ASIAN EDITION

Training of Trainers in Science and Technology Education

COMMONWEALTH SECRETARIAT

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Training of Trainers in Science and Technology Education

Commonwealth Secretariat

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Contents

Preface

Many developing countries are striving to provide quality Science, Technology and Mathematics Education (STME) as part of basic education in a context of limited resources. The Commonwealth Secretariat's work in STME is in four main areas: training of trainers; scientific and technological literacy for all; measures to enhance the participation of girls and women in science and technology and training of laboratory technicians.

Efforts to improve STME through better quality pre-service and in-service teacher education have often neglected the needs of those who are providing training at universities and colleges of education. In order to address this issue the Commonwealth Secretariat organised in the UK a planning meeting of Science Technology and Mathematics educators from Commonwealth countries. The participants at this meeting recommended the development of monographs to assist teacher educators in the delivery of Science Technology and Mathematics teacher education programme.

The basic framework of the monographs was also developed in this meeting.

The African edition of the monographs formed the basis for the development of the Asian edition. The African edition of the monographs were reviewed in an Asian regional workshop held at the National Council of Educational Research & Training, New Delhi, India.

On behalf of the Commonwealth Secretariat, I wish to express gratitude to all the participants who have contributed to the development of these monographs. I also wish to express my sincere gratitude to the Swedish International Development Agency for sponsoring the participant from Sri Lanka, to the Government of Malaysia for meeting the travel expenses of its participant, to the National Council of Educational Research & Training, New Delhi and National Council of Teacher Education, New Delhi for co-sponsoring the workshop. Last but not the least I wish to thank my colleagues Dr. Ved Goel for conducting the review and adaptation workshop and editing the monographs, Ms. Sonia Alexis for designing the monographs and Mr Greg Covington for preparing the illustrations.

We are fully cognizant of the fact that these monographs have not been tested in the field prior to printing. I therefore sincerely request the science and technology educators in Asia to try out these monographs and send us their evaluations and suggestions for further improvement.

Prof. Stephen A Matlin
Director
Human Resource Development Division

Introduction

An important aspect of science education reform in the world today is the implementation of science and technology education. Technology bridges science and society, brings relevance to science teaching, and unifies different subjects. It provides approaches to problem solving, relates different subjects to life and helps to link theory and practice. The science teacher educators in many developing countries are finding it difficult to prepare science teachers for this kind of science education. They recommended in a Commonwealth Secretariat meeting that monographs be developed which could guide science teacher educators in their attempt to prepare science teachers for science and technology education. These monographs have been developed to meet that felt need of science and technology teacher educators.

Science graduate programmes in the Universities have long been organised in terms of separate subjects namely botany, chemistry, physics, zoology etc. Consequently the scope of science knowledge of most science teacher educators is limited - they are familiar with one or two science subjects. However science and technology education usually involves inter-subject teaching. This requires teacher educators to have a broad base of science knowledge. In Monograph 1 'Training needs of science and technology educators', it has therefore been highlighted that while recruiting teacher educators, candidates with broad-base knowledge of science subjects be preferred. Selected candidates and existing teacher educators who lack breadth in their science knowledge be provided opportunities to acquire the perceived deficiencies through in-service courses or attachments with science departments in universities/colleges.

It has also been recognised that most science teacher have tended to stress science while neglecting technology in their classes because of lack of training in linking technology with science. The priority task is therefore to improve the pedagogical skills of science teacher educators themselves such that they could relate science and technology using examples of local technology. This also requires that teacher educators will be able to help teacher trainees to think in many different ways, including the selection of methods and the use of different materials and tools. Science teacher educators must provide this kind of experience to the teacher trainees during the courses they conduct for science teachers. In Monograph 2 'Teaching practice for science and technology', a four-tier approach to the training of science teachers has been suggested whereby the science teacher educator first explains the theory underlying a methodology then demonstrates the use of a pedagogy followed up with practice by the prospective teachers and finally the follow up in the actual classroom. Considerable emphasis has therefore been laid on practice teaching and its supervision.

Effective science and technology education requires the use of variety of resources. Lack of availability of material resources specially the science equipment has been regarded as an impediment in providing quality science and technology education. Many science teacher educators fail to recognise the use of locally available and improvised materials as an opportunity to provide relevant and life related science and technology education. The reason for this cynicism partly lies in the lack of their ability to identify, use and improvise suitable locally available materials. Monograph 3 'Resources in science and technology education', has therefore been written to help teacher educators' first in the identification and use of locally available material and how they can go about improvising such materials in their own teaching. Secondly, it helps them to provide guidelines to teacher trainees in the use of such resources.

An important feature of the monographs is that they not only provide guidelines to the teacher educators to improve their own teaching but also provide strategies which could be used by them with their trainees to make them better science and technology teachers. Another common thread throughout the monographs is the emphasis on the regular use of those methods, materials and approaches by the teacher educators in their own teaching which they expect teachers to use. It is based on the understanding that when the trainees observe a skill in action, and get the opportunity to practice that after observation, the chances of transfer of skill improve.

Science teacher educators require tools and techniques to assess teacher trainees both at the formative and summative levels. They also have to provide training to the prospective teachers in evaluation to enable them to evaluate their students. Monograph 4, 'Evaluation', precisely does this by discussing purposes, uses and techniques of different kinds of evaluation.

To improve the training of science and technology teachers in the teacher training institutions, and the delivery of science and technology education in schools requires coordination at all levels and professional development of all concerned. Monograph 5, 'Professional development of science and technology teacher educators', discusses the important interactive relationships within and across teacher training institutions, schools and external institutions and provides guidelines on achieving coordination for professional development. Monograph 6, 'Participating in science and technology education research', has been written to stimulate action research amongst teacher educators and demonstrates how they could generate such research among teachers.

Dr Ved Goel
Chief Programme Officer
Science Technology & Mathematics Education Education

MONOGRAPH 1

Science and technology teacher educators: Profile, needs and responsibilities

Overview 1.1

In most developing countries the provision of a good basic education is a matter of great concern. High quality science and technology education depends on effective and efficient training of teachers. This in turn depends on the quality of the teacher educators. At present, there is little comprehensive information available about the academic and professional qualifications of science and technology teacher educators, or about their responsibilities and training needs. The best intentions for improving teacher education will fail unless attention is paid to improving the quality of science and technology teacher educators.

Objectives 1.2

The objectives of this monograph are to help teacher educators, policy makers and administrators to:

- identify the professional and academic qualifications and training needs of science and technology teacher educator;
- consider ways of improving the qualifications of science and technology teacher educators;
- enable the science and technology teacher educator to keep abreast of developments in their fields.

Profile of a science and technology teacher educator 1.3

Ideally the science and technology teacher educator should have the following qualities:

1 Academic qualifications indicating a broad basic grounding in science and technology, including, a first degree in a science related area or equivalent qualifications in technology.

2 An appropriate professional qualification such as diploma or degree in education.

3 Relevant teaching experience at the appropriate level (Preferably at primary or basic level of science and technology education).

4 Membership of some relevant professional organisations related to science and technology education.

5 Research interest and commitment to research in science and technology education as evidenced through academic, professional or popular writings.

6 Positive attitude towards science and technology education, including the gender perspective, and knowledge of current developments in science and technology education.

7 Ability to adapt to, and understand, the contextual needs of the specific institution and the community it serves.

1.4 Academic and professional needs

In order to improve the quality of science and technology education at the basic level, the science & technology teacher educators must meet the academic and professional needs. The quality of science and technology teachers depends on the availability of science and technology teacher educators with sufficient grasp of the challenge and complexity of introducing young learners to the basics of these disciplines in a holistic and integrated way.

Currently, there are no courses that specifically train such teacher educators. In the short term, quality In-Service Education and Training (INSET) for science and technology teacher educators will be required. In the long term, a clear route will need to be developed to enable potential, science and technology teacher educators to gain the academic and professional qualifications they need. Their **academic** needs may include updating on knowledge of subject matter and content. Their **professional** needs include an understanding of and confidence in the use of subject-specific pedagogical skills, together with an understanding of appropriate methods for science and technology education research.

Thus, the major components to be included in the training of science and technology teacher educators are:

(i) **Liberal education** through mastery of content knowledge of various subjects at primary level and awareness of inter-relationships of science, technology, society and culture.

(ii) **Professional education** which mainly includes the educational psychology, development of history and philosophy of science, specific knowledge and skills pertaining to characteristics of learners, techniques and practices in science teaching and basic process skills in science and technology education research.

These specific requirements exist within the wider context which will include gender issues, ethical and humanistic issues in science and technology, cultural awareness and communication skills. The academic and professional needs interact with one another as well as with the context, as shown in Figure 1.

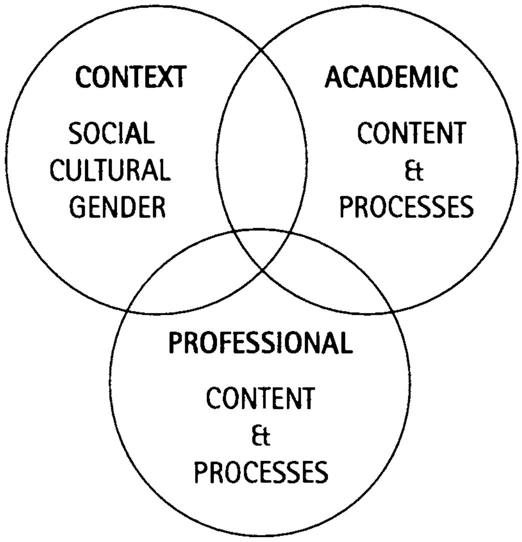


Figure 1: The interactive nature of the areas of training

Table 1 illustrates the broad training needs of science and technology teacher educators and indicates where subsequent training might be required for individuals with identified professional or academic shortcomings.

Table 1: Academic and Professional needs of science and technology teacher educators

Academic		Professional		Context	
Science and technology subject knowledge	Science processes	Education studies	Subject-specific pedagogical skills	Curriculum Studies	Manpower development studies
• Concept, Facts, Principles • Computer Literacy	Observation Classification, Experimenta-tion etc.	Education psychology, Philosophy of education. Sociology of education. Educational Technology	Teaching methods competency based teaching. Mastery learning. Team Teaching. Teaching Practices	Science and technology education research. Materials development	General liberal education. Cultural/ community awareness. Communicatio n (language skills, etc.)

Science and technology teacher educators will have to develop competence in their teacher trainees across the whole breadth of science and technology, including coverage of all the areas that the teacher will have to teach. The teacher educator must therefore:

- be able to demonstrate the activity-based investigative and problem-solving approach to science and technology;
- be able to present examples of open-ended investigations and how to report them;
- encourage teacher trainees to generate their own investigations and follow them through, so that they in turn learn how to support and encourage their learners in the same processes at their own levels;

- be able to demonstrate the significance of classroom skills in relation to real-life problems;
- be up-to-date with current learning theory, such as the recognition that different learners build up knowledge in different ways.

1.5 Academic and professional responsibilities

In Asian countries science and technology teacher educators usually have the following responsibilities:

- **Teaching:** To organise, implement, and critically evaluate the content of science and technology curricula and appropriate teaching methods.
- **Practice teaching:** To support teachers trainees in teaching practice (*see* Monograph 2).
- **Research:** To design, plan, conduct, and publish research.
- **Evaluation:** To carry out continuous review of existing programmes and the diagnostic and formative assessment of learners' academic attainment and progress.
- **Documentation:** To keep accurate records of examination results, nominal rolls, laboratory stock, workshop materials, etc.
- **Development:** To contribute to curriculum development and other developmental programmes.

It is important for science and technology teacher educators to be academically well prepared and equipped to meet the demands made on them. They should be familiar with the subject matter and content of the curriculum. They should understand how science and technology, their philosophical foundations and sociological aspects, are interrelated. This is important, because problems in science and technology tend to require skills and knowledge that are cross-disciplinary in nature and best handled by team-teaching. Science and technology teacher educators also need to have a basic knowledge of everyday applications of science and technology, their social implications and how the concepts and processes are used in industry and commerce.

For professional growth, the science and technology teacher educators should explore the possibility of

- research opportunities;
- available grants;
- attending conferences;
- organising in-service training in research methods and report-writing and providing professional support at different levels of research;
- communicating research findings through newsletters or journals.

The science and technology teacher educator needs to possess pedagogical knowledge, both of concept and procedures, and to able to pass this on to teacher trainees and in-service teachers to improve their effectiveness in the classroom. They therefore need to develop competence in the following areas:

- **Pedagogical skills:** These are the conceptual knowledge and procedural skills needed to enable teacher educators and teachers to bring about effective learning. They include selection and use of appropriate teaching strategies for particular objectives, class sizes, available materials, learning environments, etc. They also include the ability to guide teacher trainees in reflecting on their teaching and to encourage their involvement in the teaching-learning process.
- **Supervisory, guidance and counselling technique:** The science and technology teacher educator needs to develop skills in classroom observation, guidance and counselling of teacher trainees on academic and professional matters, including supervision of teaching practice and during competency-based teaching (*see* 2.6) sessions.
- **Social and psychological considerations:** Understanding the social and psychological characteristics of prospective science and technology teachers and learners at basic education level, and providing guidance to prospective teachers on how to deal with them. Understanding gender issues in science technology education and the strategies to deal with them.
- **Curriculum development:** Constructing curriculum materials and teaching-learning aids for pre-service and in-service teacher education and also for school education.
- **Research:** Carrying out 'action research' (*see* 6.6) and other types of research in education, which can contribute to understanding the needs of the learner, the classroom and the school in general.

There is currently an imbalance in the practice of these academic and professional responsibilities. Science and technology teacher educators need to put themselves in the place of teachers, attend seminars and spend time actually working in schools. This will make their own teaching much more realistic and effective, because it will be based on real classroom experiences.

Strategies for ongoing professional development 1.6

Science and technology teacher educators needs support, throughout their teaching careers, to develop both academically and professionally. In the Final Report of the International Forum on Scientific and Technological Literacy for All (UNESCO, 1993), it was stated that such support should include:

- partnerships between the world of production and the community, which would allow teacher educators to be exposed to the latest technology and also to increase society's commitment to science and technology teacher education programmes;

- updating appropriate teaching/learning instructional materials, facilities and equipment;
- updating of teaching skills, knowledge of learners and content;
- induction programmes for beginning teacher educators;
- assistance in developing leadership skills;
- salary structures attractive enough to recruit and retain the proficient teacher educators;
- adequate reward for teacher educators for those activities which are related to maintenance of their continued involvement with teaching as a dynamic profession.

These measures can be realised through:

- in-service education programmes organised by universities, colleges of education, subject associations and employing authorities (i.e. Department/Directorate of Education);
- formal links, including visits and attachments, with industry;
- teaching at the school level and carrying out action research with science and technology teachers;
- provision of resources by governments, including improved salary conditions; and career paths;
- joining professional organisations;
- corresponding with other professional science and technology teacher educators.

1.6.1 Content of INSET Programmes

INSET programmes for science and technology teacher educators should include consideration of:

- the needs of the community in which the teacher educators are likely to work and of ways of orienting science and technology towards community problems;
- the content and objectives of science and technology education at different levels;
- problem-solving techniques';
- gender issues and how they can be addressed;
- the use and maintenance of science equipment and laboratory;
- learning science and technology in a second language;
- management, co-ordination and use of resources;
- hands-on activities which integrate science and technology;
- the cultures of scientific and technological enterprises, their values, attitudes, assumptions, organisational structures and limitations.

In-Service Education and Training (INSET) is essential for updating the knowledge and improving the professional competence of science and technology teacher educators. At present, there are no regular INSET programmes specifically designed for science and technology teacher educators. Provision should focus on development needs, current issues and policy matters, as well as training and certification needs. The following are suggestions for types of INSET programmes:

Issue-based INSET

- **Workshops:** Hands-on activities designed to cater for specific professional development in terms of knowledge and skills.
- **Seminars:** Discussion- usually of short duration - of academic and/or professional issues and problems. They normally consist of talks or presentations followed by discussion, often in small groups. There should also be opportunity for plenary, summary discussion.

Certification-based INSET

- **Sandwich courses:** These can be organised by colleges of education, universities and polytechnics during long vacations to upgrade science and technology teacher educators professionally. Periods of normal teaching are alternated with short periods of full-time attendance at local colleges. Sandwich courses can be supplemented by distance-learning modules or specific practical projects or tasks (action research). Follow-up field visits by course co-ordinators contribute to the effectiveness of sandwich courses.
- **Study courses:** Science and technology teacher educators are granted full-time study leave in order to attend courses leading to a qualification. Such courses are INSET in the sense that a serving teacher educator goes on leave to study. This is a means by which under-qualified teacher educators can obtain qualifications and qualified teacher educators can upgrade qualifications.
- **Distance-learning courses:** Structured learning modules are made available to teacher educators through a variety of media. There is minimal contact with tutors, and the teacher trainees does not need to obtain study leave to be able to participate. Professional elements such as teaching practice are assessed by specially designated local personnel.

Institution-based INSET

- **In-college activities and meetings:** Organised by college departments, these enable science and technology teacher educators to exchange ideas and experiences and thus improve the quality of their teaching.
- **Conferences:** These may be local or international. They usually involve presentations, by science and technology teacher educators, of innovative methods and examples of good practice in schools. They provide teacher educators with the opportunity to update themselves on the latest equipment and published materials

for science and technology education. Such conferences are a very valuable resources for sharing problems and new ideas.

School-based INSET

It is important for science and technology teacher educators who have been in a post for some years, to be officially released for a period to update their teaching experience at the level for which they are training teachers. This gives them a better understanding of the needs, characteristics and aspirations of the teachers and learners in schools, and encourages the teacher educators to see themselves first and foremost as educators rather than as subject specialists.

Peer-group INSET

Science and technology teacher educators meet together as equals to share their problems and success stories. They can develop learning materials during such meetings. These can be at least as effective as the traditional 'course' led by an 'expert'.

Visits

Science and technology teacher educators should be encouraged to visit industries and other science and technology-based establishments such as science museums to acquaint themselves with the applications of science and technology principles in daily life. Visits may be for a day or involve extended periods of attachment to an establishment.

Type	Organiser	Length	Activities	Outcome
1 Issue-based				
(i) Workshop	Professional association, educational agency, private organisation, Department/Directorate of Education, College of education, polytechnic, university	Varies	Lectures, demonstrations, discussions, practicals	Improvement of professional and academic competence
(ii) Seminar	As in workshop	1-3 days	Lectures, demonstrations, discussions	Improvement of professional and academic competence
2 Certification-based				
(i) Sandwich courses (vacation courses)	College of Education, polytechnic, university	2-10 long vacations of about 10 weeks each	Practical, lectures, demonstrations	Degree/Diploma/ Certificate
(ii) Study courses	College of Education, polytechnic, university	1-2 academic years	Lectures, demonstrations, Practicals	Degree/Diploma/ Certificate
(iii) Distance learning	University	1-3 years	Self-instructional modules, with follow-up contact for lectures, demonstrations, discussions	Degree/Diploma/ Certificate
3 Institutional-based				
(i) In-college Activities and meetings	College of Education	Usually not more than a day	Discussions, demonstrations	Exchange of ideas, update of professional and academic knowledge
(ii) Conferences	Professional association, educational agency, university	1-5 days	Lectures, demonstrations, discussions, practicals	Exchange of ideas, update of professional and academic knowledge

Table 2: A summary of examples of INSET programmes for science and technology teacher educators is given

MONOGRAPH 2

Teaching practice for science and technology education

2.1 Overview

The quality of science and technology education in schools depends on the training of teachers which is turn depends upon the quality of teacher educators. However good the curriculum, its aims cannot be achieved if, through inadequate training, teachers lack the confidence to implement it. Practical teaching experience in the classroom is a vital part of teacher training.

Frequently, insufficient attention is paid to this aspect of teacher education. Teaching practice is often given low priority and only the minimum requirements met. For instance: Have the students carried out the required number of lessons? Have the supervision requirements been met? Have the statutory weeks of teaching practice been complied with? The net result is that teaching practice is seen merely as a set of regulations to be complied with rather than the most critical aspect of teacher education, where theory and academic content merge into practice.

In many instances, primary teacher education trainees avoid teaching science and technology lessons and fulfil the teaching practice requirements with what they perceive to be 'easier' or 'safer' options. Science and technology topics tend to be seen as difficult and complicated by students who lack confidence or poor background in the science subjects. On the other hand, confident students sometimes teach topics in a mechanical way that does not always ensure real understanding.

Technology is most often ignored in teaching practice. Teacher educators must make a conscious effort to provide opportunities where technology can feature more prominently than is presently the case. Links between science and technology should be emphasised in conventional subject teaching, and where possible the technical applications of science should be incorporated. Technologies in the local environment should be considered as possible starting points for science and technology teaching.

