
   Concepts/subconcepts:
   Procedure/Strategy:
   Methodology:
   Resources:

Lesson Presentation

Objective – to present a prepared lesson to students by:

1. motivating them to perform activities and tasks relevant to learning,
2. supervising their activities,
3. conducting interactive sessions with them,
4. evaluating the learning that occurred.

Motivating students to the lesson

The teacher should be prepared to engage his students' interest right at the very start and maintain this interest. This part of the lesson is the motivation scheme.
To give examples of motivation schemes using the topic "pesticides and fertilisers":

- Present to the class newspaper clippings reporting illnesses and death caused by household or farm pesticides; degradation attributed to excessive use of fertilisers.
- Show film/slide/transparencies/video of illnesses attributed to pesticides, and of the effects of fertilisers on soil and water.
- Discuss to explore student knowledge on the subject matter.
- Present to class containers of pesticides and fertilisers and invite students to look at skills and crossbones sign, the stated chemical components, and the instructions on how to use them.

1. Based on the prepared lesson, describe briefly the motivation to be used in teaching the chosen topic.
2. Suggest two other alternative motivation schemes for your lesson.

Discussion

Although motivation is always suggested at the start of a lesson, continuous motivation should be provided through activities, use of equipment and teaching aids, and stimulating verbal interaction in class. Consider:

3. the competencies and skills to use to motivate the students;
4. the role to be performed when motivating students toward the subject of the lesson.

Supervising Student Activities

The teacher is most needed in class during the performance of student activities. The teacher sees to it that:

- the procedure is given in simple, easy to understand language
- the activities provide opportunities for learning
- the activities proceed with little or no waste of time
- the safety and well-being of the students are provided for
- materials and equipments are correctly used to prevent breakage and wastage.

The following activities are suggested:

1. Briefly describe the activities students will perform during the lesson.
2. State reasons for choosing the activities.
3. Identify the competencies and skills needed to supervise student performance of the activities.
4. The roles performed by the teacher when supervising the student activities.

Conducting Interactive Sessions with Students

Interactive sessions with students are largely verbal. Lectures in which only the teacher talks in class is NOT an interactive session. An interactive session in a science class is characterised by the following:

- Both teacher and students talk, exchange ideas, refine, modify, reinforce, restate each others' ideas.
Science ideas are interacted on.
- The teacher tactfully and affectionately encourages the shy and reticent students to
  share their ideas.
- The teacher's manner of asking and responding to questions influences the students'
  manner of asking and responding to questions.
- No single person monopolises the session.
- A summary of the main points discussed can reinforce students' learning.
- A resource person (external to the class) may be invited to share his/her expertise on
  the subject but much time should be allotted for interaction (questions and answers)
  with the students.

In our example of a lesson on pesticides and fertilisers the following science ideas may be
discussed during the interactive sessions:
- the problems regarding the use of pesticides and fertilisers
- their effects on health
- their effects on the environment
- the lack of knowledge of users about the chemicals
- components of the substances they use
- the inability of users to follow instructions on how to use
- the carelessness of users in applying and storing
- certain pesticides and fertilisers are intended for specific pests and specific soil
  condition, i.e. NOT all pesticides kill all kinds of pests, and NOT all fertilisers are
  good for all kinds of soil
- different kinds of pesticides should be applied at different concentrations for
  different purposes, therefore the instructions on the package must be read and
  carefully understood
- individuals have different reactions to the same kind of pesticide or fertiliser
- application of a particular type of pesticide kills not only the pest for which it is
  intended but also some other organisms
- there is a right time for a profitable application of fertilisers

Some procedural matters on the strategies used in the lesson may also be interacted on, such
as:
- in the survey, the same set of questions should be asked by the students in the class
  (of their neighbours and friends, or other members of the community)
- some words of caution on the tactful manner of asking questions in a survey should
  be formulated, so as not to offend the respondent
- the need to consolidate the data obtained in the survey by the class
- how the analysis and interpretation of the consolidated data shall be conducted
- deriving the conclusion and its implication
- in the class hearing, where role play is the strategy to be used, how assignment of
  roles are made
- how long is the preparation time for those taking major roles in the hearing (role play)
- where and how sources of information may be obtained

The questions that the teacher may reflect on are as follows:

1. Using the lesson topic, what science ideas are expected to be brought out in the interactive session?
2. What procedural matters concerning the strategy used would need further discussion?
3. What kind of learning outcomes are to be expected from the interactive session?
4. What skills are to be developed in conducting the interactive sessions on the chosen topic?
5. What roles are performed by the teacher in carrying out the interactive sessions on the chosen topic?

**Resources:** This refers to all the materials to be used in teaching the lesson. It includes charts, maps, globes, instruments, equipment, chemicals and other consumable materials, films, videos, tapes, transparencies, and reference materials.

In selecting resources, consider the following:

1. the age level of the students for which the resources will be used,
2. the sufficiency of the resources to motivate and maintain the interests of the students,
3. whether the use of the resources will help in developing the science ideas and objectives aimed for,
4. whether resources will be easy enough to use under the classroom conditions available in the school,
5. whether it be possible to allow students to handle and operate/manipulate/use these resources,
6. whether students will be safe in using these resources?

Essential aspects of lesson preparation and presentation have been attempted in this specific case. While such preparation is an essential pre-requisite; equally important is the understanding that a truly creative lesson takes its final shape only during the classroom transaction. The teacher trainer has to have the preparedness to absorb new ideas, assimilate these in his plan and conduct the classroom transaction comprehensively.
Preparation of Materials for the Training of Science Teachers

Teacher Training Exemplar on

Development of Scientific Attitudes, Values and Ethics

Introduction

Traditional approaches of teaching science can no longer meet the learning needs of the children. These needs impinge upon every aspect of human life and behaviour as the impact of science and technology is gradually permeating social, cultural and ethical contexts as well. The last one, though very sensitive, is equally crucial and deserves delicate handling. The learners need to develop rational thinking, scientific methods of analysis and arriving at results. Further, they need to learn to apply these in their real life situations with full awareness of short and long term consequences. The teacher training could help in this by suitably developing these attributes among learners.