The emphasis is shifting from performance-based science courses to competency-based courses for teacher trainees in science and technology. It is desirable to follow process-based approach to understand the basic conceptual framework of the content. The science and technology teacher education programmes should be redesigned so as to meet the challenges of rapidly changing environment, curricula, nature and structure of both the pre-service and in-service training programmes of science teachers. To make the teacher training more relevant, functional and up-to-date, the focus of teacher preparation should cover all its aspects with regard to methods, materials, techniques and strategies of teaching for developing among the learners the appropriate competencies, skills, attitudes and behaviour. The teachers during training should be oriented towards learner-centred, activity-based, problem solving-oriented inquiry approaches and teaching/learning strategies using the environment as a learning resource. The class room territory has to be expanded to the whole environment. The teacher educator should act more as an activity-facilitator, guide, motivator, improviser, researcher, co-investigator and co-learner and not merely act as a communicator and disseminator of scientific and technological knowledge. They should do role modelling of an effective teacher for science and technology education. They should also have skills in materials organisation and classroom management in science and technology.

Objectives 2.2

The main aim of this monograph is to provide guidelines for teacher educators in science and technology to enable them to:

- plan and implement practical teaching experiences for pre-service education.
- design and implement programmes for in-service teacher education (INSET);
- practise different methods of teaching in science & technology education
- devise strategies for teaching large classes in science and technology;
- develop skills for competency-based teaching.
- effectively manage classrooms in science and technology;
- implement appropriate strategies for supervision.

Pre-service training of teachers 2.3

Many factors have to be taken into account while planning and implementing a pre-service teacher education programme for science and technology teachers.

Students' science background 2.3.1

The entry requirements and length of training for primary science teachers vary in different Asian countries of the Commonwealth. In some, A-level GCE, or its equivalent, is the qualification required for admission to a primary teacher training college which provides one to three years of training. In other countries a first university degree is the minimum qualification for admission to a one-year teacher training course. A formal qualification in science is not usually required for admission to a primary teacher training course, in spite of the fact that most primary teachers are expected to teach all subjects including science. This has implications for teacher training programmes. Teachers' lack of confidence in the subject matter results in them being unable to:

- understand the logical flow of ideas and translate them into meaningful classroom learning activities;
- ask questions which promote thinking and are based on the existing ideas of students;
- respond to students' questions.

Pre-service training courses, especially those of only one year duration, may not be able to make up for teacher trainees' deficiency in knowledge of subject matter. But such courses may help teacher trainees to identify areas or topics in which they do feel confident, and to translate the subject matter into a logical sequence of learning activities including thought-provoking questions. They can then try these out in the classroom under the guidance of the teacher trainer or an experienced teacher. This helps to build up their confidence. Future in-service training programmes can help to fill gaps in subject-matter knowledge. To overcome teacher trainees' lack of confidence in teaching science, it should be compulsory for every teacher trainee to teach a certain number of science lessons during their teaching practice. These need to be supervised either by science and technology teacher educators themselves or by experienced advisory or science teachers.

2.3.2 Resources

In many developing countries, lack of material resources is considered to be the main reason for the poor quality of science and technology education. It is true that there is a lack of suitable printed learning materials in the local language, based on the local cultural and physical environment, and this handicaps both teachers and learners. But lack of scientific equipment in primary schools is not as great a problem as is often claimed. This does not imply that no scientific equipment is necessary for teaching or learning primary science. For primary science teaching, the immediate local environment provides a wealth of resource materials, with plants, animals, food, housing, clothing, tools, transport, soaps and detergents, gardens and ponds offering a rich variety. In addition, empty bottles, cans, bottle tops, plastic and paper bags, and low-cost materials such as nails, moulding clay, balloons, pipes, straw and string, can all be used to improvise materials for teaching science.

Teacher trainees will need specific guidance on identifying and using locally available materials, and on procuring, storing and maintaining science materials. Science and technology teacher educators must ensure that during their own teaching they:

- improvise, handle and demonstrate low cost teaching-learning materials;
- increasingly use material from the local environment (For example, a fused bulb could be used as a magnifying glass or as a heating container);
- use improvised items made from local materials;

SETTING UP AN INSECT CAGE

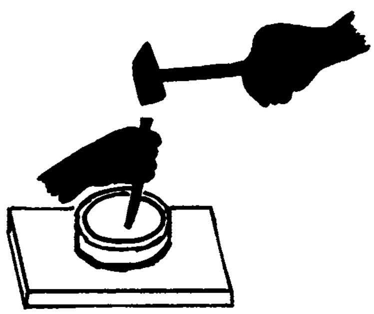
Purpose
For the study of behaviour of insects.

Materials required
Glass or plastic bottle (transparent) with lid, two small lids/soft drink bottle caps, nail, hammer

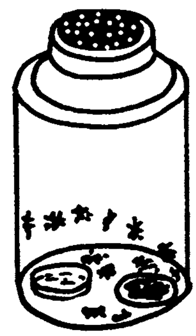
How to set up

Discarded glass or the plastic bottle can be used as insect cage. The metal/plastic lid may be perforated with the help of a nail of suitable size and a hammer. The small container lids having food and water should be kept inside the bottle as shown in the figure.

Note: House flies, ants, cockroaches, etc. may be collected but collection of butterflies etc. must be avoided.



Punching holes on lid



Insects

- give enough practice to the teacher trainees in the identification and use of local materials;
- encourage all teacher trainees to improvise;
- give tasks to teacher trainees in which they learn to use simple mechanical tools (For example, the use of hammer, screw driver, forceps etc.)
- show enthusiasm in using local materials to help to develop a positive attitude among teacher trainees towards use of local materials;
- make use of audio-visual materials such as charts, models, cassettes, films etc. and train teachers in the use and maintenance of materials available in schools.

Activity

(i) Collect some locally available materials to improvise any science activity.

(ii) State the criteria for the selection of the above items.

MAKING A HERBARIUM

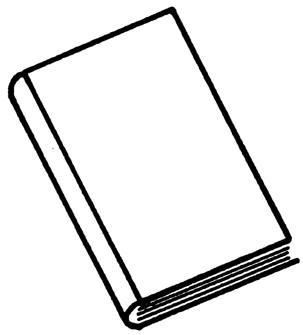
Purpose
For the study of different parts of the plants

Materials required
Newspapers/blotting papers, books, paper sheets/drawing books, leaves, flowers/small plants

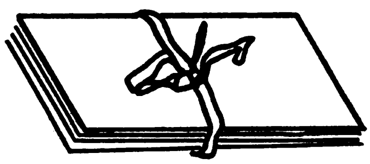
How to preserve

Keep the different types of collected leaves, flowers or small plants between two newspapers/blotting papers (which absorb moisture) and then place it under a pile of books. Let them remain pressed for about 5-6 days. Observe them if they are completely dried. Change the papers and again press them. After the collections have been completely dried, ask the teacher trainees to paste them on separate paper sheets. Help them to name the different parts of plants they have collected.

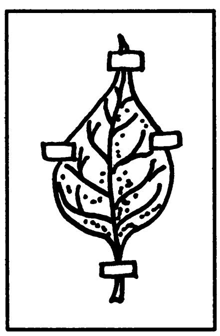
Flowers



Blotting Paper Sheets



Pressed Leaves



Herbarium Sheet

Working environment 2.3.3

Many teacher training institutions are insensitive to the range of environments in which teachers work. Training tends to be geared to an 'ideal' school environment. As a result, many teachers do not find the training very helpful. Science and technology teacher educators should therefore:

- familiarise themselves with the variety of school situations in which teachers will work after their training.
- discuss and demonstrate a variety of teaching methods which can be employed in different situations. Teacher trainees then need to practise these methods in real school situations. They need to learn classroom management techniques involving management of the curriculum, human and material resources in different working environments. Some management strategies which have been found useful in dealing with large classes and multi-grade situations are:
- use of class monitors;
- senior learners supervising the work of juniors;
- group work;
- use of printed learning materials such as work cards supplementary readers, modular lessons, 'distance learning' materials;
- the activity-oriented approach.

Curriculum 2.3.4

The nature of the science and technology curriculum in schools and the associated philosophy of teaching is another important area to be considered in planning a teacher training programme. While one curriculum may emphasise science content, others may encourage problem-solving and thinking on the part of learners or lead to a recitation of facts from textbooks.

The pre-service training of science and technology teachers cannot be limited to the curriculum currently being followed in a country or a state. Pre-service training has to be much broader and must consider a variety of methods which could be employed in science and technology teaching. The teacher educators must develop the following skills and competencies amongst the teacher trainees:

- Relating methods, materials and teaching aids to the defined objectives. An activity-oriented approach may be too time-consuming if the objective is to pass on knowledge. Similarly, if the objective is to teach science processes, the lecture method is inappropriate.
- Asking questions which can be answered by using the materials at hand.
- integrating subject matter and skills into a teaching-learning strategy.
- Use of process skills and understanding how they may be developed in learners.
- Building on learners' existing ideas and thought processes to develop scientific ideas and ways of thinking.
- Being aware of and using scientific knowledge to correct, the many false beliefs and superstitions which learners often bring with them to class.
- Relating science and technology to agriculture, health, industry, nutrition and other aspects of real life.

- Using real-life learning experiences from the local environment to develop scientific ideas.
- Using local technologies to build scientific ideas and skills.
- Developing formative and summative evaluation skills.

The teacher trainees need to be introduced to the large number of methods and techniques which can be used to achieve teaching goals. Science and technology teacher educators must explain that a particular method may be suitable for one teacher in a particular situation but not in another, and provide opportunities for the teacher trainees to practise these methods and techniques during their training.

Activity 1

(i) Identify some false beliefs and superstitions which learners bring to the class.

(ii) Give scientific reasons to the above false beliefs and superstitions in order to ensure that these are discouraged.

Activity 2

Identify five real life learning experiences from your local environment to develop scientific ideas.

Activity 3

Name two local technologies which can be used for building scientific ideas and skills.

2.3.5 Language for science teaching

Language presents a particular problem in science teaching. In many Asian countries science is taught in English in spite of the fact that it is not the first or even the second language of the learners, while many other subjects, such as social studies and moral science are taught in the local language. Even in countries where science is taught in the local language like Bangladesh there are sometimes no local words for particular scientific ideas and terms. This problem needs to be considered during the training of teachers that local, spoken language should be preferred for science teaching in classroom situation.

To illustrate this, let us consider the primary science education in Malaysia. There are three media of instruction in primary education namely, Bahasa Malaysia, Mandarin and Tamil. The primary teachers have to teach science in either of these in their respective school type. However, the teacher educators responsible for training these teachers are themselves trained in one language and they train the teachers in one language only.

In countries where this is a real problem, science and technology teacher educators should advise teachers to explain scientific ideas in the local, spoken language or the language most familiar to learners. Teachers should be trained to speak slowly in simple sentences, to use a variety of ways of communicating ideas, such as graphs, drawings and modelling, and to wait longer for learners to respond to their questions. This requires patience and practice.

In-service training 2.4

Need for INSET in science and technology 2.4.1

Many practising teachers with responsibilities for science and technology do not have recognised science and technology qualifications or experience. They require some form of in-service support and assistance if they are to be held accountable for the quality of science and technology education in their classrooms. Other teachers have taught aspects of science and technology as isolated subjects or have only been exposed to outdated methods of teaching it. They will not be able to make the links and appreciate the connections between science and technology components. Thus the In-Service Education and Training (INSET) programmes in science and technology are organised for:

- meeting the subject-matter deficiencies of teachers;
- developing teaching skills;
- introducing active-learning approaches;
- helping the teachers gain qualifications;
- implementing a new curriculum which requires additional skills related to methodology, classroom management and assessment;
- the professional advancement of teachers.

Activity

Identify any content area from science and technology curriculum and suggest three suitable active-learning approaches that may be followed for transaction.

INSET strategies 2.4.2

Direct experience of teaching practice should be the focus of teacher development programmes. Practical experience of formulating tasks, assessing and mastering content, planning, preparing and then testing out science and technology teaching approaches in realistic settings is the only sure means to ensure that teachers will develop the confidence to adopt, adapt, implement and appraise new ideas or approaches. It is essential that science and technology teacher educators responsible for INSET provision are sensitive to and committed to such experience/practice-led approaches.

The approach suggested here is that during the pre-service and in-service training, teachers experience the kind of science and technology teaching which they will be expected to practise themselves in schools. This implies that teacher educators must first explain the theory followed up with the demonstration of new skills and then create situations in which teachers experience at their own level problems which they have to investigate. Teacher educators should respond to the questions of teachers as though they were teachers responding to the questions of learners in schools, and help them solve problems in a similar way. This approach should enable teachers to achieve a better understanding of the joys and frustrations of learners in the classroom.

Activity

(i) Identify the problems faced by a science and technology teacher teaching in a rural area

(ii) Suggest one possible solution for each of the above identified problems.

Having experienced problem-solving at their own level, teachers should then be helped to formulate curriculum-based questions and problems for the learners to try out with learners in schools. It is essential that science and technology teacher educators responsible for INSET are committed to this four-tier empirical approach

i) presentation of theory of the method,

ii) demonstration of skills involved in implementation,

iii) practice of skills in actual classrooms and

iv) feedback.

INSET programmes should respond to the 'felt needs' of teachers regarding their specific roles and responsibilities. It is therefore important for teacher educators to appraise the needs of teachers through discussion. Analysis of a new curriculum to find out the skills and competencies required to implement it may be useful. If teachers request help with a specific area of content, then this should be given in a practical way. The content falls into place for the teacher and is clarified when they carefully think through how it can be taught. It is important for the science and technology teacher educators to realise that one of the aspects of training where teachers need most help is in the skill of translating content into teaching/learning activities. This can be achieved during teaching practice, and, if properly supervised by teacher educators, can avoid many of the problems of inappropriate science and technology teaching. INSET programmes are more productive when they focus on a practical approach that draws on theory and academic content.

Activity

Select any content area of science and technology curriculum and translate this area into suitable teaching/learning activity.

INSET Programme in Bangladesh

National Academy for Primary Education (NAPE) is responsible for short-term in-service training of Thana Primary Education Officer (TPEO), and Instructors of Primary Teachers Training Institute. In most cases TPEO, ATPEO and PTI Instructors are trained by the NAPE in the area of primary curriculum, teaching methods, evaluation techniques and very rarely on research methodology. In Bangladesh there is no formal short-term in-service training programme for the primary school teachers. Sometimes through some projects (such as Universal Primary Education Project), the primary school teachers are provided short-term in-service training.

After the recruitment, the primary teachers are sent to either PTIs or Teachers Training Colleges (TTC) or Institute of Education and Research (IER) for long-term in-service training. Teachers having Higher Secondary Certificate are sent to PTIs, where they are offered C-in-Ed. The duration of the course is one year.

Teachers having Bachelor's degree are sent to TTCs or to IER for a B.Ed. degree. The duration of the course is one year. In the IER, the primary teachers are placed in the Department of Primary Education and offered the courses on 'principles of education', methods of teaching, evaluation and measurement in education, educational psychology and guidance, history of education, education and development and teaching of English and Bangla language and also teaching of mathematics, environmental science and social science.

In the PTIs the teachers are offered courses on principles of education, history of education, educational psychology, environmental science, social science, English and Bangla language and mathematics.

In IER and TTC the teachers have to do practice teaching for three months. In the PTIs the teachers have to go for practice teaching for the same period.

In an INSET course teachers often expect teacher educators to do more than simply tell them what is required of them. They actually want to see how to do things. This may be achieved by means of a demonstration lesson or a video lesson. In either case, it should be followed up by practice sessions in real classroom settings, with feedback from the teacher educator. One of the problems which teachers face is the lack of in-service support after initial training. Without encouragement and assistance when new approaches are being introduced, change is unlikely to be sustained. For this to happen, headteachers, school inspectors, education officers and subject specialists all need to be included in training programmes, and their skills in classroom observation and providing feed back on the basis of observation also need to be enhanced.

An Example of an INSET course in Malaysia

Training of Resource Teachers for the Implementation of Primary Science Curriculum.

To implement a new curriculum all teachers are required to undergo retraining in order to meet curricular demands.

Since there are a large number of teachers to be trained the "cascade" model is being employed.

A number of teachers representing all the states in the country were selected to be resource teachers. These teachers are to conduct training of other teachers in their respective states.

The INSET course for Resource teachers normally takes 6 days. The course content covers curriculum emphasis, teaching/learning strategies, and evaluation. Training is also provided to teachers in communication skills.

ILLUSTRATION

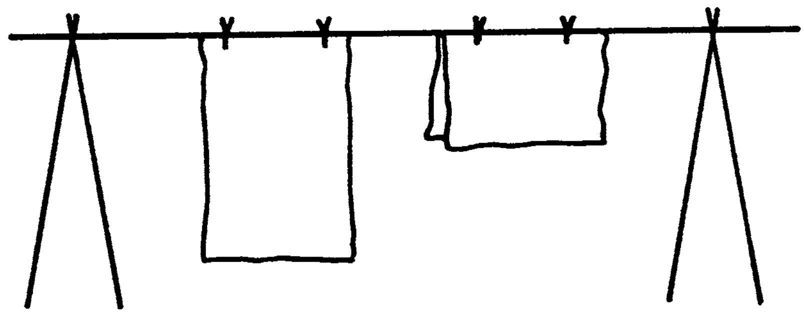
Learning Objective
Compare the rate of evaporation of liquid when the exposed surface area is large with the rate when it is very small.

Material required
Two pieces of same type of thin cloth.

Activity

Take two pieces of the same type of thin cloth. Dip them in water and squeeze them together so that the pieces may be uniformly wet. Remove wrinkles from the pieces of cloth by giving jerks. Fold one of the pieces. Ask a student to take this folded piece and put it for drying in the sunshine. Ask another student to take the other piece (unfolded) and spread it near the folded piece.

(Tell the learners that further investigations about these pieces of cloth will be made half an hour. Meanwhile engage them in some other activities). After half an hour ask a learner to bring both the pieces of cloth to the class and let all the learner feel these pieces of cloth by touching.



Large surface helps evaporation

Ask questions such as:

Which of these pieces of cloth has dried up more? What has happened to water of these pieces? From which piece of cloth has water evaporated more? Which piece of cloth has a larger exposed surface area? How does the rate of evaporation depend upon the exposed surface area? Help the learners to understand that water evaporates faster when the exposed surface area is larger.

An Example of INSET Programme in Sri Lanka

Introduction

Primary Trained teachers with no or insufficient background knowledge of science are teaching science. This created many problems and issues. To compensate for the inadequacy of competency to handle the subject, short term in-service programme was launched. But this programme too was inadequate to fulfil the requirements. A need for further improvement of teacher competencies to teach science in primary classes is strongly felt today.

Some of the essential teacher competencies identified are:

- planning of classroom activities.
- organisation of learners' activities in the classroom.
- methods of evaluation.
- ability to use environment to teach primary science.
- awareness of the scientific method.
- handling of basic equipment.
- improvisation of basic equipment.

It is necessary to equip all the teachers in the school system in the competencies during a short period of time. Therefore it is proposed to start a course in primary science and technology using the 'distance mode'. One of the reason for this was that it would not require withdrawal of teachers from their work place. Moreover, since there are large number of teachers in Sri Lanka at primary level, 'distance mode' was thought more appropriate and less time consuming for providing training to teachers.

Objectives

General

(i) To promote and provide professional growth in modern educational technology and teaching strategies.

(ii) To improve the quality of education in the primary cycle.

Specific

To provide further knowledge and skills in primary science, to meet the challenges and demands of the curriculum.

- To enhance the teacher competencies needed to teaching science.
- To introduce relevant assessment methods for primary science.
- To create an awareness in the teacher to use the environment as a resource in the teaching of primary science.

Duration
1 year

Clientele:
Trained/graduate teachers teaching in the primary cycle.

Entry requirement: Trained/graduate teachers with at least 5 years teaching experience in the primary cycle.

continued overleaf

Course Content:

1 Introduction to primary science

2 Methods of teaching primary science

3 Resources for teaching primary science

4 Evaluation of primary science

5 Science for primary science teacher

2.5 Methods of teaching

2.5.1 Whole-class teaching

Whole-class teaching in a large class can be a stimulating and entertaining learning method, if it is carried out in an interesting manner by a teacher with good verbal and presentation skills. However, over use of this method, with little feedback from learners should be discouraged. The learners loose concentration quickly, and a lesson should rarely be taught to the whole class for more than 30 minutes and even less for younger or less 'active' learners. Teacher educators should appreciate this and not often resort to whole-class teaching with their teacher trainees. Short spells of whole class teaching may be useful for conveying instructions, for introducing a lesson, for passing on simple content and for summarising.

Whole-class teaching can be made interesting by introducing demonstrations. The teacher educators should explain that demonstrations can be used for a variety of purposes, such as illustrating process skills, safety procedures and sequencing, or reinforcing a concept that has been taught. Whenever demonstrations are used, teacher educators should encourage teacher trainees to be involved in using the equipment, thereby ensuring better interactive learning. The teacher educator should also discuss where the teacher should stand during demonstrations, especially when it involves the use of apparatus. It may seem logical for the teacher to stand behind the apparatus and the learners in front, but this can present the teacher with problems. For example:

- the apparatus is back to front for the teacher, with stands, clamps, etc., on the teacher's side, making handling more difficult;
- meters and other instruments that need to be read will be pointing towards the learners.

Whilst the student teachers are likely to be quick to point out disadvantages associated with the teacher standing on the same side of the demonstration as the learners, the teacher educator should discuss possible advantages of this method. The teacher can:

- see the apparatus from the same view point as the learners , who are at a distance from the demonstration, allowing a better overall view;

- move around easily;
- hold up part of the demonstration, or take it nearer to the learners if they need a closer view;
- have the same view as the class when guiding learners in assisting with the demonstration.