In order for teachers to comfortably bring in the attitudinal, value and ethical aspects of science and technology to their science teaching, the teachers need to possess skills and competencies which can be developed through certain activities.

To assist the teacher trainees develop such skills and competencies, a series of activities are suggested as follow:

1. experiential session
2. reflective thinking session
3. planning and development of strategies/activities for children.

Topic

Effects of pesticides in farms and households

Training Objectives

After the training, the teacher trainee should be able to:

1. express/show awareness of ethical and social dimensions, particularly of the problems resulting from the effects of utilisation of pesticides in farms and households;
2. develop a feeling of concern for victims and would-be victims of the careless use of pesticides and social responsibility to disseminate correct information about pesticides;
3. present, after discussion and reflection, a view of the interplay of competencies and skills needed to develop the scientific attitudes, values and ethics in children;
4. relate teacher competencies and skills to strategies and activities development to be used with the children;
5. acquire skills in developing feelings of concern and social responsibility in children;
6. evaluate one's own knowledge and affective behaviour.
Teacher Training for Science and Technology Education Reform

Activities

1. Experiential Session

1.1 Presenting incidents/problems related to the effects of pesticides

To motivate teacher trainees to become interested in the subject matter, several strategies may be employed:

a) Present and read to class newspaper reports on illness and deaths caused by pesticides.

b) Asking students to explore their experiences or what they hear from friends and neighbours about it.

c) Present to class, containers of pesticides and invite students to look at the skull and crossbones signs and read the words of caution on the labels. Discuss the implications of these.

d) Show films, slides, video on information about pesticides.

Examples of reports that can be presented:

1. There was a report of the death of a 29-year old man who worked as a pesticide sprayer in a banana plantation. He was doing this job for the last three years. Earlier, when he first began to work in the plantation, he was not provided with complete protective suit. Later on, however, the company, under pressure from outside, did provide him and other workers with protective suits.

   It was reported that his death was the result of his being exposed to the pesticides for a continuous period of time. The pesticides affected his brain, and later he became paralyzed. It also caused organ-system malfunctions.

2. A farmer was brought to a hospital in Manila after having been taken to a provincial hospital because of vomiting and giddiness. The doctors tried their best to save him. Unfortunately, he died. It was reported that the man was mixing pesticides in a large amount by dipping his uncovered hands and arms in it. Only the following day did he start to develop certain symptoms which got worse as time passed. He, then, was taken to the hospital.

1.2 Discussion

Discussion among teacher trainees are conducted under the guidance of a teacher-educator who needs to prepare certain questions in advance to start a discussion. At some points during a discussion, trainees should be given some time to search or seek for information to be used for discussion. At any rate, a discussion is meant to stimulate thinking on scientific attitudes, values, and ethics which will hopefully lead to the development of such attitudes values and ethics.

Questions to ask concerning the reported incidents:

- Pesticides have been in use for years. What do you think went wrong in these incidents?

- What agencies are responsible for regulating/controlling the use of pesticides?

- If you were a member of the family of the victim, what would you have done as soon as you heard of the incident?

- What can be done to prevent similar incidences in the future?
1.3  **Extending the learning**

Conduct a debate or discussion on the subject of utilisation of pesticides with emphases on the following questions. This again is meant to enhance the development of scientific attitudes, values and ethics.

**Utilisation of pesticides in farming**

- What are we really trying to do when we use pesticides?
- What are some advantages of the utilisation of pesticides?
- Are there risks in doing so? If yes, what are these risks?
- How do you perceive a balance between providing sufficient food for human beings and protecting their environment?
- Can we keep the balance between desired and undesired products in this case? If so, how?
- Can we justify the use of pesticides to increase food production in order to alleviate the problem of starvation?
- What problems of storage and possible accidents, that may occur because of it, can you foresee?
- When making decisions about safety of pesticide utilisation, is it permissible (or inevitable) to allow some risks? Why?
- Are there any alternatives to pesticide utilisation which are beneficial to human beings as well as the environment?

**Utilisation of pesticides in household**

- What are we really trying to do when we use pesticides in the home?
- What are some advantages of household utilisation of pesticides?
- Are there risks in doing so? What are these risks?
- Are there any alternatives to the household utilisation of pesticides? If so, what are these alternatives?

1.4  **Evaluation of trainees by teacher-educators**

- Attitudinal test items concerning this particular issue can be prepared and administered to the trainees before and after the session.
- Essay tests can be given to the trainees after the experiential session. For example, trainees can be asked to respond to certain statements such as:
  
  "Household utilization of pesticides should be banned." Explain why.
  
  "Research and production of more potent pesticides should be encouraged since pests develop resistance to pesticides." Provide explanation to your pro or con answers.

2.  **Reflective Thinking Session**

Upon completion of the experiential session, reflective thinking session is required as a follow-up activity. It is assumed that the teacher trainees now have acquired competencies and skills required for development of scientific attitudes, values and ethics. They have also learned how a discussion is guided. There are times when discussions may lead to no conclusions. And
there are times when discussions may just help them think divergently, analytically and synthetically.

Here at this point, the trainees are asked to do some reflective thinking through individual thinking or small group discussions on the following points:

- From the beginning until the end of experiential session, what competencies and skills are required?
- To what extent does the experiential session help you develop scientific attitudes, values and ethics?
- If you were to acquire a higher level of scientific attitudes, values and ethics, what other strategies can and should be implemented?

Note:

Competencies and skills most needed during the experiential session may be as follows:

a) Science-process skills
   - communicating, interpreting data and making conclusion.

b) Information-processing skills
   - identifying, locating and utilising information
   - classifying, analysing and utilising relevant information
   - searching for ways to understand scientific information from primary sources
   - always update oneself on scientific and technological information, as well as information in other areas.

c) Decision-making skills
   - selecting reliable information and classifying values, ethics
   - identifying alternatives
   - predicting the consequences of each alternative
   - weighing the pros and cons of each alternative
   - ordering the alternative
   - taking actions consistent with the stated values
   - accepting possible consequences of the actions taken.