Demonstrations can be very effective methods of learning, especially if participants are helped to focus on exactly what should be observed.

Problem-solving approach 2.5.2

The science and technology teacher educator must make it clear to the teacher trainers that in the problem-solving inquiry method, teachers facilitate learning rather than teaching directly, through:

- identifying phenomena and selecting materials that are rich in learning possibilities, and motivate learners to pursue their own investigations;
- capitalising on learners' curiosity;
- providing suitable materials that pose problems;
- asking challenging questions;
- using good judgement about when to interact with learners and when or when not to hold whole-class discussion (not all learners may have sufficient experience of the phenomena to contribute).

The science and technology teacher educator should actually involve teacher trainees in problem solving sessions by utilising the skills stated above. Use of the problem-solving inquiry method requires a good mastery of the subject matter. The teacher trainees must learn to be open to problems as they arise and be willing to learn along with the learners. Much time needs to be spent after such activities on reviewing and evaluating the learners' experiences in terms of the knowledge, process skills, attitudes and values acquired. Problem-solving inquiry methods of teaching should be given priority in science and technology education, even though they may be difficult to introduce with large classes. In such situations, classes can be broken up into groups and practical work arranged in the form of a 'circus' for the groups to move around. The groups can also be assigned investigative project work. Parents or assistant teachers could prove very helpful in supervising these groups. To develop confidence in the teacher trainees, in the use of problem solving the teacher educator must give trainees enough opportunities and organise their own training using a problem solving approach.

Other valuable approaches 2.5.3

The science and technology teacher educator must also demonstrate to the teacher trainees that many scientific ideas could be introduced by the teachers with the help of role play, games, toys, stories and models. Their appeal to learners should be fully, but not excessively, exploited. For example, the game of push and pull can be used

AN EXAMPLE OF THE PROBLEM-SOLVING INQUIRY APPROACH

Problem – How do we breathe?

A group of primary school teacher trainers were asked the simple questions. 'How do we breathe'? A variety of responses were given by trainees. Some sample responses were:

- When we breathe-in, the lungs expand
- When we breathe-out, lungs contract
- We take air from nose and take out air from the mouth.

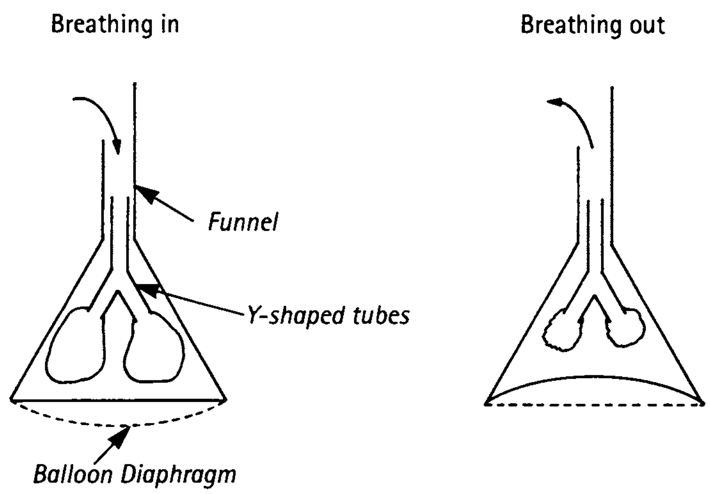
When asked 'How do lungs expand or contract', the responses given were analysed. These indicated that a large number of trainees had misconception about the mechanism of breathing and the role diaphragm plays in the process. The teacher trainees were then asked to perform the following activity. A funnel, a big balloon, a pair of small balloons and the Y-shaped plastic tube were provided to set the experiment as given in the figure. The activity simulated the breathing mechanism indicated in figure (a) inhaling – with expanded diaphragm and resulting inflated balloons and (b) exhaling – with contracted diaphragm and resulting deflated balloons.

This activity helped the teacher trainees to understand that it is the contraction and expansion of the diaphragm which helps in the breathing process.

Breathing in Breathing out Funnel Y-shape tube balloons B Diaphragm Diaphragm Balloon diaphragm

The learners are given a problem to solve which is related to their own experience. For example, if you have to buy a piece of cloth to mop the kitchen table which of the three given samples would you choose? Initially, all groups can do the same problem. Later, different groups can be involved in different problems at the same time, with parents or assistant teachers monitoring the groups.

It is important in the problem-solving inquiry approach that the teacher educator provides a situation where the student teachers are made to think, plan, execute using science processes and draw conclusions. Teacher trainees should be given many problems to solve at their own level, so that they come to appreciate fully the value of this approach. They should be helped to identify lots of problems which they can use with learners.

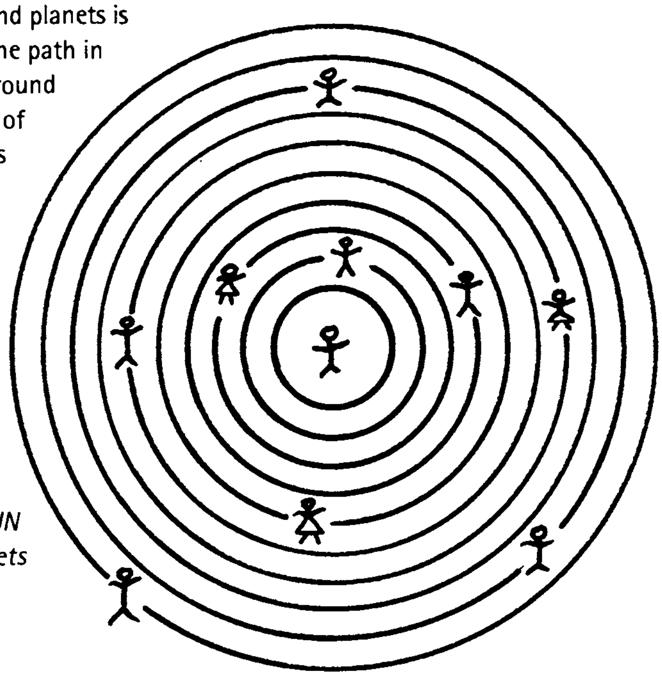


GAMES AND ROLE PLAY

Learning Objective
Identify the main characteristics of a planet

Activity

Take learners to the playground. Ask ten learners to volunteer to come forward. give to nine of them one badge each carrying the name of the planets and to the tenth the badge carrying the name SUN. Draw nine circles with a stick on the ground. Ask the learner, with the badge SUN to stand in the centre of the inner most circle. Let the other learners stand with the badges on their back with the names of the planets in the order of planets as shown in figure. Ask the nine learners representing the planets to move along the nine circles in the anti-clockwise direction around the SUN. Let the other learners observe their motion. Point out to them that it is only the planets which are moving and not the sun. Tell them that in the universe the SUN remains stationary and the nine planets revolve around the SUN. This arrangement of the sun and planets is called the Solar System. The path in which a planet revolves around the sun is called the orbit of the planet and the planets always move around the SUN in the anti-clock-wise direction.



Representation of the SUN with nine orbiting planets

Models are specially useful in science and technology since they enable the learners to grasp the concepts into concrete form. They can also be used to demonstrate various scientific principles in a practical way.

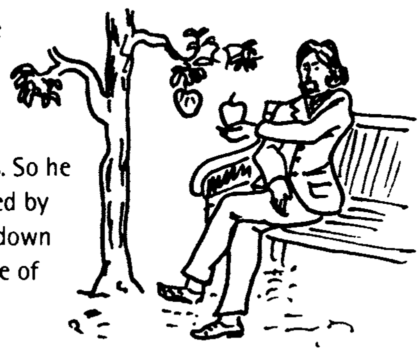
STORY TELLING

Learning by listening to stories: The stories stimulate interest and often hold the attention of the listener. Stories should be short and have relevant content of science which provides the focus of the lesson.

Learning Objective
Narrate the story of the great scientist Newton who discovered the law of gravitation.

Story

One day Newton was sitting under an apple tree in a garden. He saw an apple falling down from the tree. A thought came to his mind that there should be some reason behind falling of the apple on the ground and not going upwards. So he came to a conclusion that there is a force exerted by the EARTH which pulls (attracts) all the objects down towards it. He later named this force as the force of gravity.

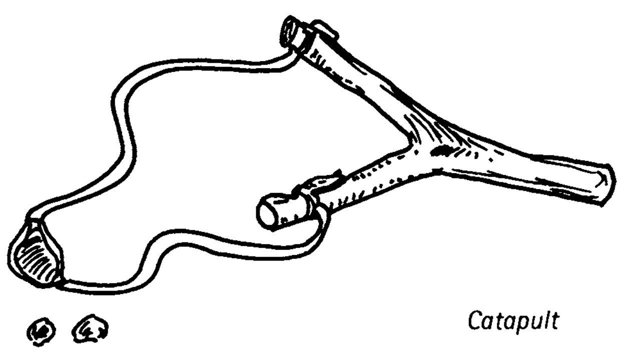


CONSTRUCTING AND EXPERIMENTING 1

Learning Objective 2
Construct a catapult and use it to identify that stored energy exerts force when released.

Activity

Help learners to construct a catapult of the shape as shown in the figure. Help them to understand the working of the catapult in which the energy stored by pulling the rubber backward is used for throwing the stone forward far away.



Catapult

CONSTRUCTING AND EXPERIMENTING 2

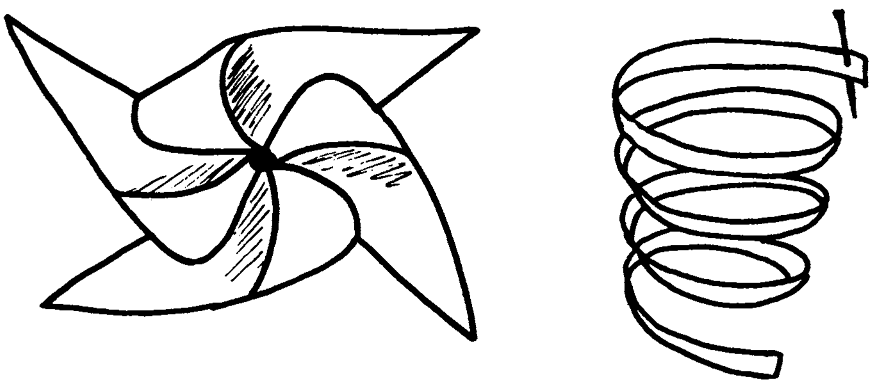
Toys are not teaching methods but are an invaluable resource to help develop scientific ideas. A simple bow and arrow can be used to develop ideas of elasticity, force, action and reaction, etc. Teachers trainees should be encouraged to ask learners to bring their own toys or construct simple toys objects/models to school for possible use in learning situations. Constructing is the fundamental process in science and technology comparable to experimenting in science.

> Learning Objective 1
> Construct a paper vane and spiral and use them to learn that energy of heat radiation can make objects move.

Activity

Help the learners to make a paper vane or a paper spiral of the shape shown in the figure. Now keep it above the flame of kerosene burner. Ask them questions such as:

What happens to the paper vane/spiral when kept above the flame? Why did it move? (Due to rising hot air above the flame) Which form of energy is making the vane move? (Heat energy)



Making of paper vane and spiral

Development of Competency-based Teaching 2.6

- **Competency-based Teaching:** Competency-based teaching provides the opportunity for teacher trainees to develop specific teaching-learning competencies until mastery level has been achieved. It has the following characteristics.
- **Nature:** Competency-based teaching is a process-based teaching-learning strategy in which emphasis is on the development of the skills until the mastery level rather than acquisition of knowledge. A competency serves as a basis for identifying, selecting, arranging and practising appropriate teaching-learning activities with a view to suit and meet learning needs of individual learners for a learner-centred and

activity-oriented competency-based teaching. The teaching-learning activities are to be organised in such a manner so as to meet the needs of an individual teacher trainee as a learner.

- **Development of Competency:** A competency is a skill-oriented predetermined learning goal/objective which is expected to get reflected in the teacher trainee's behaviour. When a competency has been developed, the teacher trainee would be able to perform specific tasks related to competency in both cognitive and non-cognitive domains. The cognitive areas of learning may include the competencies that the teacher trainee identifies such as the main parts of the human body or a plant (Knowledge), sees relationship between unclean food and water and diseases (Understanding); relates occurrence of day and night to the rotation of the earth (Application); observes various weather phenomena and records them with pictographs (Skills). The non-cognitive areas of learning may include the competencies such as that the teacher trainee realises the need for protecting soils from erosion (Values); practises personal cleanliness including toilet habits (Habits); participates in tree-plantation programme of the locality and appreciates their importance (Attitudes).
- **Mastery learning:** Each competency, arranged sequentially from simple to complex, should be learnt thoroughly or mastered which then provides the basis for learning the next higher competency, and so on. Each competency should be developed at the mastery level. In mastery learning, all the competencies or almost all the competencies are required to be mastered by all or almost all the teacher trainees. Initially there might be some difficulty in achieving the learning goal but gradually by suitably modifying the activity will help to produce teacher trainees with increased learning.
- **Competency-based Continuous and Comprehensive Assessment:** Assessment is an integral part of teaching-learning process. The competency-based continuous and comprehensive assessment provides a scheme of assessment for assessing the achievement of the competencies of the teachers trainees on a regular basis (continuous assessment) in both cognitive and non-cognitive areas of learning (comprehensive assessment). Efforts should be made to integrate assessment with the teaching-learning activities. The teacher educator while developing a competency should simultaneously try to assess the achievement level of development of the competency in the teacher trainees. The teacher educators should help the teacher trainees follow the assessment scheme of initially pre-testing, periodical testing (for assessing the development of cluster of inter-related competencies) and finally the annual testing or summative testing for assessing the development of all or almost all the competencies in science and technology.

2.7 Classroom management

Instruction in classroom management in science and technology teaching should be about the effective and efficient utilisation of both the curriculum and the available human and material resources. This entails planning, organising, co-ordinating, delegating, monitoring and controlling the teaching/learning situation. A considerable amount of time should be spent by the science and technology teacher educator on planning classroom activities (schemes of work, lesson plans and so on). Relevant resources should be organised for putting these plans into practice. For example, the apparatus or materials to be used need to be assembled, enough seating accommodation needs to be provided for all the groups, and decisions made on how groups are to be formed and who will be the group leaders. This should be practised in different working environments. Close monitoring and control of the teaching/learning situation is essential. It is important for the science and technology teacher educator to move about the groups to ensure that everyone participates and to help resolve any problems which may arise. Delegation could include identifying group leaders/monitors (in schools this might include parents or assistant teachers) to supervise the work of the groups.

A strategy to overcome the burden of big classes was implemented by an innovative mathematics teacher in a Bangladesh school

The teacher realised that learners who experienced difficulty in mathematics were in need of individual help. Since it was not possible for the teacher to provide individual attention for all these learners, the teacher appointed 10 'active' learners , who scored the highest marks in mathematics, as 'tutors'. The rest of the class was then evenly divided into 10 groups of more or less equal ability. The groups of learners sat in circles with their 'tutors'. The teacher introduced a topic and the learners carried out problem-solving exercises. The 'tutors' helped members of their groups with any difficulties.

This proved to be very effective:

- learners in smaller groups were more inclined to ask questions, mention their problems, etc.;
- learners who experienced difficulties with mathematics benefited from individual attention;
- 'tutors' were themselves stimulated and enriched;
- the teacher's burden was lightened;
- the 'tutors' eventually competed with each other, comparing 'their' groups' performances

Such an approach is well worth exploring.

Many teachers are unable to use 'active learning' techniques because they lack classroom management skills. Science and technology teacher educators should therefore ensure that they provide enough opportunities for their trainees to practise these skills. Time needs to be spent on reviewing and evaluating the teacher trainees' experiences to ensure that they have acquired the necessary classroom management skills in different working environments.

Supervision of teaching practice in science and technology 2.8

Aims of supervision 2.8.1

Supervision of teacher trainees' teaching practice by science and technology teacher educators has two broad aims:

- To assess and evaluate the level at which the teachers trainees are able to apply science and technology teaching methods and procedures. In this context, supervision of teaching practice is an evaluative process.
- To provide both the teacher educators and the teachers trainees (pre-service and in-service) with opportunity to evaluate and reflect upon class-room teaching procedures and practice, to maximise learning in the situations prevailing in particular schools.

The supervisor and the teacher trainee should work out appropriate supervisory strategies for alternative procedures in the classroom. Thus, the supervision of teaching practice of teacher trainees, becomes a reflective experience for both teacher educators and teachers trainees. It is an information-gathering process and even a research process which enhances and promotes growth in the competencies of all the participants.

2.8.2 Different strategies or models for supervision

Reflective collaborative supervision This model emphasises close, reflective growth between a supervisor and the teacher trainee, and involves four stages of development:

- **Pre-observation conferencing:** The supervisor and the teacher trainee meet before the beginning of the lesson, to discuss the objectives of the lesson and other aspects of teaching procedures to be followed. The teacher trainee describes his/her proposed classroom procedures and the supervisor gives his/her reaction to him/her until agreement is reached. The supervisor's observations are not predetermined but are based on the teacher trainee's suggested procedures.
- **Observation and teaching:** The supervisor observes the teacher trainee in action, following the agreed-upon teaching procedures, and records his/her observations with comments for further discussion during the post-observation conferencing.
- **Post-observation conferencing:** The teacher educator and the teacher trainee exchange views on the observations, feelings, strengths and weaknesses of the procedures followed during the lesson. They then agree on alternative strategies /procedures.

The guiding principle in this phase is reflective evaluation of both the classroom procedures of the teacher trainee and the supervisory practice of the supervisor. For this purpose the supervisor needs to be accurate in recording his/her observations, highlighting only those procedures dealing with specific science and technology content and their methodological treatment as agreed upon during the pre-observation conferencing phase. A suitable proforma (a sample proforma attached) may be developed to record the observations.

- **Establishing alternative classroom procedures:** The supervisor and the teacher trainee draw up alternative classroom procedures as agreed upon during the post-observation conferencing. These are not prescriptions of 'good' procedures from the supervisor, but alternatives which should be tried out by the practising teacher trainees for subsequent observation. While these alternatives may be entirely new, they may have been tried out in different contexts elsewhere. In this instance, the teacher trainee and the supervisor would be adding the 'new' alternatives to their repertoire of science and technology teaching procedures for reflective evaluation in subsequent lessons. This method of supervision gets the teacher trainees into the habit of seeking out new teaching procedures and promotes in supervisors the desire for reflective supervisory practices.

Possible constraints of the reflective collaborative supervision model

One inherent constraint of reflective collaborative supervision of teacher trainee's teaching is time. While the approach may work effectively in on-campus teaching practice settings, time constraints could prevent teacher educators from using this model in its entirety when teaching practice takes place in schools remote from teacher training institutions.

Instead, the following strategies could be tried:

- use of co-operating teachers as supervisors in the teaching practice schools (apprenticeship model);
- peer supervision;
- involvement of headteachers, education officers or subject specialists.

Using co-operating teacher supervisors (the apprenticeship model):

In this model, the teacher whose classes the teacher trainee takes over becomes the co-operating teacher supervisor, with the teacher trainee becoming his or her 'understudy'. The co-operating teacher sits in on all the lessons taught by the teacher trainee , following the procedure set out above for reflective collaborative consultation. The teacher educator supervises the teacher trainee on only a few occasions. Practising teachers have to undergo a short period of training before they are certified as co-operating teacher supervisors. This system of supervision makes the schools partners in the initial training of the teachers and therefore makes them feel responsible for training the kind of science and technology teachers they would like to employ in their schools. In order for this system to work the teachers' interest and enthusiasm in co-operating with the teacher educators must be sustained. This could be done by providing incentives for the co-operating teachers, such as:

- certificates as tokens of appreciation which could be considered for promotion purposes, earning exemptions for enrolling in teacher education programmes, etc.;
- recognition as 'lead' teachers in the running of INSET workshops, seminars, etc.;
- participation in the assessment and evaluation of science and technology education programmes;
- recognition as 'resource persons', visiting lecturers, etc.

Peer supervision

In peer supervision, with the agreement of the teacher trainee , his or her peers sit in during the lesson presentation. If four or five peer learners comment on and discuss the lesson presented, the learning process would be in line with the latest views on the 'socio-constructivist' learning approach. A variation on this is 'buddy-teaching', also used in teaching practice, when two learners are coupled for a period of time over the three-week practice teaching period. While one learner presents the lesson, the other one supervises, and vice versa.

A sample proforma for observing teacher trainees' teaching

Observable characteristics	Performance of the teacher trainee			
	Very good	Good	Average	Below average
1 Introduction of the lesson				
2 Presentation (a) accuracy of the content (b) performance of activities (c) using teaching aids (d) demonstration				
3 Explaining concepts				
4 Giving instructions				
5 Participation of learners				
6 Effective questioning				
7 Effective answering				
8 Stimulus variations				
9 Management of (a) classrooms (b) resources (c) time				
10 Summarisation of lesson				
11 Coverage of planned objectives				
12 Evaluation and feedback provided				

Involving Head teachers, education officers or subject specialists

In order to involve head teachers, Education officers or subject specialists in supervision, the following criteria for selection may be adopted:

- higher secondary certificate with science as a subject
- certificate in education with science as a teaching subject
- ten years of experience of teaching science at the primary level

It will be necessary to orient these people in the task of supervision. The essential component of the orientation programme will be classroom observation and providing feedback.

MONOGRAPH
3

Resources for science and technology education

3.1 *Overview*

A wide range of resources is available that science and technology teacher educators can use and introduce to their teacher trainees to assist with the teaching and learning process. These include conventional things like tools, equipment and consumable materials, printed materials and human resources. These also include locally available materials and technologies, thus linking what is being learnt in school with everyday life, and bringing relevance to the teaching of science and technology. The science and technology teacher educator has two main responsibilities with regard to resource materials:

- to identify the resources needed for science and technology in the teacher education programme;
- to be fully conversant with the human and material resources which schools can utilise and the skills required by teachers to develop and use them effectively.

It is also important that the science and technology teacher educators use resources during training that are similar to those available in the schools or environments where their teacher trainees are or will be teaching.

3.2 *Objectives*

The objectives of this monograph are:

- to identify resources that science and technology teacher educators might use;
- to outline strategies for making use of resources, especially those locally available, for teaching science and technology;
- to discuss issues relating to the use of resources in science and technology education.

General considerations in identification, selection and use of resources 3.3

Several factors must be considered when deciding what resources will be needed for teacher training. Decisions are guided by answers to questions such as:

What investigations are anticipated?

How will learners be grouped?

What resources may be needed to investigate problems and questions raised?

The following are general criteria for the identification, selection and evaluation of resources:

- **Appropriateness:** Are the resources appropriate to the age group, to the teaching objectives, and to the subject content? Are printed materials at the appropriate reading and comprehension level?
- **Accuracy:** Is the content of the material accurate? Are there errors, biases, including gender biases and unwarranted conclusions?
- **Cost:** Does the outcome of use justify the cost in terms of money, time and effort?
- **Demand:** Does the material engage the thinking skills of learners? Does it demand creativity, problem-solving and a high degree of participation on the part of the learner? Will the resource hold learners' attention for a reasonable amount of time?
- **Comprehensiveness:** Does the material explore concepts etc. in enough depth and breadth? Does it allow learners to gather and organise information? Do textbooks contain questions, advance organisers, illustrations, summaries and glossaries?
- **Relevance:** Are the contents appropriate to the learners' needs, interests and abilities?
- **Validity:** Will the resources bring about the learning outcomes hoped for? What evidence is there of this?
- **Variety:** Does the resource provide experiences which are not otherwise possible?

Manufactured materials 3.4

These consist of equipment and chemicals, needed specially for teaching science and technology education, and general hardware items used in the teaching of all subjects. A list of useful manufactured resource materials for science and technology education is given opposite.

Teacher educators should be familiar with materials in manufacturers' catalogues and their availability for use in schools. They should liaise closely with the Department/Directorate of Education and/or relevant professional institutions dealing with the supply of science materials in selecting 'good' resource materials to ensure that a common message is being given to teachers and teacher-trainees. In

Malaysia, resource materials such as basic laboratory apparatus, tools, and science kits are supplied to the schools. In countries like India and Sri Lanka science kits are being supplied to schools. Teacher educators need to be aware of the contents of such kits and able to demonstrate their use to teachers and teachers trainees.

Some useful manufactured items for science and technology education

Magnifying lens	Potassium permanganate	Test tubes
Measuring cylinder	Formalin	Beakers
Clinical thermometer	Alcohol	Spirit lamp
Torch and torch cell	Ammonia	Trough/Tray
Insulated wire	Dilute acids	Globe
Fuse	Chisel	Candle
Electric switch	Steel plane	Match box
Ball bearing	Hammer	Magnetic compass
Pulley	Pliers	Dropper
Standard masses	Clamp	Measuring tape
Spring balance	Screw driver	Kerosene burner
Plastic tubing	Hand drill and bits	Iron nails
Rubber tubing	Assorted tiles	Cotton thread
Metre scale	Spanner	Filter paper
Funnel(plastic)	Wire cutter	Plasticine
Bar magnet	Tin cutter	Callipers
Baking soda	Iron saw	Iodine
Test tube holder		

Teacher educators need to be sensitive to the fact that resources they have in their training institution may not be available in schools. For example, teacher training colleges may have overhead projectors, whereas schools may not. While teacher educators may wish to use such resources for teaching teachers trainees, greater emphasis should be laid on use of those materials which are easily available in schools. Locally available materials from the environment should be made use of as far as possible.

3.4.1 Procurement of materials

Policies for procuring manufactured resources for schools vary, and science and technology teacher educators need to liaise with schools about administrative aspects. They need to be fully aware of the existing policies and to ensure that their teacher trainees understand the procedures to be followed. Such procedures might include:

- award of contract or tender by the Department/Directorate of Education.
- order against a budget, where schools are provided with a budget for this purpose.
- order from a National Educational Equipment Centre as in Pakistan.

Storage and maintenance 3.4.2

It is also important for science and technology teacher educators to teach their teacher trainees about the proper storage and maintenance of manufactured resources. Many primary schools do not have science laboratories. The teacher educators need to look out for examples of good practices with regard to storage in schools, and discuss these with the teacher trainees. For schools without laboratories, materials should be stored as close to the user as possible so that the chances of their being used are increased. Also, if materials are stored in glass-fronted cupboards learners may see them and want to use them, thus reducing the possibility of teachers forgetting to use them.

> **Activity**
>
> (i) Name three manufactured items which need special care for storage and maintenance.
>
> (ii) Suggest three suitable ways for proper storage & maintenance of these items.

Manufactured materials must be properly maintained to ensure their efficient operation and long-term use. Science and technology teacher educators should learn how to maintain every manufactured item used in schools and pass on this knowledge to their teacher trainees. Poor maintenance of science equipment is a serious problem in many countries, and science and technology teacher educators have a big responsibility to correct this situation by providing proper training to trainees in maintenance.

Safety 3.4.3

Teaching about the proper and safe use of manufactured resources is another responsibility of the science and technology teacher educator. Teacher trainees need to be shown how to use equipment so that they do not damage the equipment or injure themselves. Teacher trainers also need to ensure that their teacher trainees are fully aware of possible dangers from chemicals they may use. Teacher trainees should also learn about the general safety procedures to be followed in the teaching of science and technology in schools. The safety of children is vital; and all possible safety procedures must be introduced by the teacher educators to the teacher trainees.

Equipment pools and lending systems 3.4.4

Many schools do not have the manufactured science equipment they need because of lack of funds. To overcome this problem, alternative means of supporting schools may be developed. In some places schools may be grouped into 'clusters', which share human and material resources. Other places may establish 'science centres' or 'teachers' resource centres' at the district or sub-district level, which store equipment and make it available to schools on request. For such a system to be effective, procedures need to be in place for the quick supply of equipment to schools or for the teachers to be able to come to the centre to collect equipment.

Do's	Do Not's
• Give due care to minor cuts and injuries	• Taste unknown chemicals
• Stop bleeding as soon as possible by placing clean cotton wool	• Stand very close to a burner or candle if dressed in synthetic garments
• In case of excessive bleeding, consult a doctor	• Use items for other purpose, like beakers, to drink water
• In case of burns apply cold water or ice	• Forget to wash hands after using chemicals
• Take care while lighting a burner or a candle	• Forget to store chemicals properly
• Make small groups	• Allow the use of equipment without discussing safety procedures

Add more to this list which you think is essential and necessary

3.5 Locally available materials and technologies

3.5.1 Local materials

The use of locally available materials should not be viewed as a poor alternative to using manufactured 'bought-in' science equipment. The use of locally available materials makes teaching more relevant to learners by relating it to their real life situations. Locally available materials are those available either free or cheaply from the immediate environment. They include items like wood, clay, iron filings from the blacksmith, pith, soil, grains, plants, empty bottles and bottle tops, comb, wax, nails, sawdust, coal, sugar, common salt and limestone and locally produced manufactured items such as magnets, balloons rubber bands, balls, screws, paper clips, plastic bowls and candles. Many of the items generally available in learners' homes, such as bulbs, knives, clothes pegs, razor blades, pieces of fabric, are also valuable resources. Many of the items from the list of manufactured materials such as funnels, rubber tubing, hand tools, baking soda, iron nails, candles etc. may be available in the homes of many learners. As such, the learners must be encouraged to bring them. They should be able to take them back after use.

Teacher educators should be aware of different kinds of locally available materials and their various uses in science and technology education. They should ask the teacher trainees to collect such items and in turn advise to ask their learners to collect. However, enthusiastic learners may collect too many things, so teachers should be advised not to ask every child to bring the same item. Asking learners to volunteer to bring different items, will improve their motivation and interest in learning about things in their environment. Teacher educators should mount exhibitions of locally available materials used in their institution for the training of science and technology teachers and encourage teacher trainees to mount similar exhibitions in their schools. Sessions should be set aside for teacher trainees to gain practice in adapting locally available materials for teaching /learning situations and illustrating their use in making teaching /learning more meaningful.

Local technologies are as important a resource as locally available materials. Young learners bring with them to school, experiences of science and technology which they have observed within their homes and the wider community. Teacher trainees will also have lot of such experiences with them. Science and technology teacher educators should use these experiences during training and help their teacher trainees to utilise similar experiences. It should be emphasised to them that local

In many schools mathematics is taught in an interesting way using a calendar

Choose any month and play a game of numbers and addition as follows:

M	T	W	T	F	S	S
1						
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

Select any two consecutive dates and add diagonally across from each as follows:

Suppose we select 2 and 3. The number diagonally across from 2 is 10; 2+10 = 12.
The second number is 3 and the number diagonally across is 9; 3+9 = 12.
The sum is the same. Try this with any other two numbers. What is your conclusion?

1 2+ 10 = 12

9 + 3 = 12

2 In the same way, add three numbers diagonally across:

3 + 11 + 19 = 33

17+ 11 + 5 = 33

The sum is always the same. Try with any other three number diagonally across.

3 Add numbers making up a 'Z' shape:

e.g.
5 + 6 + 7 + 13 + 19 + 20 + 21 = 91

You have added seven numbers. The middle number is 13. The multiplication of these two numbers (7 and 13) will give 91. Do more of these with this month or any other month.

4 Choose a rectangle of nine numbers and add them together:

e.g.
6 + 7 + 8 + 13 + 14 + 15 + 20 + 21 + 22 = 126

The total is 9 times (the total of numbers added) the middle number (14).

Hint: Always check your middle term and compare it with your answer. Is there a quicker way to get to the answer?

JELLY PAN 'PHOTOCOPIES'

This technique was extensively used when photocopy machines were not available, and is still being used in rural schools in many countries. It works very well for drawings, graphs, sketches and printing large-letters.

You need:

500 ml glycerine 75 ml gelatine 450 ml water 80 g sugar 2 flat baking trays (about the size of A4 paper) 1 sheet of spirit carbon paper. The spirit carbon paper is not ordinary carbon paper, and must therefore be ordered by your institution from an office supplies dealer. The advantage of using it, however, is that with this method, a school can produce hundreds of copies with a single sheet of spirit carbon paper.

Method

1 *Preparation of jelly pan*

Dissolve gelatine in a tin of hot water. Add sugar. Boil the mixture. Add glycerine. Now boil mixture gently for another 15 minutes. Stir continuously with a bread-knife or flat spatula. The mixture should have no bubbles and must be dissolved properly. Pour gently into the two baking trays, spreading it evenly. Smooth any little bubbles to the sides. Leave for 24 hours. Now your jelly pan is ready to be used.

2 *Making a master copy*

Arrange the paper from which you want to copy, the carbon paper and the paper on which you want to make the master copy as follows:

Top: Paper with design, drawing, graph etc. (face up)

Middle: Spirit carbon paper (can be used to make hundreds of master copies), carbon side (face down) on the white paper.

Bottom: Clean white paper (will be the master copy: can be used to make imprints on a number of jelly pans).

Take a drawing or big letters which you want to copy. Arrange the plain paper, the carbon paper and your drawing on a hard surface such as a table. Make sure the face of the carbon paper is on the clean white paper. Now trace the boundary of the drawing or each letter so that it leaves an imprint on the white paper. Now take the white sheet with the imprint on it and place it on to the jelly so that the imprint side of the paper faces the jelly. Press the paper gently over the jelly pan. You will find the imprint on the jelly. Now use this jelly pan as a master. Place paper sheets over it and press gently by hand to obtain hundreds of copies.

3 *Making copies in learners' exercise books*

It is not necessary to tear a page out of a learners' exercise book. Simply, put a clean page face down on to the jelly pan, smooth over the page, and the drawing is in the learners' book! You will be able to make more than a hundred copies with one tray before it goes 'dull'. You can use the same jelly once again, just cook it for a while and repeat the process.

A method that is well worth trying out!

Use of Medicinal Plants in India

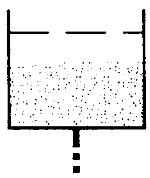
In India, leaves and fruits of some plants are frequently used to control some common diseases.

Tulsa (Ocimum sanctum) leaves are boiled in water which is then used for drinking. If helps in controlling common cold and cough. Leaves and fruits of Neem (Azadirachta Indica) are boiled in water and used for taking bath. Repeated use of this water helps to reduce and control some skin diseases.

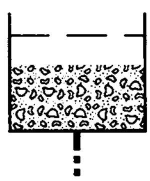
Drawing water from a well

A common sight in many villages of different countries in the Asian region is the use of rope and simple pulley to draw water from a well. The pulley makes it easier to draw water from the well and works as a simple machine.

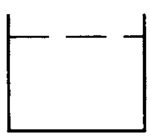
SIMPLE TECHNOLOGIES ARE USED IN WATER FILTRATION



Water sand and collects the sediments sand



Water charcoal traps the germs and charcoal



pure water

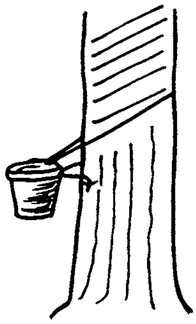
Making clay pots

In villages potters have been making clay pots for many years. They have learnt to choose suitable soils and to control the drying and baking processes to reduce cracking.

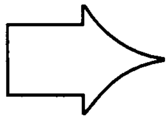
The fact that evaporation causes cooling is used in keeping water cold for a long time using specially designed porous clay pots.

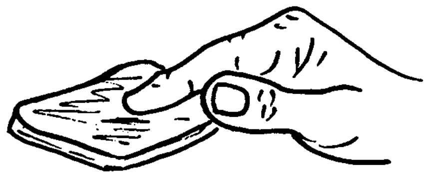
LOCAL TECHNOLOGY IN MALAYSIA

1 Using latex as glue to mend a puncture in tyres and tubes

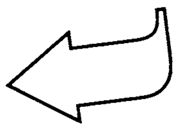


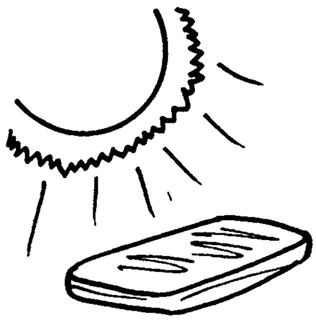
Collect some latex from rubber trees



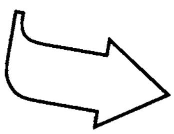


Spread latex over a cut piece of rubber that is going to be e used to mend the puncture.

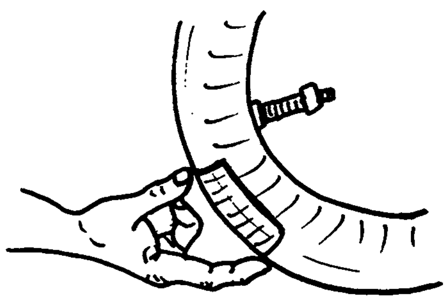




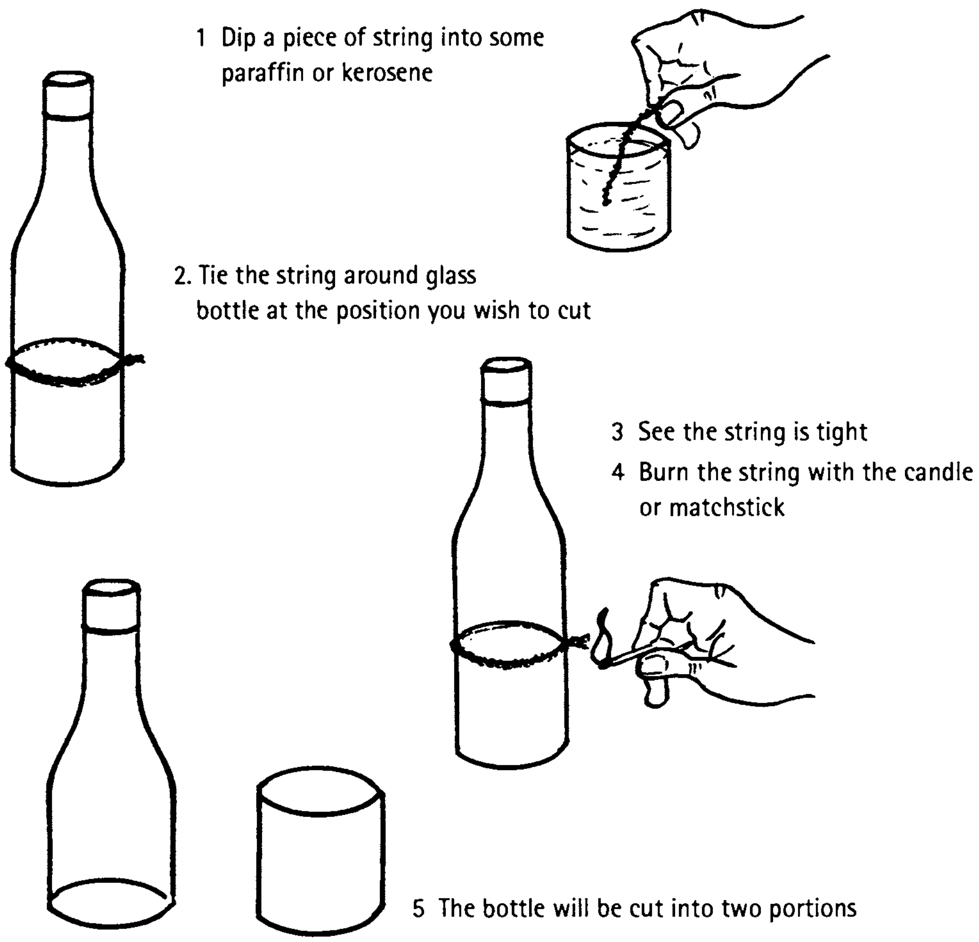
Leave the rubber piece in the sun for four minutes.
The white appearance of the latex turns into a clean and sticky film



Stick the rubber piece over the puncture



2 Cutting the base of a glass bottle



Preparing Charcoal from wood

Large number of logs of wood are piled in a pit specially designed for the purpose. Openings are kept on two sides so that air can enter into it. The pile is then covered with soil from the top and sides and put on fire. It is kept burning in an insufficient supply of air for about a fortnight. Wood, on burning in an insufficient supply of air, gets converted into charcoal.

technologies have the potential to make learning more relevant and meaningful for the learners by linking their real-life experiences with what they learn in school. The use of community resources for teaching science and technology also provides an excellent opportunity of introducing learners to social concerns which need to be addressed. Such interaction can allow learners to gain useful insight into the purposes served by technology, how technologies influence individual people's lives as well as their interaction with each other and with their environment. Moreover, parents also start taking interest in the education of their children as they feel children are learning useful things. The following panels give some examples of local technologies with relevance to science and technology education.

Making manure from Garbage

A pit is dug in the field and is filled with leaves, branches, fruit and vegetable peels and other types of garbage. The garbage is covered with soil. The mouth of the pit is also kept covered. The garbage is left in the closed pit for about a month. The garbage decays and the manure is obtained on opening the pit after a month.

Transporting ice without getting melted

In many countries, during hot summer days, big ice blocks covered with saw dust or jute sacks or with both are often seen to be transported from one place to another. The saw dust or jute sack is used to prevent the ice from melting. They act as bad conductors insulators of heat.

3.5.3 Out of School local resources

Teacher educators also need to be aware of, and to encourage teacher trainees to use, other local out-of-school resources. These might include:

- Visits to different construction sites to study the methods, materials and tools used. Learners must be encouraged to put 'why?' and 'what?' types of questions to the people doing different jobs.
- Visits to a furniture-making factory or a carpenter's workshop to study measurement tools, materials and techniques used for joints, techniques used to strengthen furniture, different shapes and their relationship to strength and design of the furniture.
- A local blacksmith or potter's workshop are also useful resources for learning about tools, skills and techniques.
- In the local market place learners may observe and learn about different types of foods and the popular food choices, transportation used, how different items are measured and sold, methods of preserving food, materials used to pack food, hygiene and sanitation aspects of food, etc.
- Visits to zoo, gardens, parks and sanctuaries
- Visits to a local hospital, health centre, doctor, restaurant, nursery, plant shop, railway station, etc., can be very rewarding as a means of linking real-life experiences with school science and technology.
- Visits to science museums, Planetarium, Science exhibition, science parks, science clubs, science fairs, science centres and mobile science laboratories.