At this point, the teacher educator may need to provide explanations and examples concerning such competencies and skills. Moreover, the trainees may need to be given more exercises to practice such competencies and skills

3. Development of Strategies/Activities for Children

The teacher trainees should discuss among themselves (with guidance of teacher educator) about strategies/activities to be used in real classrooms in order to bring about the development of scientific attitudes, values, and ethics.

Certain points need to be taken into consideration during this session. They are as follows:

- establishment or enhancement of the relationship between children, schools and community.
- level of children (maturity level, as well as, intelligence level).
- linkage with real-life activities.
- integration of science process skills.
- access to sources of reliable information.

Possible outcomes (for grade 8/9 students)

The teacher and the children discuss possible activities they can undertake in order to learn more about the subject. Eventually they decide on one or two. They then proceed to plan in detail how to carry it out.

Suggested activities are:

a) Use of newspaper clippings about pesticide cases.
b) Research (collection of pamphlets, books, articles from magazines and from journals).
c) Record observations in the community - use logbooks, scrapbooks, etc.
d) Field trips/visits by the whole class
e) Student reports
f) Film shows
g) Survey of community members or people's knowledge, practices and observations - whether they use pesticides, what kind of pesticides, frequency of use, noticeable effects on humans, do people read labels and instructions.
h) Role playing of a public hearing situation - the features and functions of each role should be made clear so as to avoid the wastage of time and to facilitate interaction among role players.
i) Community service - the service must be beneficial to the majority of students and is approved by members of the community.

4. Evaluation of Classroom Students

This can be done in various ways.

4.1 Through observations - what to observe (event); whom to observe (individuals, small group); when to observe (short period of time); how to observe (checklist, notes).

Example of assessment sheet

Could either be a remark sheet or a checklist.

<table>
<thead>
<tr>
<th>Name of students</th>
<th>Remarks or Checklist on scientific attitudes, values, ethics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rational</td>
</tr>
<tr>
<td>------------------</td>
<td>----------</td>
</tr>
</tbody>
</table>

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Observation can be done regularly throughout a semester. What to look for?

**Rational**
- always provide reasons or evidence to support the ideas.
- judgment is usually based on information

**Open-minded**
- accept other people's ideas that are different from oneself's
- willing to change one's idea if more information are provided
- willing to listen to others

**Honest**
- sincerity of observation, accuracy, commitment all combine together to indicate the honesty of effort or activity.

**Social responsibility**
- think collectively (always take into consideration the factors concerning community or group)
- take action (if need be) for the benefit of community/society/group
- concern for others

**Belief and apply process of science**
- recognise the value and importance of the process of science (scientific method)
- apply process of science in daily living (tackle problems systematically)

In addition, observations can be done as the activities proceed. Children's behaviour can be observed through the following questions:

- Does the child show interest in the activity?
- Does the child co-operate and participate actively?
- Does the child initiate/lead in planning and carry through activities?
- Is the child developing manipulative skills as the activity proceeds?

**4.2 Through paper-pencil tests**
- Attitudinal test items can be administered before and after the course to partly measure the development of scientific attitudes, values and ethics.
- Essay type of test can be administered after the course. For example, some statements such as those given in 1.4 or stories can be given in a test and students are asked to express their ideas as a response to given statements.

**4.3 Evaluation by parents and community**
- Parents and community can be asked to evaluate students' performance regarding their involvement in family and community activities.
Preparation of Materials for the Training of Science Teachers

Teacher Training Exemplar on Teacher as a Facilitator and a Motivator of Learning and a Community Collaborator

Introduction

The exemplar teaching-learning materials are intended for teacher trainees. These trainees will be prepared not only to play the roles of facilitator and motivator of learning, and community collaborator as well as conscientious members of society and who will serve as teachers in different environmental situations (rural, urban, agricultural, industrial, etc).

It is assumed here that the teacher trainees have studied science at least up to the elementary stage. This exemplar thus, provides for the development of a teacher with the necessary knowledge, skills and attitudes. It is envisaged that the roles, as mentioned earlier, are performed, and relevant skills and competencies are developed, through science activities, discussions, demonstrations, lectures, field work, project work and assignments.

The skills relevant to a subject are acquired through practice work, observations, etc. The subject matter must be based on real life situation and, wherever possible, it should give the idea that education in science is a quality for living and not merely for acquiring knowledge.

Objectives

The following are the objectives of this training material:

1. To develop an ability in teacher trainees to become innovators/facilitators/motivators of learning and community collaborators, as well as a conscientious member of society.

2. To develop competencies/skills and positive attitudes in teacher trainees, which would finally lead to the development of scientific skills and positive attitudes of pupils in order to prepare them to be citizens with scientific temper.

3. To use different modes/strategies for evaluating pupil performance.

To attain the above stated objectives the following exemplar lessons are presented for teacher trainees who will teach science at the elementary level; to demonstrate to them the roles of the science teachers and the competencies and skills (especially science process skills) through the science activity, relate science to real life situations (problems which a trainee may deal with when he goes to the classroom) and illustrate alternative strategies in lesson presentation. It also includes suggested strategies on assessment of student performance.

Exemplar: Teacher as a facilitator, and a motivator of learning

Competencies and skills to be achieved

Observation

Improvisation

Science Process Skills: observation, experimentation, inferring, hypothesising, confirming the data, generalising

Creating a joyful class learning environment

Science Activity

Corrosion and its prevention

Grade Level: Class VIII
Teacher Training for Science and Technology Education Reform

Concepts to be developed

- Corrosion is wasting away of metals layer by layer by electrochemical action
- Metals corrode faster when exposed to moist air
- Protection of metal surface prevents corrosion

Teaching strategy

- Activity-based teaching learning method; Field trips
- Time allocation: Approximately 3 hours. 6 periods

Objectives

1. To be able to identify and observe the process of corrosion
2. To be able to identify the causes of corrosion
3. To be able to take steps which would prevent corrosion and protect metals
4. To be able to select materials which are not liable to be corroded easily.