All of these will help to integrate what the learners learn in school with real life in their communities.

Improvisation is an important aspect of science and technology education. It involves scientific processes such as problem solving, planning, decision making, designing and evaluating, which are all important for living in the modern world. Improvisation not only helps to overcome the shortage of equipment, but, equally importantly, it helps to develop teacher trainees' scientific process skills, technological skills and a positive attitude towards improvisation of science and technology equipment. Many of the 'bought-in' manufactured items used in science and technology education could be improvised from locally available materials. Books are available which give guidance on preparing improvised materials. Some examples of items which can be improvised include:

- balances;
- measuring cylinders from discarded saline bottles
- measuring cylinders or air pressure pumps from discarded syringes;
- corks from bamboo pith/raffia palm/jute stick;
- gum from mixing discarded styrofoam packing material and petrol;
- concave and convex mirrors from bottoms of tins;
- indicator dye from leaf extracts;
- rulers from graduated sticks;
- acid from the juice of unripe fruit;
- funnels from the top parts of discarded plastic bottles;
- weather instruments - wind vanes and water gauges;
- match sticks
- balloons to be used as membrane sheets

Science and technology teacher educators may suggest other items which could be improvised and are suitable for particular situations. They should encourage teacher trainees to put forward their own lists of items which could be improvised, and, more importantly, demonstrate the use of improvised materials during the normal teaching situation. The teacher trainees should actually produce a few improvised items during their training.

Activity

Select items from local resources which can be used to improvise

(a) a beam balance

(b) water filtration model

In learning how to improvise, pre-service teachers should consider who might be able to help, for instance fellow teachers, local artisans or craftsmen, and the learners themselves. Improvisation by learners can represent a valuable learning experience if handled appropriately. Science and technology educators should advise teacher trainees on how they might go about creating a learning situation that involves learners in improvising materials. A common approach is through problem-solving exercises or projects.

3.6.1 How to go about improvisation

An important aspect of improvisation is having the initial idea: some have been listed above. Teacher-trainees will need advice on the procedures to be followed for improvisation. A suggested procedure might be:

- examine lesson contents and specific objectives;
- identify the need for use of equipment/materials;
- write procedures for assembling improvised materials;
- assemble materials;
- try improvised materials out before final use.

Improvisation ideas should be disseminated in science magazines or newsletters, such as the newsletter of a local science teachers' association.

Activity

Analyse the contents of a science textbook for primary level and identify lessons where improvised scientific equipment can be developed and used.

3.6.2 Basic equipment required for improvisation

Improvising materials will sometimes require use of tools. Training institutions should have simple mechanical tools such as wooden compasses, callipers, measuring tape, screw driver, punch, wood saw, metal saw, pliers, chisel, steel plane, hammer, hand drill, clamping and holding tools, spanners etc. Science and technology teacher educators should be conversant with the use of these tools and be able to guide teacher trainees in handling them in a safe and purposeful manner. Provision should be made in pre-service and in-service training courses for teachers to handle many of

these tools by either using a tool kit or making visit to a machinery workshop. Teacher training institutions should also provide facilities in the form of various types of machine workshops (e.g. wood, metal, etc.)

AN EXAMPLE OF IMPROVISATION

Improvised stethoscope

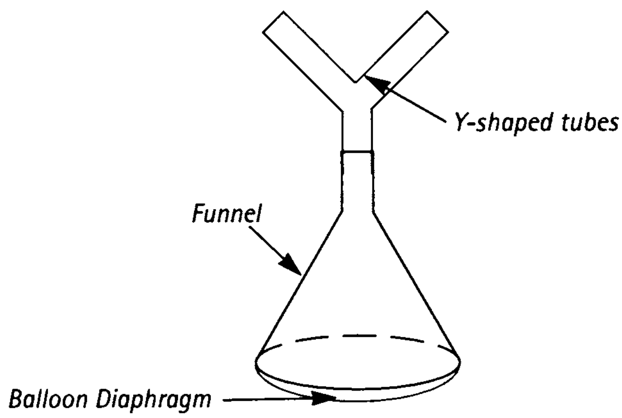
Material required
A balloon diaphragm, a funnel and a plastic tubing.

Learning Objective
To demonstrate the effect of doing physical exercise/hard manual work on rate of breathing.

Procedure

- Plastic tubing is fixed with the stem of the funnel.
- Balloon diaphragm is fixed on the rim of the funnel.
- The diaphragm is placed on the heart to note the heart beat rate of a teacher trainee before and after running or doing physical exercise

It can be inferred that rate of breathing increases after doing physical exercises.



Improvised stethoscope

3.6.3 Attitude to improvisation

Many teacher educators and teacher trainees do not have a positive attitude towards improvisation. They regard improvisation as an activity forced upon them by shortage of funds, and consider improvised items as inferior. It is important for them to appreciate the positive advantages of improvisation and the common disadvantages of 'bought-in' manufactured materials:

- Many manufactured items or kits are supplied to schools without funds or a policy for replacement. They get locked into the stores or head teachers' office for fear that, if the items get destroyed or broken or misplaced, either the teacher will have to pay or they may not be replaced for a long time.

- There are educational advantages in using familiar materials which can stimulate investigations and can be replaced fairly quickly and cheaply.
- Improvised materials can be available in larger quantities, possibly for handling by each learners, which may not be possible with sophisticated and costly manufactured items.
- Improvisation leads to development of problem-solving skills amongst teacher educators and teacher trainees which may be passed on to learners.

3.7 Teachers' resource centres

Teachers' resource centres and educational equipment centre as in Pakistan, have been found to be very useful in many countries in promoting the development and use of locally available materials. At these centres, teachers and teacher educators meet frequently to share and develop teaching and learning materials using locally available materials. These centres can be established in such a way that 25-30 teachers work together for a whole day once in every month or two. Such a centre could be located in one school for a year or two and then perhaps rotated amongst the other participating schools. This requires some initial funding by Department/Directorate of Education or non-governmental organisations for buying consumable and non-consumable materials.

Such resource centres, if they are to serve the purpose, must be established within easy reach of the teachers whom they serve. Science and technology teacher educators and teachers should be able to go to the resource centres to work in groups to develop teaching and learning resources, share resources, and discuss problems and successes experienced in promoting science and technology education. These centres can also display examples of good improvised materials and other work and take the responsibility to organise seminars and conferences to disseminate ideas and information.

Since teachers may not have time during regular school hours to improvise materials, the teachers' resource centres may provide an appropriate forum where teachers can pool their efforts and skills to generate improvised materials. For example, organising an exhibition of teachers' improvised materials for teaching and learning of science at the district, state or national level may motivate teachers. Every time teachers meet at these centres there should be time earmarked for improvisation.

Science and technology teacher educators must develop skills amongst teachers to use the resources efficiently. School timetables may have to be arranged in such a way that there is no competition for materials. For example, in a school with several science teachers the timetable could be arranged in such a way that not more than one or two science classes take place at the same time.

Evaluation in science and technology education

Overview 4.1

Evaluation is an integral part of the teaching-learning processes. Through systematic evaluation procedures science and technology teacher educators can measure the progress of pre-service and in-service teacher trainees in attaining the objectives of teaching programmes. Evaluation also enables teacher educators to measure the effectiveness of their own teaching strategies and methods. Similarly, teachers trainees need to develop skills and competence in evaluation techniques which they can then apply in their own teaching in schools. Evaluation results can also play a part in an accountability system for ensuring that institutions, teacher educators and teachers deliver good quality science and technology education.

It is important that the objectives of a lesson or course should be clear, so that science and technology teacher educators can select appropriate learning experiences, teaching methods and information-gathering techniques in order to achieve the objectives.

Objectives 4.2

This monograph aims at helping science and technology teacher educators to:

- acquire the necessary knowledge and skills to evaluate teacher trainees;
- acquire the skills of evaluating their own teaching;
- become aware of the problems associated with evaluation;
- become aware of the need for and methods of record keeping;
- develop the necessary understanding and skills of evaluation amongst teacher trainees.

4.3 The purpose of evaluation

Evaluation is carried out for the following purposes:

- to measure progress;
- for accreditation and certification;
- to determine whether objectives of a teaching programme have been achieved;
- to rank learners;
- to identify gaps in the knowledge and skills of learners;
- to provide information on progress to parents, teachers, teacher educators and decision makers;
- to improve the teaching-learning process.

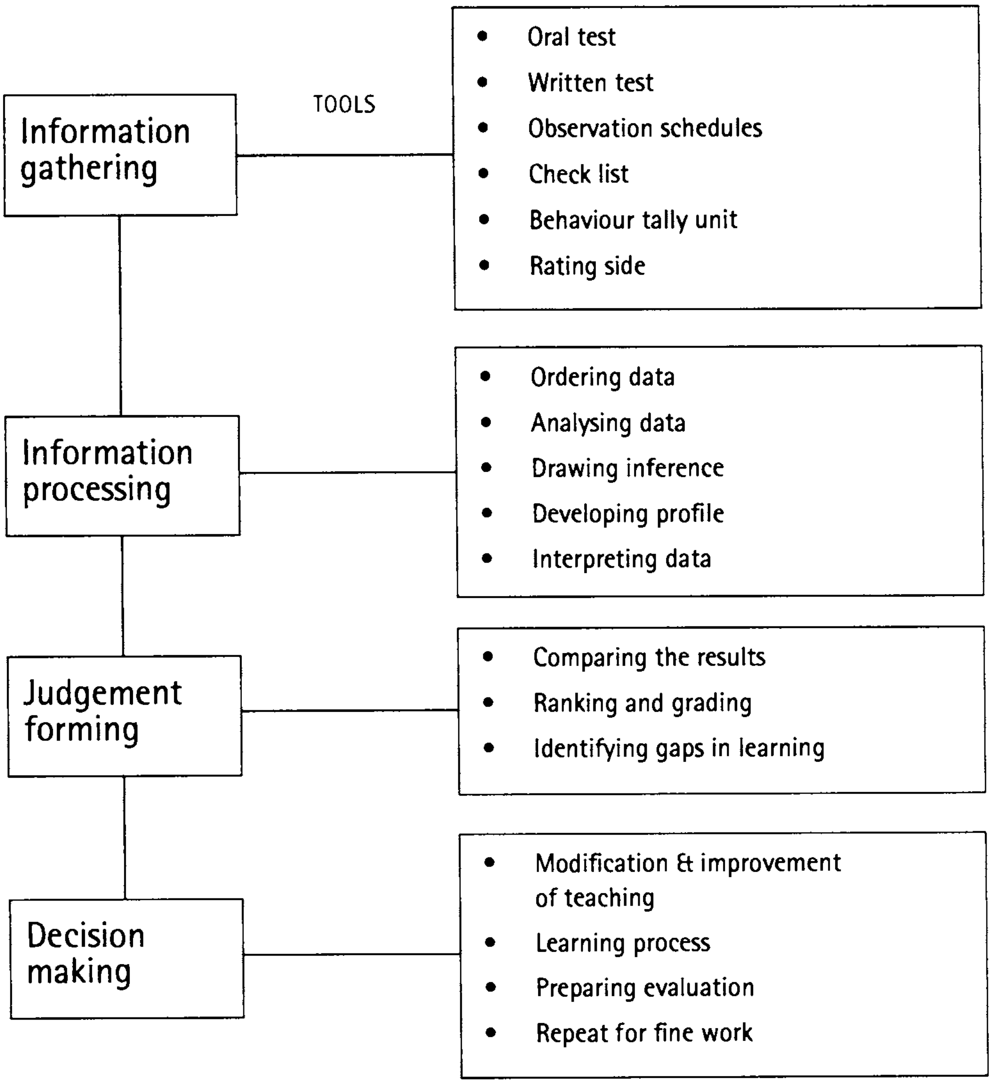
The teacher educator should emphasise to the teacher trainees that the purpose of evaluation is not only to let the learner and parents know about the progress of the learner, it is also of vital importance to teachers because it informs them about the success of their own teaching. Information from evaluation can be used by teachers to plan and improve their lessons. This should be demonstrated by the teacher educator.

4.4 Types of evaluation

Evaluation is a process of information gathering, information processing, judgement forming and decision making.

Evaluation may be carried out to collect a variety of information about teacher trainees, such as academic performance, performance in the classroom, ability to handle classroom material, presentation and communication skills and ability to plan and execute practical work. Similarly, teacher educators may evaluate trainees with regard to their knowledge and skills in planning and administering evaluation in schools.

The purpose of evaluation and the use of information collected determine the nature of evaluation. If the information is used to diagnose the cause of a particular problem faced by a teacher trainee, the evaluation is called diagnostic. If information gathered is used to monitor teachers' progress during pre-service or in-service programmes and to take corrective measures whenever required, evaluation is called formative. This type of evaluation is carried out periodically and is therefore also called continuous evaluation. Evaluation which is carried out at the end of a course or session is called summative evaluation. The scheme of evaluation should be both continuous and comprehensive. A procedure of evaluation which adequately measures both cognitive and non-cognitive learning outcomes is commonly known as comprehensive evaluation. The scheme of evaluation which takes care of both the aspects - continuity and comprehensiveness of evaluation, is called continuous and comprehensive evaluation.



4.4.1 Formative evaluation

Formative evaluation is carried out to provide the teacher, as well as the learner, with feedback that can be used in taking corrective measures at different stages in the teaching-learning process. Objectives of formative evaluation are:

- to determine the progress being made by the learners and the difficulties they may be experiencing;
- to guide the learning process;
- to decide which learners need further help and the nature of activities and strategies that might help them;
- to pace the learning process and make the learner more alert to his or her performance.

Formative evaluation is conducted mainly to improve learning. This does not mean that tests used for formative evaluation cannot be graded. However, the grading is done to find strengths and weaknesses in the teaching-learning process. Formative evaluation, therefore, provides both teachers and learners with feedback on the achievement of the objectives. Teacher educators should model how this can be done in their own teaching.

4.4.2 Continuous and comprehensive evaluation

Evaluation forms an integral part of teaching-learning process. continuous evaluation of learner's achievement is carried out periodically during the teaching-learning process to judge if the competency has been mastered by the learner. Evaluation is commonly done only in the cognitive areas of learning such as knowledge and understanding and some basic skills. Evaluation of non-cognitive areas of learning such as values, interests, attitudes, habits, etc. is hardly attempted. Effective evaluation procedures need to be employed so as to measure both cognitive and non-cognitive learning outcomes. Emphasis should not be on measurement of learner's learning alone but for improvement of their achievement on a regular basis. If some 'slow' learners not ready to develop or learn competency completely, their weaknesses need to be diagnosed and the hard spots of learning identified and followed by appropriate remedial programme. Evaluation therefore should be continuous and comprehensive for evaluating learners' achievement in both cognitive and non-cognitive areas on a regular basis for their scholastic and non-scholastic growth, by the teacher through periodical tests by employing variety of tools, techniques and regular feed back. The final grade a learner receives in a course or session is not based on a single final annual examination, but takes into account the results of the evaluation through the session.

Characteristics of continuous and comprehensive evaluation

The continuous and comprehensive evaluation need to be:

- **Continuous:** The word continuous refers to regularity in testing. The development of learner is a continuous process, we need to know at every stage the degree of development so as to initiate appropriate remedial or enrichment measures as and when needed. This can be ensured only when assessment is carried out on continuous basis through periodical tests by the teacher.
- **Comprehensive:** Through education we want all round development of learner which includes development of both cognitive and non-cognitive abilities. The development of cognitive and non-cognitive abilities can be ensured only when we go in for comprehensive evaluation taking into cognisance of each and every specific objective pertaining to both the domains. Besides, comprehensive evaluation is an integral part of system of education, interlinked with educational objectives and teaching process. This holistic evaluation provides valuable information on the teacher trainee's performance.
- **Systematic:** All measurements at different time interval have to be planned systematically.
- **Guidance-oriented:** Test result should be used for improvement of learning process. The emphasis should be more on improvement rather grading the achievement.

Evaluation is oriented towards providing guidance in that the information obtained is used to guide the teacher trainee's future professional development.

- **Flexible:** The teacher educator should be able to adapt his evaluation programme in accordance with his/her own teaching schedule and needs of his/her class along with other factors.
- **Economical:** Evaluation should be carried out in such a way that it is economical in terms of time, effort and money.
- **Diagnostic:** The deficiencies identified in learning should provide basis for remedial measures.
- **Co-operative:** There should be involvement of teachers, learners, parents, peers, observers and even community members to make it more objective, reliable and valid.
- **Functionality:** Evaluation should not be too technical and cumbersome. It should be based on possible available resources and inputs.
- **Gender sensitive:** In framing questions attention should be taken to ensure that there is no gender bias of any kind.

It is important that teacher educators demonstrate these characteristics of continuous and comprehensive evaluation in the evaluation of the teacher trainees and then enable the teacher trainees to use the strategies with their learners during teaching practice. This will help the teacher trainees to develop appropriate skills.

Problems associated with continuous and comprehensive evaluation

Teacher educators should be aware of the problems outlined below, discuss them with teacher trainees, offer suggestions and allay fears.

- **Workload of the teacher:** There can be no denying that continuous and comprehensive evaluation makes demands on the teacher. Whether this work is above and beyond that which the teacher can reasonably be expected to undertake as part of teaching depends on particular situations. As was stressed above, evaluation and feedback are essential in teaching. Where continuous and comprehensive evaluation is used to provide feedback, it is reasonable to expect teachers to integrate this into their normal workload.

  The problem with continuous and comprehensive evaluation arises, however, when the learning outcomes need to be recorded for use by other teachers and outside agencies. This usually has to be done in a standard format that involves the teachers in additional record keeping work and carrying out evaluations at stipulated periods for record keeping rather than at times most appropriate to the teaching situation.

- **Teacher learner relationship:** Some teachers are concerned that formally evaluating learners will interfere with teacher learner relationships and with the role of the teacher in providing feedback and counselling. The perception is that learners will be afraid to give ideas and opinions because they may be penalised during evaluation.

Teacher educators must realise that evaluation and feedback are one and the same and that evaluation, of any form, needs to be an integral part of teaching. When learners understand this and are able to establish and accept the need for evaluation and feedback, the teacher learner relationship can be enhanced. It appears that the fear of teacher trainees is associated with an inability to link evaluation with teaching.

4.4.3 Summative evaluation

Evaluation which is carried out at the end of a course with the sole purpose of grading, promotion or selection is termed summative evaluation. Results of summative evaluation are also used for accountability purposes of individual teacher educators or teachers or of their institutions. Summative evaluation also informs policy makers about the standards of education and the efficacy of the curriculum.

Summative evaluation is normally carried out using paper and pencil tests and/or practical tests administered towards the end of a term or academic year. Such tests may be conducted by the institution itself or by an external examining agency.

In some countries, teacher trainees' success or failure at the end of a teacher education programme is mainly determined by an external examination body. It has been advocated that teacher educators should have some input in determining the final grades of their teacher trainees.

For a valid evaluation of the teacher trainee , the results of continuous and comprehensive evaluation should be used to supplement summative evaluation.

4.5 Tools and techniques for Evaluation

The objectives of science and technology education about which information will have to be collected are in the areas of :

- knowledge and understanding of science facts, principles, methods and materials;
- process skills such as observing, classifying, communicating, inferring, hypothesising, experimenting, designing and problem solving;
- attitudes, interests, curiosity, critical thinking, perseverance and openness.

A variety of techniques can be employed to collect information about learners' progress. Some of the important techniques are given below:

- written tests;
- practical tasks carried out by individuals or groups;
- questionnaires;
- scheduled interviews;
- rating scales;

- check lists;
- observation during normal activities;
- written records of work produced including drawings;
- listening to oral explanations.

Evaluation through observation during normal activities 4.5.1

Observation (as a technique to collect information) provide qualitative information about the objectives being evaluated. Through observation skills, attitudes and acquisition of concepts can be evaluated over an extended period of time. Since the learners are being evaluated through observation of their normal activities, they are not under stress; also, there is no loss of teaching-learning time. All the learners need not be evaluated at the same time through one activity. To aid observation, actual classroom activities could be video-recorded. These recordings could also be used by teacher trainees to develop and practise observation skills.

Observation is a very powerful information-gathering technique since it can be used to collect information about a wide range of behaviours spread over several objectives. However, the teacher educators and the teacher trainees need to recognise that observation goes beyond simply looking at what learners are doing. For the technique to be used successfully, the activities to be observed and the particular stages within them, must be clearly identified. The emphasis is not on observing whether or not the learner is doing the right things but on what the learner can or cannot do.

In addition, criteria have to be established, against which observations can be measured and recorded. The criteria are generally derived from the learning objectives and the stage of development of the teacher trainee. This aids proper interpretation of the observations and in establishing the learners' progress, information which is very useful for the teacher educators and teacher trainees in planning future activities for the learners.

One disadvantage of collecting evaluation information through observation is the element of subjectivity. The observer has to be skilled in the technique. An unskilled observer may miss certain important factors that should be noted.