Teaching Hints

Introduce the lesson by enquiring from the class what are the various metals that they use in daily life. Help students recall at least five different instances where metals are used.

Discuss the care taken to ensure the proper functioning of the metallic parts. Let students experience, that a shining metal surface is smooth when touched, whereas a metal which is dull and tarnished is not smooth.

Student Activities

A. Observation Done during Class Period

Student Activities

   (It becomes dull gray or gets tarnished because oxygen dissolved in water reacts with aluminium to form an oxide layer)
2. Observe what happens when iron nails, screws, and pipes, are exposed to moist air.
   (On standing, all develop a fine reddish brown-coating called rust which is responsible for the corrosion of iron).
3. Observe that on longer exposure, copper and silver also lose their shine, copper at times might develop a green deposit and silver may get blackened. (Copper reacts with carbon dioxide and forms greenish copper carbonate, rubid silver reacts with hydrogen sulphide and gets blackened due to coating with silver sulphide).
4. Observe whether polishing helps to regain the metallic lustre. (Showing that the corrosion occurs layer by layer)
5. Observe the aluminium and iron vessels (a) in regular use (b) not in regular use.
6. Galvanise iron nails by dipping them into molten zinc. (Zinc is resistant to corrosion by air)
B. Observations Made Over a few days

8. Apply a coat of oil or grease on the iron tools. Expose to moist air for a few days. Record observations (Rusting is not there).

9. Paint the iron rods, door hinges with white paint. Record observation.
   (No corrosion is observed even during heavy rainy season).

Discussion

Allow for class discussion to arrive at the following concepts:
- moisture and air are responsible for corroding metals
- corrosion is prevented by avoiding contact with air or moisture
- boilers and machine parts can be protected from wear out by regular oiling
- community members use material metals specific to their needs
- damage by corrosion of metals cause heavy loss to the nation's economy
- plastic-coated metal sheets will not corrode and therefore, are used in construction of buildings
- anodization process prevents corrosion of aluminium.

Questions to answer after the lesson and for further class discussion:
1. During rainy seasons metallic door hinges make creaking sounds.
   a) What could be the reason?
   b) What is done to restore the normal functioning of the door hinges?
2. Why are chrome-plated or nickel-plated objects more resistant to corrosion?
3. Give reasons why silver gets easily tarnished?
4. Does polishing of metals take away the outermost surface layer?
5. Is it safe to eat acidic food served in brass plates? Why? Why not?
6. Why do we recommend that pickles be stored in ceramic vessels only?

Further Activity

1. Field Trips
   Make trips to
   (a) the cycle repair shop and see how the different parts of a bicycle are greased to prevent corrosion;
   (b) a shop where nickel/chrome/copper plating is done;
   (c) a factory where galvanisation of iron wares/sheets is done.

2. Assignment
   Observe an electrician at work. (Why does he use the rough sandpaper to clean the wire surface before making any connections?)
3. Observe how the hand pumps, agricultural tools, the swings, etc. are oiled. Inquire from the farm mechanic why agricultural tools need occasional oiling. (Oil is used for lubrication as well as for prevention of corrosion)

**Exemplar:** Teacher as a facilitator, motivator of learning and a community collaborator.

**Competencies and skills to be developed**

Science process skills: observation, experimentation, problem identification, communication

Science Activity: Soil Structure

**Grade Level:** Class VII

**Objectives of the lesson**

1. To be able to identify different soil structures.
2. To be able to select soil suitable for planting.
3. To be able to relate the concept of soil structure to daily life situation.

**Concepts to be developed**

1. Soil is made up of different structure.
2. Loosening of soil structure helps in planting.
3. Different soil structures are needed for different purposes.

**Teaching Strategies**

Experimentation, Group discussions, Field trips

Time allocation: Approximately 7 hours

**Procedure**

1. Identify and visit places in the surrounding environment having different soil structure.

2. Observe what happens on pouring equal amounts of water to different selected areas with different soil structures, in terms of time required for water to percolate through. Take students out to these selected spots in the field. Let them perform the experiments on water percolation and see how much time it requires for the water to pass through in different cases. Back in class, encourage the pupils to discuss their observations, and also help them to think of problems related to their observations.

3. Involve students in discussion on topics like "water passes more easily at some places than at others."

   - Guide students' discussion wherever it is necessary.

4. Allow students to perform different experiments found in the syllabus about soil structure and their percolation properties. Discuss results with the entire class members.
5. Allow students to interview community members on the importance of soil structure in farming (farmers), construction of buildings and houses (engineers), etc.

Assessment

Find out what type of soil structure is needed for constructing a cement flooring.

Follow-up Activities

Prepare a resource folder for extra readings, taking newspaper clippings about research and experimentations carried out on soil structure, especially relevant to a community.

Assessment of Learning Outcome

1. Observation of students in the field and in the classroom activities. A check-list has to be prepared in terms of students participation in group discussion, whole class discussion, participation in field activities, use of science process skills, awareness about learning concepts of soil structure related to daily life situations.

2. Project work on role of soil structure in development activities which are on-going in the community, e.g. building construction, cementing of roads, etc. and how the results could influence policy decisions made for the community.
CHAPTER FOUR

STRATEGIES FOR EVALUATION OF
TEACHER COMPETENCIES AND SKILLS

This task is to be performed by teacher educators. It should also be assisted by teacher trainees. The present position, as discussed earlier remains wide open for modification and changes in view of new role expectations of teachers and new skills and competencies that need to be acquired, and hence evaluated. The shift in emphasis to affective competencies and behavioural changes demands new approach to evaluation practices, and consequently, new techniques and instruments are to be thought of and validated. These achievements could be judged through the following areas:

(i) Classroom techniques and methods as evidenced through actual observation of practice in teaching lessons.

(ii) Analysis of cognitive learning through report writing, test sheets, assignments and interaction with teacher educators.

(iii) Manipulative skills through improvisation of equipment, mobilisation of resources, uses of educational technology, preparation and use of models, charts, teaching aids.

(iv) Attitudes acquired through interaction with community, commitment and sense of responsibility, willingness to take responsibility and evidence of managerial capabilities.

(v) Professional development through self-learning, by peer group interaction and ability to find sources of new knowledge and technologies.

(vi) Social skills as judged by interaction with parents and members of the community.

(vii) Self image to be judged by participation in social, cultural and community activities and through willingness to accept new responsibilities in these areas.

The above list is only indicative and should be rewritten by every teacher educator himself as per his perceptions. So far, maximum concentration in evaluation was in cognitive attainments (tested through essay type answers, mostly) and cursory observations of the classroom teaching situations' where the trainee is usually unnerved more when the teacher educator enters the classroom to observe his performance. It is a most amusing situation. While the teacher educator's presence prevents normality of the teacher trainee, the learners (children) know that 'sir' (the trainee) is being examined and usually enjoy themselves. It may not be desirable to state that the situation becomes comic if not farcical.

In such a situation, the need for fresh approach becomes imminent. While proceeding to develop instruments of evaluation certain suggestions are listed below and these could be utilised as guidelines, along with others, to formalise the evaluation tools and techniques.

Classroom Situation (Practice Teaching)

(i) Asks questions
   - frequently
   - infrequently
   - appropriately
   - inappropriately
Strategies for Evaluation of Teacher Competencies and Skills

(ii) Responds to the students response
- encouragingly
- cautiously
- indifferently
- ignores
- get unnerved (becomes nervous)

(iii) Response to students ideas
- praises pupil ideas
- incorporates ideas in discussions
- discourages their ideas
- ignores them completely
- discourages all interventions

(iv) Participatory teaching learning
- ensures participation of all
- neglects some
- forgets about pupil participation
- encourages participation of talented only
- unfamiliar with the technique of participatory teaching/learning

(v) Conducts activities
- prepares well-thought-of design
- comes unprepared
- is unsure of objectives
- avoids conducting activities
- mobilises resources
- gives too many directions
- is indirect in guiding

(vi) Communicates
- at a level beyond learners
- too fast
- conscious of learners' comprehension
- knows the technique and ensures comfortable transaction to learners

(vii) Nurtures creativity
- never
- rarely
- instinctively/compulsively
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- is himself not creative

(viii) Classroom environment

- pays attention to it
- Neglects it
- makes it enjoyable
- makes learners disinterested
- remains serious throughout

(ix) Achieve objectives

- concerns only with the cognitive transfer of knowledge
- ensures learning
- is more concerned about how children learn than the final 'product'
- allows no digression to his planned lesson
- changes transactions incorporating learner ideas during the progress of the 'lesson'

(x) Provokes

- new thinking and connections
- more learner ideas
- greater participation
- more activities
- peer-group learning

(xi) Uses education technology

- never
- adequately
- infrequently
- frequently
- appropriately
- inappropriately

(xii) Focuses on

- concept development
- skill development
- relationship to real-life situations
- utility
- applicability
Strategies for Evaluation of Teacher Competencies and Skills

And beyond classrooms

(i) Decision-making
- avoids
- takes quick decisions
- slow in decision-making
- incapable of decision-making
- confused
- depends on others

(ii) Management of resources, time and activities
- committed manager
- resourceful
- utilises time gainfully
- makes activities challenging
- concerns only with ‘teaching’
- leaves these aspects to others

(iii) Community collaborator
- avoids meeting people
- has ego problems
- meets people pleasantly
- pleasing manners
- understands their problems
- earns their confidence

(iv) Interaction with parents
- communicates assessment to them
- seeks their collaboration
- avoids meeting them
- is unconcerned
- commands respect from them

(v) Attitudes
- rational
- chauvinistic
- principled
- committed
- concerned

(vi) Personality
- likeable
- friendly
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- unapproachable
- dynamic
- dull
- dependable
- undependable

(vii) Relations with school authorities
- unconcerned
- cordial
- strained
- business-like

It may indeed not be desirable to make a sharp distinction between classroom and classroom-plus-outside-the-classroom assessments as the two are closely interlinked. However, on the lines suggested above, an evaluation instrument can be developed and standardised or validated by teacher educators themselves.

Evaluation of Instructional Methods and Behaviours in Science Classroom

(a) Pre-service training programme

The ultimate goal of pre-service teacher training is to have the trainee teachers gain competencies and skills in teaching. An evaluation of the classroom practices is a way to investigate the teacher's competence and skills as applied in teaching. This could also be done by peer-group teaching, teaching practices and teaching demonstrations. Responses could be obtained from the teacher trainers, peers, classroom students and even from the trainee through self-evaluation.

Evaluation of the trainee's classroom practices can be made by using a checklist on types of instructional methods applied by the trainee (See List I), together with observation questionnaires on teachers' and students' behaviours in the science classroom (See List II).

List I: Types of instructional methods applied by science teachers

1. Question-and-answer methods for presenting information to the whole class.
2. Lecture to the whole class followed by questions from individual students.
3. All students do the same assignment, working from their textbooks or other printed materials.
4. The class is divided into smaller groups who work together on the same assignment or different assignments, including practical/laboratory work.
5. Students follow individualised programmes, which may include individual printed materials and laboratory work.
6. Presentation of audio-visual materials to the whole class: for example, slides, films, TV.
7. The whole class goes on field trips or excursions in connection with the science programme.
8. Students in groups, visit industries, research institutions, botanical/zoological parks and places of scientific importance. They are exposed with the details,
processes and methods therein. They relate these to scientific concepts and grasp the actual processes and methods.