Using written tests for gathering information 4.5.2

Written tests may contain a variety of questions such as:

- Objective type questions (multiple choice, fill in the blank, True/False and matching)
- Very short answer
- Short answer
- Essay type

Written tests are used mainly for collecting information about learners cognitive abilities and some drawing skills. They cannot be used for testing a wide range of psychomotor skills. They can, however, be used for both formative and summative evaluation. Most written tests include essay-type and multiple-choice questions, and some characteristics of these are listed below. The language used should be simple, precise with no ambiguity.

Essay-type questions

These questions require more extended written answers and the ability to integrate and express ideas involving:

- description, explanation and prediction of processes and structures;
- description of instruments, apparatus, etc.;
- factual knowledge;
- interpretation of experimental numerical data;
- discussion of results of experiments and solutions of problems.

Advantages

- They reduce guesswork in answers.
- They reduce the possibility of cheating.
- They provide freedom of response.

Disadvantages

- In marking essay type questions, the teacher tends to carry impressions from one paper to another.
- Essay type questions cannot be used effectively with learners with low levels of language development.

Evaluation through essay type questions at primary school level should be limited to short paragraphs only.

Multiple-choice type questions

Multiple-choice questions can be useful in covering a range of curricular objectives. A multiple-choice question usually consists of a question or statement, called the 'stem', followed by four or five choices of answers or 'options'. The stem may also be a partial statement that is completed by one of the choices. Only one of the options is the correct answer to the question or ending to the statement. The other options are called 'distracters'.

Other forms of multiple-choice questions include:

- **True/false questions:** These are not particularly useful since there is a 50% chance of guessing the right answer.

- **Fill-in-the-blank questions:** Here possible responses may or may not be supplied to the learner. If responses are provided the learner selects the most appropriate response. To reduce the chances of guessing, more than two response should be provided.
- **Matching questions:** These are presented in the form of two lists of statements. For each statement in one list there is one correct statement in the other list and the learners have to match them. The primary cognitive skill tested by matching exercises is 'recall'.

Teacher education programmes should include practice in the construction and review of different types of questions and written tests. The review should include analysis of each item of the test.

Using oral test 4.5.3

Formal examination at least in the first two classes of the primary stage may be avoided and 'oral mechanism' of evaluation for these two classes can be devised so that the learners gain competencies of the basic skills which are expected to be mastered in these classes.

Exemplars of oral mechanism

Oral questioning has all along been a part of the classroom activity. At this stage the teacher can use the following mechanism.

- Quiz contest
- Single question put to individuals in a group while lesson is being taught.

The following aspects in language used for science and technology education could be tested through oral mechanism.

1 To speak with correct articulation and intonation.

2 To speak grammatically correct language

3 Vocabulary and its usage

4 Delivery (communication skills)

Also, a quiz competition can be organised.

The techniques for oral examination are:

(i) reading aloud picture story card;

(ii) prepared questions;

(iii) conversation on prepared topics;

(iv) general conversation;

(v) questions on pictures and role playing, etc.

4.5.4 Other tools and techniques

In order to keep a record of learners qualitative account of behaviour teacher educator can resort to a variety of tools such as checklists, behaviour tally charts and rating scales.

Some examples of these tools are given below:

Rating scale

Instructional focus: Enquiry of the quality and process of work

1 Relevance of action to word:
   - (a) Seldom
   - (b) Sometimes
   - (c) Most of the time

2 Shows keen interest:
   - (a) Seldom
   - (b) Sometimes
   - (c) Most of the time

3 Clarity in pronunciation
   - (a) Seldom
   - (b) Sometimes
   - (c) Most of the time

Name of pupil ____________________ Observer ____________________

Activity ____

S. No	Criteria	Rating A	Rating B	Rating C
1.				
2.				
3.				
4.				
5.				
6.				

Check-list

Check-list for evaluating desirable health environmental and sanitation habits.

Instructional focus: Obeying of safety and health rules.

Name of pupil ______________________ Observer ______________________

S. No	Criteria	Rating Yes	No
1	Washes hands before and after meal		
2	Covers the mouth when coughing and sneezing		
3	Avoids spitting		
4	Urinates at proper place		
5	Uses latrine properly		
6	Does not throw garbage indiscriminately		
7	Always keeps face, eyes, nose and ears clean		
8	Trims the nails regularly		
9	Combs the hair daily		
10	Puts on clean clothes		
11	Takes bath daily		
12	Does not insert nails, pencils, etc., into nose, ears and mouth		
13	Does not drink dirty water		
14	Prevents contamination of food from flies and dust		
15	Does not eat uncovered food		

Oral test

Oral test on observation

1 What is the name of your school?

2 Are there extra rooms other than your classroom?

3 On what does your teacher write while teaching?

4 Name five living and five non-living things in the school.

5 Of what material is your school walls made of?

4.6 Evaluation of problem solving – some examples

To solve a given problem, a learner has to use certain ideas and skills. From the point of view of evaluation, it is vital that these are carefully identified and documented, so that the extent to which they have been used successfully can be evaluated. For the purposes of grading and assessing progress, a series of statements in terms of what learners will or will not be able to do at each stage, should be needed. Each stage can be assigned a mark.

Possible developmental stages and investigative skills to be assessed

SKILL 1: **Using and organising techniques, apparatus and materials**

Stage 1: Can follow written, oral or diagrammatic instruction to carry out one operation; needs help to do more; uses familiar apparatus adequately, but needs showing how to use unfamiliar apparatus; rather thoughtless over safety points.

Stage 2: Can follow written, oral or diagrammatic instruction to carry out an operation involving a series of steps and uses familiar apparatus adequately and safely; needs demonstration of how to use unfamiliar apparatus.

Stage 3: Can follow written, oral or diagrammatic instruction to carry out an operation involving a series of steps and is able to modify the instructions to improve the operation of the equipment; uses familiar apparatus adequately and safely; can make a fair attempt at using unfamiliar apparatus.

SKILL 2: **Observing, measuring and recording**

Stage 1: Can follow detailed instructions to make observations; can make simple measurements using a simple measuring device; records results in an appropriate way when shown how to do so.

Stage 2: Makes measurements, given a brief outline of how to do it; can use some more complex measuring devices such as those having a scale where 1 division is equal to 0.1 of unit or 2 units; reads most devices but may not do so with complete accuracy; records results in an appropriate way given an outline format.

Stage 3: Makes relevant observations that are as accurate as possible; can read any scale correctly; records results correctly without being given a format.

SKILL 3: **Handling experimental observations and data**

Stage 1: Can process results adequately given detailed instructions on how to do it; can draw one obvious conclusion from the results.

Stage 2: Can process results adequately given outline instructions on how to do it; can recognise results that might have experimental errors; can draw conclusions from the data.

Stage 3: Can process results adequately without help, recognises experimental errors and knows how to deal with them; can identify possible reasons for the error; can draw conclusions; and also makes general deductions from data.

SKILL 4: **Planning and investigating**

Stage 1: Can suggest a simple experiment to investigate a practical problem, although this may not work; can attempt modifying the experiment if it does not work.

Stage 2: Can list a series of steps to carry out an investigation; can modify the steps that do not work well; can recognise the need to control variables though may not be very clear about how to do it systematically.

Stage 3: Can list a series of logical steps to carry out an investigation that is likely to work in practice; modifies the steps that do not work well; recognises the need to control variables in a systematic way.

Evaluation of individuals in group work 4.7

Most evaluation in science and technology education is carried out by teacher educators, but teacher trainees can be good evaluators of each other especially when they work in a group on an activity. An example of how an individual in the group work can be evaluated is given below.

An innovative teaching in a school came up with an interesting approach to evaluating group work.

An overall point (percentage) grade is awarded for the activity or assignment of the group of the learners as a whole. The members of the group then decide how the marks should be distributed amongst themselves, according to the contribution each made to the work. The total marks for individual learners must, in the end, equal the mark the teacher gave to the group. If they feel they all contributed equally, they can each earn the same percentage. According to the teacher, this strategy works very well. Within a group, each individual learner knows very well who did the work or who was just sitting around!

4.8 Record keeping

Information processing is part and parcel of tools and techniques of evaluation. How information is processed is reflected in the design of tools and organising techniques of evaluation. Judgement formation and decision making will be possible through good and proper record keeping.

There are many different ways to keep records of learners' achievements and progress. The nature of the record depends to a large extent upon the technique used to collect information. For example, the record of an observation tends to be descriptive, giving information on the absence or presence of the trait being observed. Similarly, the record of a written test tends to be numerical. The type of record to be maintained also depends upon the purpose or use of the record. In general, a numerical record is not useful if one wants to know what learners can or cannot do. But if the purpose is grading the learners, then a numerical record is more useful than the descriptive record.

During formative evaluation, most of the information gathered is interpreted and used immediately for taking corrective measures in the learning activities of individual learners and for planning future activities. A record of the stages of development reached by the learner can be very useful in deciding long-term activities.

A common practice is to prepare a list of activities and tick them off as individual learners complete them. This kind of record is not very helpful since it does not tell the teacher what the learner can or cannot do. To improve the usefulness of such a list, a 'remark' column can be added where the skills observed/achieved could be written. Alternatively, a list of possible skills to be assessed could be drawn up, and for each learner the particular skills observed/achieved ticked off.

4.9 Profiles

A profile is a method of building up a picture of attainment that allows separate grades, scores, marks and other measures to be recorded for each learner. The picture can be broadened by including factors such as attitudes, health data(cleanliness), punctuality, co-operation, truthfulness, absenteeism and self-esteem. These additional attributes can be judged on, say, a 3- or 5-point scale.

Profiles can be of two types:

- An extension of the conventional evaluation data, in the sense that learner performance is reported on a large number of dimensions.
- Information presented as a record of the learner's abilities, skills and attitudes, which are explicitly stated and which describe the learner's characteristics and attributes on a criterion-referenced basis.

Conventional Evaluation Profile 4.9.1

In the first type of profile, the data obtained from examinations is put forward as a kind of report. The data are presented in greater detail in the sense that greater numbers of subdivisions are included. But the data themselves are still either the percentage scores, or the percentages related to a 3- or 5-point scale, which may be numerical or labelled, for example, 'above average','average', 'below average'. When the middle grade is labelled as 'average' (average for the learner population), the profile is said to be based on norm-referenced evaluation.

Developing criterion-referenced profiles 4.9.2

If adequate information is given about the learners, the profile system mentioned above can be meaningful. But in the absence of such data (which is often the case), more meaning is attached to the profile by including the specific criteria against which measurements are taken. There is however a tendency for the profiles to be based on criteria and be related to criterion-referenced evaluation.

Relationship with fellow learners

4 A leader/dominant personality

3 Accepted member of learner groups

2 Likes to join with other learners, a follower

1 Independent, quite isolated; tends to be on his/her own

Ability to work with others

4 Works well as the leader of a team

3 Works well as a member of a team

2 Prefers to work on his/her own

1 Does not fit in well as a member of a team

Punctuality in the last year of school

3 Excellent

2 Some lateness

1 Poor

Regularity in the last year of school

1 Excellent

2 Some absenteeism

1 Poor

Discipline

4 Self-discipline – able to relate to a normal adult/child, teacher/learner situation

3 Accepts a specified pattern of behaviour and rules

2 Accepts an imposed pattern of behaviour and rules where there is a degree of supervision

1 Does not always accept a pattern of behaviour required by the learner group.

In a criterion-referenced profile, the numbers represent a 5-point range, with 5 being a high proficiency and 1 a low proficiency rating. The numbers could be easily substituted by grades or use could be made of other systems. for example the ability to use a scientific instrument could be graded as:

5 = can use a scientific instrument accurately and safely;

4 = can use a scientific instrument, with guidance, and is aware of safety aspects;

3 = can use a scientific instrument, with guidance, but is not aware of safety aspects;

2 = can not use a scientific instrument, even after guidance, but is aware of need for safe practice;

1 = cannot use a scientific instrument, even after guidance, and does not consider safety aspects.

4.9.3 Problems with profiling

There are three main problems associated with the profiles as a method of record keeping:

- the time it takes to develop and maintain the profile;
- the type of profile to be designed and the qualities to be described in them;
- the technical aspects of the educational measurement on which the profile is to be based, including validity and reliability.

The type of profile developed depends on the needs of the end-user.

Profiles are usually developed to show what a learner can achieve. It is a record of achievement and attitudes. The technical aspects of the profile are to do with the development of levels that show gradations in academic achievement or attitudinal development. The acceptability or validity of the profile depends on how meaningful the statements being made are to the end-user.

Profiles can be extended beyond characteristics that relate to cognitive ability or practical skills. The example below shows part of a profile covering aspects of attitude. Again, a criterion-referenced format is being followed.

MONOGRAPH
5

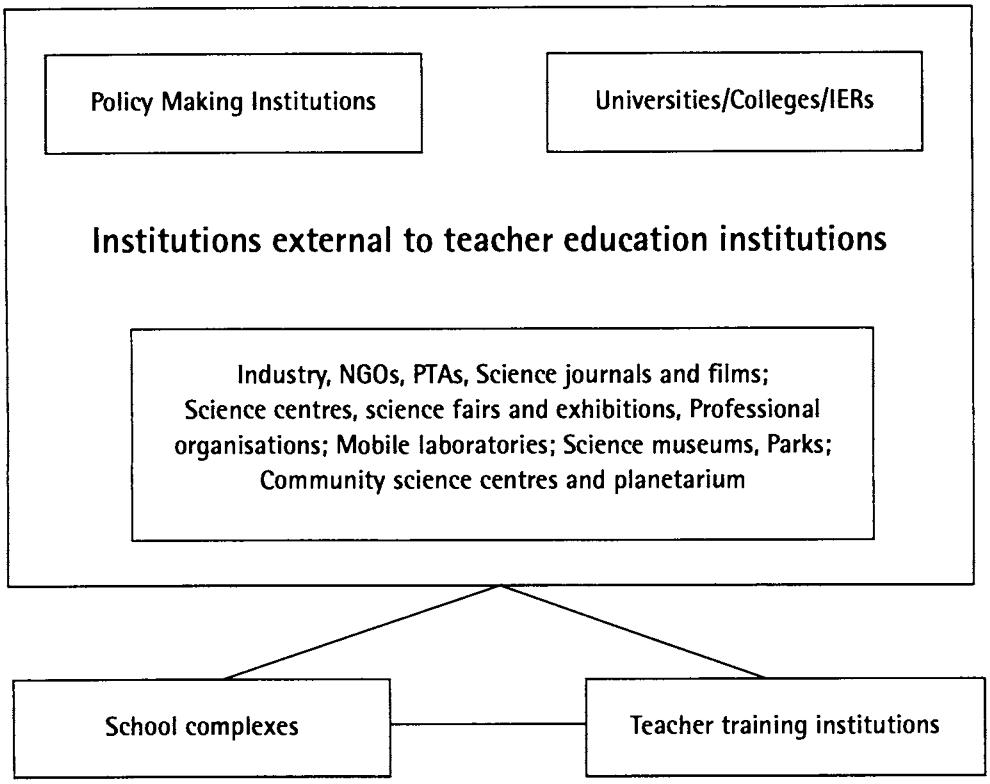
Professional development of science and technology teacher educators

Overview 5.1

The importance of professional development of science and technology teacher educators is crucial in the context of emerging trends in science and technology education. The role of science and technology education is being increasingly recognised as a means of developing objective and rational human beings having specific competences and skills to cope with the rapid socio-economic, cultural and environmental changes brought about by the applications of science and technology for improving the quality of life.

In order to meet these emerging needs, science and technology education calls for a curriculum which will produce socially responsible, technologically and scientifically literate citizens who are able to solve problems in real-life situations, use local technologies, improvise materials and develop rational decision-making skills. The science and technology teacher educators are required to handle teacher education programmes at basic level comprising liberal education, with sound knowledge of content and professional education. To improve the quality of science and technology educators, suitable ways and means need to be devised for enabling them to keep abreast of developments and advances in the scientific and technology areas. Continuous professional development is now universally acknowledge as one of the pivots of science and technology education programmes. This further demands suitable professional development programmes for science and technology teachers as well as teacher educators in view of emerging needs and trends in science and technology education.

Professional development of science and technology teacher educators depends upon the role of institutions of teacher education and those agencies and organisations which influence them directly or indirectly. For effective professional development, it is essential to have collaboration and coordination within and between teacher education institutions, other educational agencies professional support services, and organisations and the schools. It has been envisaged that the purpose of the coordination at school level is mainly for the professional development of science and technology teachers. Figure 1 gives a comprehensive view of mutually interactive relationship between school complexes/schools, teacher-training institutes and other agencies/organisations affecting professional development of science and technology teacher educators.



5.2 Objectives

The objectives of this monograph are:

- to help science and technical level for professional development of teachers and improved science and technology teaching in schools.

5.3 Professional organisations and institutions involved in the professional development of science and technology teacher educators

A large number of professional organisations have been considered which could contribute to the professional development of science and technology teacher educators. Some of these are concerned with policy, others with professional training and/or academic growth, and still others with providing support for teacher education.

5.3.1 Organisations and institutions concerned with policy

Ministries of Education

The Ministry of Education decides on the national priorities and policies for education. Science and technology teacher educators should be aware of relevant policies. These may be contained in a general policy document of the Ministry of Education with a section on science and technology or there may be a separate policy document. This is likely to include policy statements and guidance on:

- the type of science and technology to be taught in schools;
- the general methodology to be followed in delivering science and technology to learners;
- the assessment procedures to be followed;
- any in-service training which will be provided to teachers and others.

Department/Directorate of Education and other educational institutes, such as NCERT in India, IPSP in Pakistan, National Curriculum and Textbook Board in Bangladesh, NIE in Sri Lanka usually provide material resources to schools and advises on textbooks and other learning materials. Science and technology teacher educators should be aware of the role of these institutes and the kind of physical resources provided to schools by them. Teacher educators should have an input into various activities of these institutes.

Practices with regard to school supervision and inspection, such as its frequency, procedures and nature, are also determined by the Directorate/Department of Education. Teacher educators can help to allay teachers' understandable apprehension about the content and method of inspection by making teachers trainees aware of inspection procedures.

Curriculum development units

The importance of a well developed and managed curriculum is well recognised. The responsibility of curriculum development in various countries resides with national as well as state provincial level institutes, usually the Departments/ Directorates of Education. Tuition given by the science and technology teacher educator is more likely to be relevant and contextual if curriculum development is a collaborative effort involving teacher educators. Teacher educators should size every opportunity to participate actively in curriculum development process.

Science and technology education can benefit from a cross-curricular approach. The curriculum guidelines provided by the curriculum development unit should encourage such an approach and facilitate its implementation.

Organisations and institutions concerned with professional training and/or academic growth 5.3.2

Universities and Institutes of Education

For their own professional and academic growth, science and technology teacher educators should co-ordinate with higher education institutions such as universities, colleges and other institutes, concerned with science and technology content and pedagogy. They should attempt to attend meetings, workshops, seminars and short courses organised by these institutions in areas which are of interest to them. Within teacher education institutions, opportunities for participation in these seminars, workshops and courses, need to be planned for to enable all members of the science and technology education staff to participate.

In order to facilitate a cross-curricular approach in science and technology, teacher educators should urge the institutions of higher learning to provide:

- short courses which allow teacher educators to upgrade their knowledge as required. For example, technologically oriented courses by using resource personnel from industry.
- broad-based degree programmes to allow teacher trainees the opportunity to pursue integrated degrees.

In-service Education and Training (INSET) for in-service teachers as well as pre-service teacher training for teacher trainees is usually conducted by the teacher training colleges and other institutes. These institutions aim at imparting similar teacher qualifications. It is essential that the philosophy underlying them is similar. Such agencies should be in constant communication so that those completing their courses will have equal opportunities in the workplaces.

5.3.3 Support organisations and institutions

Examination agencies

If teachers are taught to follow a teaching approach which emphasises processes and problem-solving in science and technology, but the examinations test only recall of knowledge, teachers will abandon or modify their approach and adopt a didactic approach more suitable for memorising the knowledge needed for passing the examination. At the teacher training college level and within and across colleges, teacher educators in all subject areas should co-ordinate their efforts to ensure that examinations reflect the teaching approaches used.

At teacher-training institute the problem calls for co-ordination between the curriculum development unit and the examining agency. If there is no co-ordination, teachers will tend to follow the approach most suited to getting learners through the examination. Differences between examination practices and curriculum policies clearly have implications for the education of teachers.

Problems may also be caused if the examination system does not take account of learners' performance in continuous and comprehensive assessment (discussed in Monograph 4)in the award of the final grade. It will need to be made clear to teacher trainees, that continuous and comprehensive assessment in the classroom provides valuable feedback for the improvement of learning and teaching, even if it is not required for formal examination.

Professional Support Services and organisations

Science and technology teacher educators will find it helpful to be involved with relevant professional organisations, to know of their current activities and understand the issues that concern them. Such professional contacts will help the science and technology teacher educators to make teachers trainees aware of current issues and work with them so that they themselves can contribute to current debate and appropriate activities when they become teachers.

professional associations of teacher educators, Association for the Advancement of Science, Science and Technology Teacher Associations at the district, state and national level play an important role and contribute significantly, provide forum for interactions and help in disseminating new ideas, concepts, activities through journals.

Community science centres, Science Teachers' Centres, Science Resource Centres at the local school level could be of much help to a science and technology teacher educator as well as teacher involved with the activities of these organisations in discharging role as a community worker and as an interpreter of technology to the community.

Mobile science and technology laboratories could help the science and technology educators and teachers by offering them on-the-spot training and orientation even in remote areas where science laboratory facilities are inadequate. Such a facility in the form of charts, models experiments and low-cost improvisations would allow teachers of such schools to improve their teaching and also provide learning experiences to the learners.

Professional science magazines/journals containing interesting articles on science and technology can be of great help in updating the science and technology teacher educators and teachers. Mobile libraries containing books, films and other resource materials on science and technology can be of great help for the science and technology teacher educators and teachers update their knowledge.

Local industry

To ensure that science and technology is relevant and realistic, particularly in its technology aspects, teacher educators will want to draw examples from local, traditional and modern industry. Local industry is an excellent resource since it provides real contexts and genuine problems. Teacher educators should co-ordinate with local industry so that they may draw on their human and material resources. This should be a two-way flow of information and skills. If possible, science and technology teacher educators should visit various industrial plants for short periods, so as to familiarise themselves with the demands of these industries. Similarly, persons from industry must be invited to visit teacher education institutions for lectures, discussions or demonstrations some industries might provide teaching materials or equipment.

Such two way exchange of experiences will not only help science and technology teacher educators develop realistic activities, but help industry to understand how science and technology are taught in school, and thus develop confidence in their local teaching institutions. Science and technology educators will also gain an understanding of the requirements of industry, and the kind of curriculum which will meet these requirements.

Schools

Co-ordination with schools is needed for the purpose of:

- practice teaching;
- action research;
- providing professional support for the professional development of teachers and improved science and technology teaching;
- understanding the working environment;
- acquiring first-hand experience of working with learners.

To keep up to date with current practice in schools, it is important for science and technology teacher educators to devote regular periods of time to working in the primary school, alongside science and technology teachers. Such time, is invaluable in helping teacher educators to keep their own teaching realistic.

Most teacher training colleges do not have a practice school or a demonstration school attached to the training college. As such, most of the training colleges use the neighbouring schools for the purpose of practice teaching. For arranging effective practice teaching teacher educators must have firsthand experience of working with the science and technology teachers of the neighbouring schools. They must know the strengths and weaknesses of each teacher so that their competencies may be utilised for the purpose of practice teaching of teacher trainees. This would require that teacher educators must devote time in the actual classroom teaching and helping teachers. Efforts should be made to identify enthusiastic "headteachers" to take the role of teacher educators in helping teacher trainees and other teachers in neighbouring schools.

Teacher educators must also undertake collaborative action research projects with the neighbouring schools. This will not only help them in solving problems of local schools but will also enable them to provided success stories to teacher trainees thereby marking their teaching more lively and realistic. This way they will be able to train teacher trainees in techniques of action research.

Inexperienced teachers and teachers working in schools located away from cities suffer from professional isolation. In case of difficulties they hardly find anybody who could provide the required professional support. Teacher educators must realise that such teachers to be effective require continuous professional support. Similarly, when teachers are required to introduce an innovation, provision of continuous professional support is absolutely necessary for the innovation to be sustained. Teacher educators must develop mechanisms by which such support may be provided to teachers. It does not help to blame the lack of resources and constraints for not providing the support. Every effort should be made to develop mechanisms of professional support within the existing resources and constraints.

As stated in Monograph 1, teacher educators must aquatint the teacher trainees with different kinds of working environments and train them to cope with such environments. It can be possible only if the teacher educator has familiarised himself/herself with different kinds of environments and what methods/resources are useful in those environments. This would require the teacher educator work for some time in different kinds of environment to develop good understanding.

School-based orientation and enrichment to teachers could be provided by science and technology teacher educator. Teacher educators might also utilise the school clusters and school complexes as a resource base in which a centrally located institution helps and assists other schools and school science teachers in the neighbouring area/region. This strategy will provide on-the-spot remedial solutions to teaching-learning problems of the teachers on a continuous basis.

Teacher educators must also collaborate with the neighbouring schools to develop an understanding of how children learn. This would require actual teaching children at different levels. This will enable the teacher educator to provided realistic guidelines to the teacher trainees of working with children.

Co-ordination within and between teacher education institutions 5.4

Co-ordination and collaboration between the colleges of education will provide an avenue through which teacher educators can foster their own professional growth, promote some uniformity in the quality of experiences provided for teacher trainees, and develop cross-curricular links and interdisciplinary approaches. These may be achieved through:

- Developing professional organisations for science and technology educators. These may relate to the two disciplines separately, or in any combinations as required by the specific circumstances of a country.
- Promoting regional co-ordination between such national professional organisations and associations of advancement of science and technology.
- Mounting workshops, seminars or conferences for sharing ideas on teaching approaches and resource materials, and for engaging in discussion on current issues and trends in science and technology education.
- Preparing position papers representing the consensus views of teacher educators as a means of influencing policies and decision-making with respect to teacher education.
- Making proposals for new directions in teacher education in response to prevailing social, economic or cultural influences.
- Fostering collaborative approaches to teaching, such as team teaching and team planning.
- Developing theme and project approaches to teacher education, as well as improving the delivery of the science and technology teacher education curriculum. Such approaches will benefit teacher trainees by providing them with models for cross-curricular approaches in their own classrooms.
- Exchanging human and material resources within and between colleges.

5.5 In-school activities for professional growth of science and technology teachers

Teaching science and technology in schools involves the organisation of a number of activities. These may be broadly classified as:

- those directed towards the professional growth of teachers;
- activities directed towards effective teaching and learning;
- co-curricular activities leading to promotion of science and technology amongst learners and the community.

In order to equip the teacher to organise these activities efficiently, science and technology teacher educators themselves should be fully aware of all such activities and effectively train the teachers accordingly.

5.5.1 The science and technology education co-ordinator

For effective implementation of science and technology education programmes, a staff member needs to be designated as a science and technology education co-ordinator. He/she takes on professional development programmes of teachers of his/her school or in a cluster of neighbouring schools. It could be the head-teacher, or an enthusiastic class teacher in the school with an interest in developing science and technology. If the co-ordinator is a teacher his/her teaching load may have to be marginally reduced to make room for the demands of co-ordination. The science and technology teacher educator should organise training programme for the science and technology education coordinators in such a way as to help them develop skills of coordinating activities related to the professional development of teachers and improved science and technology teaching in schools.

5.5.2 Participation in meetings/seminars/workshop

Activities which promote the professional growth of teachers normally take the form of participation by teachers in meetings, seminars, workshops and INSET courses. Such activities are usually organised by the Departments of Education, colleges or institutes education and teacher associations. Activities are also organised in schools by those teachers who have had the benefit of attending INSET programmes.

Institutes of education organise INSET courses for a variety of reasons:

- to introduce a new curriculum;
- to introduce a new teaching methodology;
- for upgrading content;
- for certification of untrained teachers;
- for introducing a new assessment or supervision system.

Depending on the nature of the INSET course, the Department of Education may specify the number of teachers from each school who will attend the course. If the course is for a limited number of teachers from a school, the science and technology education co-ordinator will be responsible for selecting those teachers who would benefit most from a course. If it is a course for content upgrading, for example, it would be inappropriate for a new science graduate to attend. On the other hand, a course leading to teacher certification would be most suitable for an uncertified teacher. To facilitate selection, the science and technology education co-ordinator will need to maintain the following record for each teacher in the schools;

- educational qualification;
- teaching experience and results produced;
- participation in science and technology education workshops, seminars and so on, with dates;
- strengths and weaknesses.

The science and technology education co-ordinator must ensure that the teacher who attends an external INSET course organises a meeting of all the school's science and technology teachers and briefs them on the course attended. This feedback will serve three purposes:

- it will help the INSET course trained teacher to consolidate what he or she learnt on the course;
- the teacher attending INSET course will have to be more attentive when on the course, knowing that he or she will have to present it himself/herself to other science and technology teachers when he/she returns to school;
- other teachers will benefit from the course.

Thus one course can benefit more than one teacher in a school. In addition, the course organisers can benefit from the teacher's report on his or her feedback to school, so that the course itself may be improved.

The focus of the teacher's feedback briefing to fellow teachers in the school should be on:

- implications for teaching and learning within the school;
- changes which could be made within the school in relation to these implications, which would make the science and technology teaching more effective.

School-based INSET programme 5.5.3

In the busy school schedule, teachers rarely have time to sit together and share experiences. In a large school, teachers may be facing some common problems which could be resolved through sharing experiences and discussion. Similarly, some teachers may have success stories and unique classroom experiences which may benefit other teachers. It is therefore always useful if the science and technology education co-ordinator can arrange for the teachers in a school to meet, possibly after school or at a weekend, for, say, half a day each month. The object of this meeting would be predetermined through mutual consent, and known to all teachers concerned beforehand, so that everybody comes prepared. It is important for the science and technology education co-ordinator to plan the meeting, draw up a timetable, and assign responsibilities. Science and technology education teachers should be encouraged to volunteer to take up responsibilities rather than be coerced.

School-based INSET programmes, though generally short, can be useful in:

- preparing teaching-learning materials by sharing ideas;
- improving materials;
- resolving conflicts arising out of the use of resources;
- disseminating action research findings and generating ideas for action research;
- developing collaborative work amongst teachers.

A major advantage of a school-based INSET programme is that the innovations can be sustainable. Since new ideas are being generated and tried out by colleagues, the chances of successful innovation are greater. A new idea coming from a colleague is much more likely to be accepted than one imported from an outside source. Thus, school-based INSET programmes are not only useful for the professional growth of science and technology teachers, but contribute to improved teaching and learning. Alternatives to school-based programmes may be needed for smaller schools and for those where science and technology teachers are not willing to try new ideas.

5.4.4 Access to the resources

This is another important role of the science and technology education co-ordinator. In primary schools, the resources supplied by the Department/Directorate of Education are generally limited. Most of the materials required for science and technology education will be drawn from the immediate environment. The science and technology education co-ordinator will need to ensure that while the materials are safely stored,these are also easily accessible to the users. This means discussing this with the relevant teachers and identifying a place suitable for all of them. Over a period of time learners and teachers of senior classes may develop new teaching and learning materials which could be useful in junior classes. Such products should be identified, displayed and stored, and teachers encouraged to use them.

5.5.5 Extra-curricular activities

The science and technology education co-ordinator can help the teachers enabling them to organise and conduct activities such as those listed below aimed at developing the interests of learners in science and technology.

- **Science Debates and quizzes:** Science, technology and mathematics-related issues can be debated by learners. Quizzes taking the form of question and answer can be devised. As part of an INSET programme, teachers could build up a bank of topics for debate and questions for quizzes. Careful selection of topics for debate and quiz questions within the school setting can arouse interest and encourage learners to explore the relevance of science and technology to the out-of-school environment. Topics which encourage girls to participate in science and technology should be given preference. Inter-school competitions allow science and technology teachers to exchange ideas about more effective ways they may have developed for teaching science and technology concepts and skills. Learners could also gain from sharing ideas with their peers in other schools.

- **Science Fairs, exhibitions and museums:** Periodic school fairs and exhibitions of science and technology materials made by learners and teachers can be arranged. Exhibits can form the basis for a more permanent school museum that can become a resource for future generations of learners. Labels showing the names of students and dates should be attached to exhibits to boost the morale of their creators. The items exhibited could be projects carried out by the learners. Exhibits that show links between science and technology in schools and community activities can be particularly encouraged. Schools should also be encouraged to participate in exhibitions organised by other schools and agencies. Science fairs, science exhibitions at the district, regional/state and national levels provide refreshing and motivating impact on the science and technology teachers. The visits to science and technology museums and planetaria could also be very much enlightening.
- **Science and technology clubs:** Science and technology education co-ordinators should discuss the formation of a science and technology club within a school and how this might function. Ideas from the science and technology teachers and learners can be shared and a report compiled with recommendations for teachers to implement. Science and technology clubs can be a useful way of encouraging the exchange of ideas and promoting excellence in science and technology. In such clubs learners can pursue science-related hobbies and extend the concepts that they have learnt in the class. The clubs could be organised as a junior engineers' club, a technicians' club, flying club, photographic club, maths club or general scientific club. The clubs could be named after well-known scientists or engineers, or a local traditional industrialist whose skills are widely respected. Every effort should be made to name some clubs after women who have achieved prominent positions in the field of science and technology.
- **Weekend rallies:** Science and Technology teachers can encourage informal learning by organising weekend rallies. In a relaxed atmosphere, learners can exchange ideas and work on science and technology activities. These rallies can be used to attract and encourage girls to study science and technology and to pursue related careers. They could take the form of science and technology 'clinics' where girls could meet and talk to role models and mentors. Girls could be encouraged to visit science and technology based institutions and industries and engage in hands-on-activities. These rallies serve to stimulate learners' interest and popularise science and technology in the community.
- **Science and technology news and bulletins:** A bulletin board on which learners' and science and technology teachers' work can be displayed, along with relevant news items, can be a very effective means of stimulating interest inscience and technology. The content should reflect learners' activities and teachers' accomplishments. Learners can be asked to write short descriptions of their science and technology class activities for display on the board. They should also be

encouraged to read the news or bulletins during school assembly. Any science and technology-related news from the newspapers should be read and explained for the benefit of everybody.

- **Science and technology awards and souvenirs:** Awards and souvenirs for outstanding learners as well as science and technology teacher performance can also stimulate interest in science and technology. To promote science and technology amongst girls there could be awards exclusively for girls. Award winners can be identified and presentations made to them by pupils or by well-known figures from the community. Similarly, awards can be given to science and technology teachers for effective teaching and innovations in science and technology education. The community must be encouraged to promote such awards. Involving the community in the choice of award winners will develop an active interest in science and technology in the school amongst the community.

Participating in science and technology education research

Overview 6.1

Educational research is a sound basis for achieving improvements to the educational system. Its practitioners - teacher educators and teachers are the most important resource in science and technology education. With them lies our best hope of finding solutions to the problems of science and technology education at the primary level. They are the agents of change. They know the problems, the subject matter and the demands of the relevant disciplines. They know their learners' changing needs, interests and aspirations. They are aware of the local community, they are conscious of what parents expect of schools. No one is better placed than teachers to recognise the first indications of success or failure in implementing curricula, and to effect the necessary improvements and changes in the classroom.

Science and technology education research is for improving the teaching/learning process in the classroom. Improvements to science and technology education at the primary level can be realised through teacher educators' and teachers' participation in research, both as researchers and as users of research findings. Areas of research in science and technology education at the basic level are vast, and more importantly interesting to conduct. The research process in itself is an interesting and challenging experience, while the research finding provides satisfaction to the researcher. The returns from conducting research are therefore beneficial not only to education but also to those who conducted the research.

It is therefore vital that teacher educators participate in research and are able to guide and steer teacher trainees towards developing a positive attitude to research in their classrooms.

Objectives 6.2

The monograph aims to:

- stimulate the interest of teacher educators in science and technology education research by outlining the advantages of participation in research;
- encourage teacher educators to participate in research activities and develop their research skills;
- assist teacher educators in developing the action research skills of teacher trainees.

6.3 What is science and technology education research?

Science and technology education research can be broadly characterised as activities that:

- encourage teacher educators to participate in research activities and develop their research skills;
- assist teacher educators in developing the action research skills of teacher trainees.
- through problem identification, information-gathering and analysis of data, lead to a better understanding of problems in science and technology education;
- produce findings which lead to improved classroom practices, programme planning and implementation, and more informed policy decisions at the school or college level.

An example of research leading to improved practice

Rita is a teacher in a well-endowed urban primary school situated near a teacher training institution. She became anxious about her learner's difficulties in understanding the 'particulate nature of matter'. After consulting Abdul, a science teacher educator at the teacher training institution, they decided that Abdul should observe Rita's classroom as she taught the topic 'particles in nature' to her class the following year.

Abduls' study of Rita's class involved observation, audio-taping examination of the textbook, and interviews with Rita and some of the learners in the class.

Three issues became clear from the information Abdul Collected.

- Rita's teaching in class was text-bound;
- she worked on the assumption that the particulate ideas were simple enough for learners to understand;
- Learners were unable to apply the particulate ideas. They thought that particles expand, melt, reduce in sizes, break up on application of heat, and that in a solution of water sugar particles remain particulate while the water is continuous.

Rita with Abdul's help, then developed five lesson plans on the 'particulate nature of matter', which utilised the constructivist approach. The development of these plans took Rita out of her classroom once a week for six weeks. Part of this time was used in trying out the activities with Abdul's help. Rita taught the new lessons while Abdul observed and recorded. After each lesson, which required learners to carry out activities that challenged their prior ideas about particles, Abdul interviewed Rita on some of her actions. Learners also interviewed, using questions prepared jointly by Abdul and Rita.

The findings indicated a marked change in the initial ideas of almost all the learners in the class. Rita commented on the confidence she had gained in using the constructivist approach and was determined to use it in teaching other topics.

Research can be carried out using interview, observation and audio-video recording to collect in-depth information on a problem such as teachers' and learners' use of curricular materials, and teaching particular science and technology topics. When narrative information is collected and used to give a detailed account of the problem under investigation, the approach to research is described as qualitative. In this approach to research, the emphasis is not on drawing generalisations but on describing a situation in details.

In the quantitative approach to research, a problem is analysed by collecting numerical data through the use of questionnaires, tests, attitude scales and observations. In the quantitative research the emphasis generally is on drawing generalisations. Qualitative research can support quantitative research and vice versa.

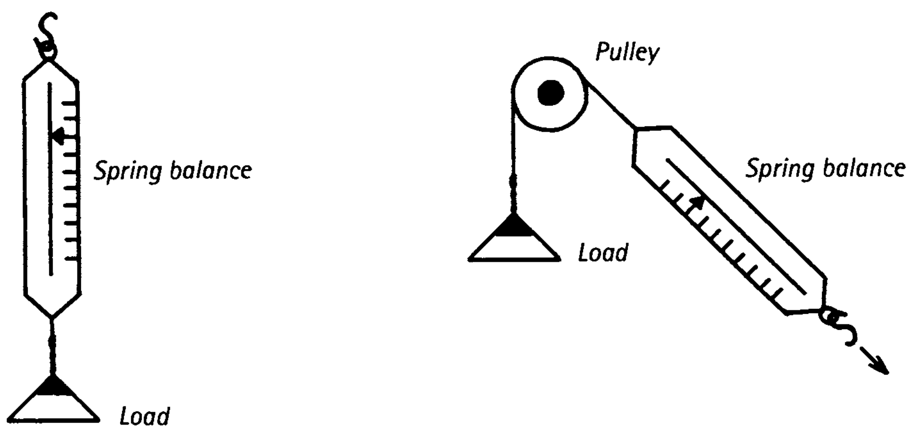
QUALITATIVE RESEARCH

A piece of qualitative research was done to find out the concept of a fixed pulley and its working. The sample consisted of 81 primary school learners of urban and rural areas. Learners were asked the following questions:

In which case the force required for drawing water from a well is less (a) using a pulley (b) directly without using a pulley.

The response sheets indicated that all learners responded that, "it takes less force to draw water by passing rope over a pulley". Analysis revealed that learners had misconception about the function of a fixed pulley. The pulley simply makes the work easier. The learners were not able to associate the change of direction of a force with actual effort done.

The same group of learners were directly involved in an activity to lift an object using a spring balance (a) Directly or (b) passing a string over a pulley as shown in the figure. The learners were able to associate that a single pulley is a simple machine which helps to change the direction of the force to make the work easier without changing the magnitude of the force.



Pulley makes the work easier with same effort

6.4 Relevance of Science and technology education research

Primary science, integrated and environmental science, and technology are some of the more recent innovations at the primary level of education. Teachers at this level are expected to put into practice the intentions of curriculum developers as specified in different curriculum documents. In reality, observations of learners' and teachers' activities in science and technology classrooms reveal that the intentions of curriculum developers are often reinterpreted by teachers to suit particular classroom contexts. Teachers face problems in putting curriculum specifications into action, and in making the far-reaching decisions expected of them in carrying out managerial responsibilities in the classroom. Teachers need opportunities to familiarise themselves with information on new curricula and on curriculum-related issues. This suggests the need for modifications in policy as well as in classroom practice, and of providing a focus of reflection to enable all parties to take appropriate decisions.

Activity

Identify some curriculum-related issues and suggest modified classroom practice for them.

This is where knowledge of research findings and action research become relevant. Very often research findings have not been widely applied in classrooms because teachers have limited access to them. This limited access may also be the result of a lack of awareness on the part of science and technology teacher educators about research findings, or difficulty in understanding the findings and interpreting them for classroom applications.

By taking advantage of relevant research findings, teacher educators can improve their own classroom practices and help teacher trainees to improve theirs. This could ultimately lead to informed and improved policy decisions and better classroom practices.

In sum, what research has to say to science and technology teacher educators may be defined in terms of **feedback** providing a focus for further **reflection** and **action**. The following case study, overleaf, illustrates this point.