List II: Teachers' and students' behaviours in science classroom

1. At the start of each science lesson, the teacher reminds the students about the work they covered and concepts and ideas learned during the previous lessons.
2. At the end of each science lesson the teacher gives a summary of what was learned in the lesson.
3. The students are allowed to make their own choice of science topics to study.
4. The teacher uses students' ideas and suggestions when planning science lessons.
5. The teacher does demonstrations to help explain scientific ideas.
6. The teacher makes science lessons interesting for students.
7. During science lessons, the students copy teacher's notes from the blackboard.
8. For science homework, students' reports of their laboratory and practical work.
9. The teacher explains how the science that the student are learning relates to their own life.
10. The teacher discusses possible careers in science with the students.
11. Students have tests on what they have learned in science.
12. The science teacher helps students who have difficulties in learning science.
13. Students do field work outside the classroom as part of their science lessons.
14. Students do practical work (experiments) as part of their science lessons.
15. The science class is divided into small groups of students to do practical work (experiments).
16. When students perform experiments, the teacher gives instructions about what to do.
17. When students perform an experiment, they use a practical book or other written instructions on how to perform it.
18. In their practical work, students identify their own problems and then the teacher helps them to plan experiments to solve problems.
19. When students do experiments, the teacher provides them with problems to solve and then leaves students to work out their own methods and solutions.
20. In their practical work, students identify their own problems and work out their own methods to investigate the problems.

(b) In-service training programme

Although huge investment has been made on the provision of in-service training programmes for science teachers, the evaluation of these programmes has been neglected. In the actual situations where in-service education programmes are offered to a large number of teachers, and that the "multiple-tier technique" is applied, it was found that such training programmes faced a number of limitations, like lack of essential equipment and materials. Rarely, systematic evaluation was incorporated. This situation creates a lot of possible
losses which may affect the quality of the in-service education programmes offered for science teachers (See Figure 1). Thus, in many instances, certificates awarded at such training programmes were just of attendance, and not of the quality of the learning. In these situations, extreme care must be taken to ensure the quality of the training programmes, so that the huge amount of efforts, time and money, both from the government budget and from other sources which are continuing to be spent in many countries are effectively used.

Guidelines for the Teacher Educators In Using Checklist Prepared for Evaluating Teacher Trainees

In assessing the role of the elementary science teacher as a facilitator the following points are to be observed and assessed.

1. The science teacher should be well familiar with the science concepts. The fluency with which he deals with students' questions and the competence with which he organises to impart the science learning are important aspects.

2. The science teacher needs to be aware of the prior knowledge of the student. He should be able to relate the new concepts to the prior knowledge of his students.

3. In his role as a facilitator, the science teacher should encourage children's inherent curiosity. Problems and issues related to the natural phenomena and questions concerning these could be considered as an encouragement on the part of the teacher.

4. It is important that the science teacher feels free and works along with the pupils. How he joins in with pupils to solve their problems and how he guides them in trying out different activities are aspects that can be observed.

5. The science teacher continuously learns from his day-to-day experiences. In this, his interaction with students play an important role. He should be willing to listen to children's ideas and suggestions, and learn from them, as well.

6. Science learned with no relation to daily life may give the students the idea that science is a difficult or abstract subject. Hence, science should be related to daily life situations to make it more meaningful to the students.

7. The teacher has to play an important role in encouraging students through activities and suggestions which relate the science concepts to identifying and solving community problems.

8. The science teacher should help and guide students to link science with other subjects. In questioning and formulating activities, consideration has to be given to link science with other subjects.

9. The science teacher should motivate students to ask questions relevant to their observations. This could be mainly done through reinforcement and student appraisal.

10. Science education should be thought of as a continuous process. This stimulates pupils' interest to initiate their own projects related to learning and would encourage continuity and further learning.

11. Different ability groups have to be taken into consideration by all teachers and more so by science teachers. Hence the teachers' ability to organise, plan and cater for different ability groups has to be considered.

12. Effective communication can occur only within the comprehension level of the students. Communication is an important process of learning, and cannot be ignored.

13. Learning based mainly on curriculum texts restricts scope of wider learning. Utilization of all available resources whether they be human, natural or environmental
Figure 1: Possible Loss Throughout Stages In Teacher Preparation Programme

<table>
<thead>
<tr>
<th>Task</th>
<th>Procedure</th>
<th>Possible Loss No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of teachers</td>
<td>Training of master trainers</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Complete programme</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of equipment</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Equipment and materials are adequate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No evaluation</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Evaluation is included</td>
<td></td>
</tr>
<tr>
<td>Fail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pass</td>
<td>Qualified master trainer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No opportunity to conduct training</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training of teachers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incomplete programme</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Complete programme</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Insufficient equipment and materials</td>
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<tr>
<td></td>
<td>No evaluation</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Evaluation is included</td>
<td></td>
</tr>
<tr>
<td>Fail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pass</td>
<td>Qualified Trainers</td>
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</tbody>
</table>

and so on
Teacher Training for Science and Technology Education Reform

should be considered by all science teachers.

14. Interaction takes place in every single learning process. The interaction varies for different activities, making it impossible for the same classroom organisation to be successful for all activities. The activity whether it be carried out in the class or outdoors has to be thought of in terms of the interaction expected to occur and well-planned before hand.

15. Evaluation is a major component of a teaching/learning process. Continuous evaluation using different modes has to be a built-in process in the science teaching programme.

16. It is in terms of the possible learning outcomes that the science teacher can carry out self-evaluation or evaluation of the students. A full awareness of the possible outcomes is a competency required of a science teacher.

Checklist to Evaluate Science Teacher Trainees by Teacher Educators

Role: The Science Teacher as a Facilitator of Learning

Direction: Tick to what extent the teacher has developed the competencies and skills.

<table>
<thead>
<tr>
<th>Competences/Skills</th>
<th>MOST</th>
<th>TO</th>
<th>LEAST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>The science teacher,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) demonstrates confidence in science concepts.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(2) relates new concepts to prior science knowledge that the students possess.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(3) encourages children to be more curious about natural phenomena.</td>
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<td></td>
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<tr>
<td>(4) joins with pupils in solving problems and trying out different activities</td>
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<tr>
<td>(5) listens to children's ideas intently.</td>
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<td></td>
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</tr>
<tr>
<td>(6) relates science concepts to daily life situations.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7) encourages children to relate science concepts that they learn in school to solve community problems.</td>
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<tr>
<td>(8) appreciates the role that science plays in solving community problems.</td>
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</tr>
<tr>
<td>(9) helps to link science with other subjects.</td>
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<tr>
<td>(10) reinforces student answers to motivate them to ask questions relevant to their observations.</td>
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<td></td>
</tr>
<tr>
<td>(11) encourages pupils to initiate their own science projects related to what they learn in school.</td>
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<td></td>
</tr>
<tr>
<td>(12) handles pupils of different scientific ability</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(13) communicates effectively within the level of comprehension of the children.</td>
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</tr>
</tbody>
</table>

70
Strategies for Evaluation of Teacher Competencies and Skills

<table>
<thead>
<tr>
<th>Competencies/Skills</th>
<th>MOST</th>
<th>TO</th>
<th>LEAST</th>
</tr>
</thead>
<tbody>
<tr>
<td>(14) uses suitable resources for every science learning activity, e.g. human, natural, environmental resources, etc.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(15) organises for desired interaction in science activities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(16) assesses pupils performance in science using different modes of evaluation, e.g. observation, paper and pencil, test assessment and practical skills, project work, etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(17) adjusts to the situation to get the desired or possible learning outcomes.</td>
<td></td>
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</tr>
</tbody>
</table>

Exemplar Evaluation Material

For any project or activity to consistently improve, a systematic way of arriving at a basis for improvement must be devised. Evaluation is one such systematic device. A well-planned evaluation system should be able to identify the flaws and weaknesses (if any) of an activity or project and give direction to attain the desired change.

A teacher training programme, immersed as it is in a continually changing social, cultural, political and economic environment, must necessarily change, if it is to remain in harmony with its environment.

Evaluation for a training unit or lesson, as a component of a training programme, can take many forms: oral, written, essay test, objective test, attitudinal test, content test, etc. A single evaluation instrument cannot assess all aspects of instruction. However, an evaluation instrument can be designed to assess a particular domain of instruction, for instance, the competencies and skills being developed. We have attempted to design a few strategies and instruments to evaluate teacher competencies and skills as shown in the foregoing.

1. **Self Evaluation (by Trainee):**

Each trainee can and should evaluate himself on his or her performance. This can be done after each teaching practice unit. A checklist form provided below is meant to be an example. Modification should be done in accordance with the situations.

<table>
<thead>
<tr>
<th>Competencies/Skills</th>
<th>Level of Acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(least) (most)</td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Information processing skills</td>
<td></td>
</tr>
<tr>
<td>identify, locate and utilise information</td>
<td></td>
</tr>
<tr>
<td>classify, analyse and utilise relevant information</td>
<td></td>
</tr>
<tr>
<td>search for ways to understand scientific information</td>
<td></td>
</tr>
<tr>
<td>from primary sources</td>
<td></td>
</tr>
<tr>
<td>always update oneself on scientific and technological information</td>
<td></td>
</tr>
</tbody>
</table>
### Teacher Training for Science and Technology Education Reform

#### Competencies / Skills

<table>
<thead>
<tr>
<th>Level of Acquisition</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Decision-making skills</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>select reliable information and clarify values, ethics</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>identify alternatives</td>
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<td></td>
</tr>
<tr>
<td>predict consequences of each alternative</td>
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<tr>
<td>weigh the pros and cons of each alternative</td>
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<tr>
<td>order the alternatives</td>
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</tr>
<tr>
<td>take actions consistent with stated values</td>
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<tr>
<td>accept possible consequences of the actions taken</td>
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</tr>
<tr>
<td><strong>Instructional skills</strong></td>
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</tr>
<tr>
<td>use a variety of resources</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>use, improvise, develop teaching aids</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>design certain activities</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>effective utilisation of laboratory and instruments</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>stimulate/arouse students interest</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>bring in real-life situation to class and vice-versa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Science process skills</strong></td>
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</tbody>
</table>

2. **Evaluation by Teacher Educator:**

2.1 **Systematic observation throughout the training**

The sheet below lists only skills that are mostly required for development of scientific attitudes, values and ethics, and as an example on how a grading can be done. The performance of the trainee is rated from the least which is 1, to the highest point which is 5.
### Strategies for Evaluation of Teacher Competencies and Skills

<table>
<thead>
<tr>
<th>Competencies/Skills</th>
<th>Planning</th>
<th>Presentation</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chosing Topic</td>
<td>Writing Objectives</td>
<td>Selecting Resources</td>
</tr>
<tr>
<td>Decision-making skills</td>
<td>select reliable information and clarify values, ethics</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>identify alternatives</td>
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<td></td>
<td>predict the consequences of each alternative</td>
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<td></td>
<td>weigh the pros and cons of each alternative</td>
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<td></td>
<td>order the alternative</td>
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<td></td>
<td>take actions consistent with the stated values</td>
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<td></td>
<td>accept possible consequences of the actions taken</td>
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<tr>
<td>Science process skills (observing, classifying etc.)</td>
<td>use a variety of resources</td>
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<tr>
<td></td>
<td>use, improve, develop of teaching aids</td>
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<tr>
<td></td>
<td>design certain activities</td>
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<tr>
<td></td>
<td>effective utilisation of laboratory and instruments</td>
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<tr>
<td></td>
<td>stimulate/arouse students interest</td>
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<tr>
<td></td>
<td>bring in real-life situation to class and vice-versa</td>
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</table>

Comment on the competencies/skills a trainee has acquired including the strength and weaknesses.

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______________________________
2.2 Open-ended questions: reactions to situational problems

This type of evaluation is an exercise to develop an appreciation of ethics and values in the trainees with regard to the application of science in real-life situations. The format is as follows:

1. A brief description of the present real-life situation is given.
2. Questions are posed to the trainees to debate among themselves.