6.5 The science and technology teacher educator as researcher

Science and technology teacher educators, as researchers, are mainly concerned with gaining a better understanding of their own classrooms, so as to enable them to make informed decisions before, during and after teaching/learning transactions. Such improved understanding will lead to improved quality in science and technology teacher education. It is not sufficient for teacher educators' work to be studied solely by outsiders. They need to study their work themselves. An insider, science and technology teacher educators has a more intimate knowledge of the setting, even though he/she sees it in his/her own way. An outsider, who may be a

An agriculture-related innovative teaching strategy for primary schools in Sri Lanka

The Ministry of Education of Sri Lanka was very much concerned about the growing incidence of malnutrition among primary school learners leading to poor health, erratic school attendance, school dropouts and low academic performance.

A project was developed by the Primary Education Department of National Institute of Education, and launched in 1993 with the school as the converging point of all nutrition-related activities in rural areas.

Objectives of the project:

- To upgrade the health and nutritional levels of primary school learners.
- To reduce the related incidence of poor health, low school attendance, school drop-out, low academic achievement, etc.

Implementation Strategy

As a first step of implementation of this project, a baseline survey was conducted among the families of learners of the small schools in rural areas. As the parents were mainly farmers and the knowledge of their modern farming methods, use of improved varieties of seeds, fertilizers were also noted down.

Findings of baseline survey

The baseline survey revealed many short comings related to the socio-economic status, education, health, hygiene etc., which need immediate attention.

Some activities were suggested for early implementation. One such activity that was implemented proved to be successful. It was the maintenance of agricultural plots in schools.

Agricultural plots were designed and carried out in some schools with the help of the agriculture instructor of the area and the teachers. These plots were used to teach not only agriculture but also concepts in science, mathematics, nutrition, social studies, etc. These plots also served as demonstration plots for the community. In addition these were used at nurseries to provide seeds and plants of improved varieties to the farmers.

Outcomes and follow-up

Teachers & parents (farmers) were given a training programme, where they learnt how to develop agricultural plots, nurseries, and techniques of seed culture and how to collect and retain rain water etc;

Back in the schools, teachers guided the learners in agricultural plots with the active participation of some parents.

The parents and learners started their home plots and transmitted all the knowledge and techniques they had acquired to others in the community.

Simultaneously a nutrition programme was launched with the assistance of the home economics unit of the NIE. The objective of that programme was to demonstrate the preparation of a nutritious meal using the agricultural produce of the areas. It was expected to prepare and supplement the mid-day meal using the given recipes.

Pedagogical outcomes

Lessons in language, mathematics, environmental studies are now being taught based on the theme of agriculture. Much enthusiasm has been shown by both learners and teachers in this novel approach.

Learning has become experimental and more purposeful, with reduced malnutrition, improve health and hygiene practices and also better academic performance.

colleague or research expert, is best used in a collaborative pact with the teacher educator, bringing specialist skills of 'seeing' and thinking about events.

The science and technology teacher educator as a researcher can collaborate with science and technology teacher at the primary level in order to understand and clarify aspects of the classroom situation at that level. The aim is to use the findings to improve science and technology teaching as well as teacher education. In such a research partnership, the roles and responsibilities of each partner could be as shown below. The teacher's role as researcher is rooted in their everyday practice in the classroom.

Relationships and responsibilities in a teacher-development research partnership

	Phases of research			
Key factors	Planning and preparation for research	Data-collection techniques	Analysis and interpretation	Report writing and use
Science and technology teacher educator	Primary responsibility for articulation of purpose, co-ordination of research and negotiation of activities	Identification and negotiation of possible strategies; primary responsibility for gathering mutually agreed information	Preparation and presentation of preliminary analysis; mutual interpretation of preliminary analysis leading to final analysis	Primary responsibility for writing account; responsive to teacher's editorial comments; perceived mutual benefit
Teacher	Negotiated participation in terms of perceived benefit, commitment and procedure	Identification of information sources and negotiation of appropriate strategies;	Responsive to preliminary analysis; mutual interpretation leading to final analysis	Negotiated representation in report writing and editing of personal accounts; perceived mutual benefit

Source: Adapted from Cole, A.L & Knowles, J.G. (1993) Teacher development partnership research: a focus on methods and issues. Americal Educational Research Journal, 30(3), 473-495

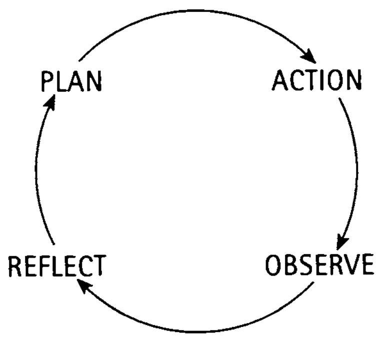
When teacher educators are researchers, they are co-learners too. As co-learners, in their daily classroom activities, science and technology teacher educators have a responsibility to listen to their learners' ideas and language, to assess their own teaching approach, to observe their learners and to reflect on classroom transactions in an attempt to make changes that will improve learning.

Thus science and technology teacher educators are, at least informally, carrying out action research - using classroom data to clarify curriculum and learning problems. As researchers, teacher educators develop problem-solving skills and questioning attitude. This questioning attitude can further refine their data-gathering methods and analysis techniques and so improve the quality of teaching and learning.

Action research 6.6

Action research has been defined as 'research carried out by practitioners with a view to improving their professional practice and understanding it better'. It is a form of inquiry centred on relevance and context to bring about change in practice. Action research involves trying out ideas in practice as a means of increasing knowledge about and/or improving curriculum teaching and learning. Collaborative action research with science and technology teachers helps to eliminate the isolation that has long characterised teaching, as it promotes professional dialogue leading to the creation of a professional culture in schools. Collaborative action research can also assist teachers doing research for the first time.

There are a number of models for action research. Problem-solving projects are common forms of this type of research. Action research models usually involve a cycle of reflecting, planning, collecting data, trying out strategies, obtaining and analysing feedback, modifying plans in the light of feedback, and continuing on the cycle as summarised in below.



Characteristics of action research 6.6.1

Action research, like other types of research, seeks to increase knowledge and understanding of a phenomenon or event. However it differs from more formal research methods in a number of ways:

- Action research does not require extensive training in research methods. Teacher educators can carry it out on their own, in collaboration with another teacher educator, a research specialist or a teacher.
- The goal of action research is to obtain knowledge that can be applied directly to the situation being studied. It also helps to improve the teacher educators' performance.
- Problems investigated in action research are ones that teacher educators view as interfering with their efficiency or that of their colleagues.
- Action research does not require the rigorous literature review expected in more formal research. A literature review using secondary sources is usually adequate to begin with.

- Action research can use the learners, with whom the teacher educators work, as subjects.
- Action research is flexible: immediate changes can be made to plans in response to the particular conditions of a situation.
- The tools used do not need to be tested in separate trials and reliability and validity established.
- Analysis of most action research data involves use of simple descriptive statistics instead of inferential procedures. The subjective opinion of the researcher is given prominence. The focus is on practical significance of the results rather than statistical significance.
- In contrast to formal research, where research findings are reported in terms of their theoretical importance, action research findings are reported to portray the impact of the findings on the science and technology teacher educator's work. They are also reported to inform other science and technology teacher educators about the implications of the research for professional development.

6.6.2 Focus areas for action research in science and technology education

Since action research is geared towards helping practitioners to study their own practice in order to solve their problems, the content of the research should be relevant to the teaching activities of the teacher educators and teachers.

Research based on the activities carried out by science and technology educators and teachers can be classified into the following broad areas:

- **Pupils' learning:** This may involve using strategies to explore learners' ideas about science and technology or identifying the problem-solving strategies of learners. Areas such as learners' misconceptions; questioning; designing and making; scientific vocabulary and 'second-language-science learning' could be investigated.
- **Teaching strategies:** This may include trying out different approaches to teaching science and technology topics. For example, the teacher may be interested in finding out how he or she can help learners to have a better understanding of the 'scientific concepts and processes. The teacher educator may also be interested in finding out how a teacher trainee uses a teaching technique to which he or she has been introduced.

Example

Does an alternative strategy to traditional practical work in schools, which is more cost-effective, achieve similar objectives?

Will participation in 'hands-on' activities help learners to develop:

- a more positive attitude towards science practical work?
- an increased understanding of certain basic scientific concepts?
- designing and making skills?

Exemplar Case Study

1 An innovative experiment in science teaching in rural areas in India – discovery approach

For improving the quality of science teaching in formal system and to overcome the problem of dropout in rural schools and to help the learners in developing self confidence, self reliance, initiative and skills of innovation, a science teaching programme, popularly known as Hoshangabad Science Teaching Programme (HSPT) was started. It laid emphasis on learning through the use of local specific materials and was environment-based. Its emphasis was on discovery approach to science teaching. The objectives of the project were to investigate the feasibility of science teaching through discovery-approach through environment, develop scientific attitude among the learners, to apply scientific method in different situations. The curriculum was based on 'process-approach' rather than 'product-approach' with a view to give opportunities to the learners to explore scientific phenomena of their local environment. Thus the emphasis of the programme was to shift from 'textbook oriented' teaching and learning to 'learning by doing'. In this case study more than 206 government middle (upper primary)school, 500 school teachers, 120 school officials, 50 trainees/co-ordinators and 40,000 learners were involved.

The teachers were trained for teaching science through discovery approach. Excursions and field trips were organised during the training programme for teaching the topic related to the environment.

The case study focused on to nurture and develop the inherent analytical power, ability to formulate and observe problems, make logical analysis and to impart training to tap resources in their own areas. In HSTP all the basic components of science education, that is, curriculum, textbooks, teaching methods, time table, teacher's training and examination system were innovative. A desirable change that took place in teacher's attitude was to encourage learners to find out answers to problems by themselves. HSTP succeeded in bringing the concept of learning through environment based on discovery approach.

- **Attitude:** This will include developing ways of increasing learners' interest in science and technology and counteracting negative attitudes. It may also involve developing ways of increasing the involvement of girls in science and technology. For example: Is there a gender difference in learners' enjoyment of practical work? What kinds of 'hand-on' activities increase the motivation of girls to study science and technology?
- **Assessment and evaluation:** Assessment and evaluation are integral parts of the educational process because they provide vital feedback about the extent to which the objectives of science and technology education are being achieved. The information obtained through assessment and evaluation can be used to take corrective measures. Teacher educators and teachers can conduct research on issues and problems related to assessment and evaluation, such as:

  good assessment practices for the measurement and evaluation of learners' behaviour, ethics and values;

  techniques for assessing the skills of acquiring, organising and using information.

6.7 Promoting science and technology education research

As stated earlier, science and technology teacher educators are expected to conduct research for their own professional development, on their own, in collaboration with colleagues, teachers and with other researchers. Relevant research findings can have beneficial effects on their competence, on the content of the curriculum, and on the learning environment. They need to know how to initiate, execute and use research.

2 Improved Science Education in Primary and Middle Schools in Madhya Pradesh and Uttar Pradesh, India

To improve the quality of science and technology education taught as environmental studies at the elementary level in the states of Madhya Pradesh (MP) and Uttar Pradesh (UP) an Indo-German Project was started in 1986 it provide technical and logistic support to the schemes formulated by these states under the National Policy on Education (NPE), 1986. The main work plans of the project were the improvement and development of teaching materials, a versatile portable laboratory in the form of a kit. Three workshops were established for production of Primary Science Kits one each at the National Council of Educational Research and Training (NCERT), New Delhi, Allahabad (UP) and Bhopal (MP). Training programmes were conducted for pedagogical and technical staff of the project. Training was also provided to the primary school teachers of Madhya Pradesh and Uttar Pradesh. The Primary Science Kit (PSK) package consisting of teacher's handbooks on environmental studies – science, a set of 70 chart cards, PSK and the manual of PSK were developed under the project.

The main emphasis in the handbook has been on motivating the learners to formulate questions and how to guide, help and supervise them in their investigations. The learner-centred, activity-oriented, problem-solving activities given in these teacher's handbooks have been possible with the help of the PSK package and other locally available materials from the environment. The Teacher's handbooks and other items of PSK were finalised after proper trial. During the trial, teachers with or without a science background who were teaching environmental studies to both urban and rural schools participated in the development of PSK package.

In order to train a large number of teachers in MP and UP a 'Cascade system' of training was chosen which operated from State Council of Educational Research and Training (SCERTs).It operated at three levels. Firstly, the experienced science teacher educators from SCERTs of MP and UP and NCERT who were involved in the different developmental stages of the PSK package were selected and trained to act as Key Resource Person. Then the experienced science teacher educators from District Institute of Education and Training (DIET) and other teacher training institutions of MP and UP were selected and trained by the Key Resource Persons to act as Resource Persons. Finally the primary school teachers of various schools, were trained by the Resource Persons. The cycle of training was to be repeated to induct more new teachers at regular intervals at the selected training centres/DIETs of the two states.

The training of teachers added a new dimension to the teaching-learning of environmental studies at the primary level by allowing teachers to have hands-on-experience and exposing them to learner-centred, activity-based, environment-oriented and problem-solving-based approach. Follow-up courses were also conducted for teachers to obtain feedback for the improvements of teaching-learning and to find solutions to the difficulties and pitfalls, encountered while using the PSK package.

Science and technology teacher educators may obtain problems or ideas for research by:

- observing and listening to learners and teachers in the classroom;
- obtaining feedback from research findings which may motivate them to initiate action research;
- reflecting on their own teaching procedure;
- observing and examining classroom teaching practice of teacher trainees;
- developing a habit of questioning and testing the ideas of other practitioners in the field;
- critically examining assessment results and assignments;
- critically reviewing research studies conducted by others.

This list is by no means exhaustive. However, for science and technology teacher educators to take a research approach to their teaching, they should be able to identify discrepancies between the reality (in their classrooms) and what is considered 'good practice'. Such an approach requires open-mindedness on the part of teacher educators.

Some problems for Action Research

1 To study the effectiveness of teacher's demonstration and learners' activity method for science teaching.

2 To find out causes of disinterest among learners towards activities in a science class.

3 To identify difficulties faced by teachers to teach concept of 'nature of matter'.

4 To study the factors responsible for lack of interest among science teachers for activity-based science teaching.

5 To compare achievement in science of girls and boys among the learners at the primary level.

Why a research proposal? 6.7.1

Once a research idea has been conceived, or a problem identified for research, it is good practice to write it up as a research proposal.

Apart from possibly being needed for an application for funding or a proposal for studying a higher degree, writing a formal research proposal can also serve to focus attention on:

- clarifying and stating the problem;
- clarifying the objectives of the research';
- identifying the population, sample and procedure for collecting and analysing data;
- specifying the individual activities in the study and when to perform them;

- identifying the materials required for the study;
- estimating the cost of various aspects of the study.
- estimating the time/duration.

A written research proposal also allows the researcher to receive feedback from colleagues on the clarity with which the problem is presented, the procedures to be used in the study, and on the relevant literature available.

6.7.2 Writing a research proposal

Science and technology teacher educators need to develop the skill of writing research proposals, as part of their professional responsibilities and development. A research proposal is a systematic description of the researcher's whole plan of action designed to collect the data intended, resolve the problem, provide and answer or demonstrate a need for further research.

The basic elements of a research proposal are:

- The title
- An introduction and background to the study.
- Identification of the problem to be investigated - a precise statement of the problem or purpose is needed.
- Identification of research questions or objectives arising from the problem statement, and the hypothesis, if any, to be tested.
- **Details of the research design and procedure:** Describing the activities that would lead to the attainment of the objectives - answering the research questions or testing the hypothesis. These should include: identification of target population and sample, and instruments/materials to be used; phases of the activities, their components, methods or procedures for collecting data and techniques for data analysis.
- **The time schedule:** This should give an indication of the starting date for the research, when it will end and the timetable for the different phases.
- **A budget:** this gives an indication of how much the research will cost. It should be detailed and comprehensive and should include all items of expenditure and the total amount required.

Activity

Identify the problems of action research in science and technology and prepare a research proposal for your research problem.

One of the most important aspects of a research study is communicating the results to others. Research reports are means of documenting and disseminating research information. Science and technology teacher educators and their learners need to be conversant with the skills of writing research reports.

There are many formats for writing reports but there is general agreement on the format detailed below.

- **The title:** The report must start with a title. The title must clearly indicate the subject of the research to the reader/user.
- **The abstract:** After the title comes the abstract, which contains the important ideas and main steps of the study. It is a brief summary of the whole study and should include a statement of its purpose, the type of subjects used, brief statement of design, data and analysis techniques, results and findings. The whole matter should be no longer than three-quarters of a side of A4 paper.
- **Statement of the problem:** The statement introduces the reader to the problem which should be clearly described. If research hypotheses were formulated, these should also be included in this section of the report.
- **Design and procedure:** In this section, the researcher should clearly explain the following aspects:
  - The nature of the design including the sample: whether it is a descriptive survey, correctional or experimental design; the characteristics of the samples, including number, sex, age-range, class or form, and sampling procedure.
  - The instruments, such as questionnaires, rating scales, tests, etc., which served as the main tools for obtaining data, including the name of the instrument, complete details of its source, and psychometric characteristics such as reliability and validity information;
  - The procedure followed to conduct the study: a detailed step-by-step description of how it was carried out.
- **Results:** There are many ways of presenting results depending on what they are, how they were collected and what they are intended to show. Tables, graphs, lists or figures should be used wherever possible to help present results clearly, and referred to in the account of the results. All tables, charts, graphs and terminology used should be clearly explained so that they help the reader to understand the report. Where statistical tests of significance have been indicated, it is useful to include all formulations that led to the rejection or acceptance of the stated hypotheses. In qualitative research, a detailed description of observations made, including some of key atatements made by the source of data should be included.
- **Discussion of results:** In this section, the results should be carefully explained (of course within the limitations of the study), question by question or hypothesis by hypothesis. Part of the discussion should include explanations of the results within the context of existing knowledge of the problem. Do the results contradict or corroborate other findings? Or do the results stand out clearly on their own? Are there unexpected results? Why? Here the researcher should explain, argue and

possibly make predictions based on his or her findings. This is the section for the researcher to propound his or her views.

- **Suggestions and Recommendations:** Research results present some notions on the nature of a problem to the researcher. From such understanding it will be possible for the researcher to suggest solutions to the problem. It is in this section that conclusions, possible solutions and recommendations are discussed. Suggestions might also include scope of further research.
- **Bibliography and references:** The bibliography is a list of the publications studied by the researcher. Questions or particular references to other work in the report are listed under "References". If the report is intended for publication in a journal, the author should refer to that publications and follow their style for setting out the references or bibliography.

6.8 Recommendations in support of research in science and technology education

- **Research data banks:** To promote research in science and technology it would be immensely helpful if data banks were created where research data could be stored and made available to researchers to support action research. The data bank could also provide researchers' and teachers' research findings for use in their research/teaching.

  The Commonwealth Secretariat may like to support the establishment of such banks and their networks.
- **Workshops in action research:** Many science and technology teacher educators working at the primary level do not have enough experience of research. They do not lack knowledge of research problems and issues but they lack competence and experience in research methodology. It would be very useful if workshops could be organised for teachers and teacher educators to develop their skills of research methodology. This would help promote action research. The Commonwealth Secretariat may like to support such training programmes or conduct workshops in member countries.

Case study: The Toray Foundation Award in Malaysia

Some private sectors provide funding and awards to encourage and support research.

The Toray Foundation involved in textile manufacturing in Malaysia, for example, provides cash awards to practising teachers for any research conducted in the area of teaching and learning of science and mathematics at the school level.

The Foundation started giving the award in 1993 and managed to arouse research interest amongst teachers in schools. When it first started, the award attracted a total of nine proposals from schools throughout Malaysia. However, in 1994 as many as 11 proposals per state were received. The quality of proposals have also shown considerable improvement.

- **Private sector involvement:** Education authorities, industry, public and private sectors should be called upon to encourage and support research.

- **Regional clearing houses:** Science and technology research materials, such as research reports and evaluation instruments published in the local language, should be collected in regional centres. Many educational institutions cannot subscribe to journals. Ways should be found to make journals available to educational institutions doing research.

- **Networking:** Networks of researchers and institutions conducting research in science and technology should be established.

- **Dissemination:** Mechanisms should be set up for the dissemination of research information, particularly at the local level through newsletter, occasional monographs, seminars and discussions, conferences, teachers' meet, symposia, etc.

- **Support mechanisms for novice researchers:** Teacher educators of primary teachers generally lack research skills. To promote research, teacher educators need training in research methodology. They also need support at different stages of research through the establishment of suitable mechanisms. The establishment of local research advisory committees could be one way forward.

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Training of Trainers in Science and Technology Education

This collection of monographs provides useful information to the educational administrators in the recruitment and training of science and technology teacher educators in the light of the recent orientation of science education at the basic level. Furthermore, this volume is a valuable resource for the science and technology teacher educators. It aims at improving their own pedagogical skills and also provides strategies which could be used by them with their trainees to make them better science and technology teachers. Effective delivery of science and technology education requires co-ordination at different levels. These monographs provide guidelines and practical suggestions on achieving such co-ordination at the teacher training institution as well as at the school level.

These monographs were produced by experienced science educators of Asia under the Training of Trainers Programme in Science, Technology and Mathematics Education (STME) of the Commonwealth Secretariat.

Other current programmes in the area of STME of the Commonwealth Secretariat:

Improving participation and achievement of girls

Scientific and technological literacy for all

Training of laboratory technicians

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