Real-life problem situations presently occurring in the region are recommended for the discussion, among which are:

1. Pollution (air, water, soil)
2. Alternative energy resources (nuclear power)
3. Utilisation of chemicals in farms and households (pesticides, fertilisers)
4. Deforestation
5. Health

Problem 1

The construction of dams to provide water is inevitable to ensure a continuous supply of water to an ever-increasing population. But before the construction begins, vast deforestation has to be carried out. This results in floods and droughts and destroys the ecosystem of the area. Erosion due to land clearance and construction activities may lead to siltation of the rivers. Vegetation clearance increases temperature and reduces rainfall. Once the dams are constructed, more forest land will be destroyed as it becomes submerged with water for the reservoirs.

Questions

1. Is there any way we can increase water supply to populated areas without having to destroy vast areas of forest?
2. Do you think the benefits of a dam outnumber its disadvantages?

Problem 2

It is found that approximately only 10% of total petrol sold in Southeast Asia is lead free. Lead has the effect of decreasing the body's metabolism and has an adverse effect on the liver. Incomplete combustion in most vehicles also results in soot, haze and poisonous gases being emitted which includes the killer gas carbon monoxide.

Question

Is there any way to reduce air pollution caused by vehicles?

Problem 3

A very poor woman was being slandered and ostracized by people in town for auctioning one of her kidneys in order to ensure food for her children.

Questions

1. Do you agree with the people in town?
2. What were the rights and wrongs of a very poor mother in doing so?
3. Are there alternatives to this?
**Problem 4**

While an airplane was spraying pesticides on a plantation, strong gusts of wind blew the pesticides over to a field where small farmers were ploughing. The farmers became very seriously ill and had to spend many weeks of suffering in a hospital.

*Questions*

1. To what extent should plants be protected at the cost of human welfare?
2. If the plantation gives farmers compensation, would they be free from blame?

**Problem 5**

A woman needs a large amount of money for taking care of her aging sick mother. She agrees to become a surrogate mother for a couple, who in return, provides that large amount of money she needed. The contract was signed. Upon delivering the baby, the woman refuses to hand over the baby to the couple because she feels attached to it during her pregnancy. She was forced by the court to hand over the baby to the couple.

*Questions*

1. Do you agree with the court's verdict? Why?
2. Should surrogacy be legalised?

### 3. Evaluation by Peer Group:

During teaching practice, a trainee can also be evaluated by peer group, as well. Informal observation can be done by using a form of checklist as illustrated below:

<table>
<thead>
<tr>
<th>Competencies/Skills</th>
<th>(low)</th>
<th>(high)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
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<tr>
<td>1. uses a variety of resources available</td>
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<tr>
<td>2. designs non-traditional activities (child-centred)</td>
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<tr>
<td>3. brings in real-life situation to class</td>
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<tr>
<td>4. integrates controversial issues related to science and technology</td>
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<td>5. encourages students to think divergently, analytically, systematically</td>
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<td>6. leads a discussion impartially</td>
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<td>7. encourages students to search for relevant information</td>
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<td>8. encourages students to hold their final judgement until there is sufficient information</td>
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<td>9. encourages all students to participate in discussion</td>
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<td>10. assists students to be willing to listen to others</td>
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<td>11. motivates students to ask more questions</td>
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<td>12. accepts the possible learning outcomes</td>
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<td>13. is able to handle students' different ideas</td>
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</table>
Teacher Training for Science and Technology Education Reform

<table>
<thead>
<tr>
<th>Competencies/Skills</th>
<th>(low)</th>
<th>(high)</th>
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<tbody>
<tr>
<td>14. encourages students to think of alternatives</td>
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<tr>
<td>15. encourages students to weigh the pros and cons of each alternative</td>
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<tr>
<td>16. encourages students to take actions consistent with the stated values</td>
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<tr>
<td>17. arouses the students' awareness to accept possible consequences of the action taken</td>
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<tr>
<td>18. assesses students' performance by using various methods</td>
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</table>

Comments

The suggestive checklists and other indications attempted in this Chapter are to be reexamined and refined by individual teacher educators and teachers. No exhaustive list of competencies and skills could be prepared as the same has to be developed in each institutional/regional situation, depending upon the general and specific expectations from the teachers. No doubt there would be considerable commonality and the presentation here is an attempt in the same directions. It incorporates possible curriculum transaction situations, teachers' skills and competencies needed for this transaction, the groups which could assist in evaluating the outcomes and finally how each assessment could be utilised as remedial input for enhanced learning outcomes, both in cognitive as well as in the affective learning. Learning is important for the trainee. It is equally significant for the trainer.

Concluding Remarks

The sharing of experiences amongst the group brought out clearly the concerns of member countries in imparting science and technology education at elementary level which is very crucial in the life of young learners. While the limitations were noted, potentialities in each country were also found adequate to proceed further and strengthen the science and technology education. It was agreed upon that there were some very prominent areas that need immediate attention, strengthening and assignment of specific roles to institutions. While practically every country has developed some expertise, produced materials linked to real life situation and have modified their teacher education programmes, shifting emphasis to practical training, they still need to strengthen the links between school and community and establish a visible mutual accountability between the two. To achieve this, it was felt that there was a need to strengthen or establish comprehensive teacher training institutions, fully equipped to look after the training needs of teachers of science and technology in a particular area or region. Resource institutions at state level or national level, which exist in all countries may concentrate on resource-person training and production of exemplar materials. Sharing of experiences through workshops, seminars within the country and also on bilateral basis among countries should be regularly organized and attempted. UNESCO may also continue to provide more opportunities for sharing of experiences at international level.
ANNEX 1

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              Mrs. Perla Roxas (SEAMEO-RECSAM)
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4. Reconstructuring secondary education;
5. Educational technology and information technology;
6. Training of personnel including professional support services and distance education;
7. Science and technology education including science for all.
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