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

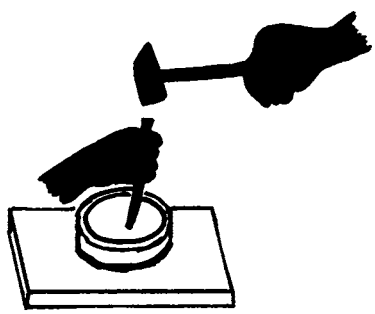
Purpose
For the study of behaviour of insects.

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

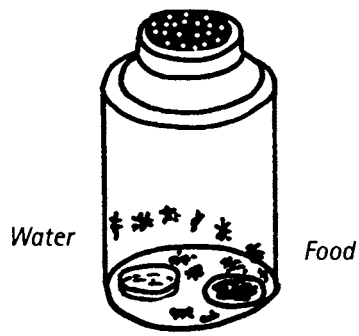
How to set up

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

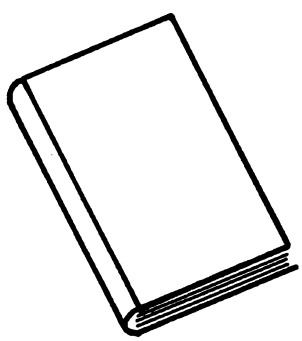
Purpose
For the study of different parts of the plants

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

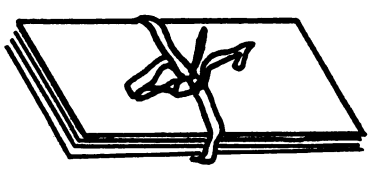
How to preserve

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.

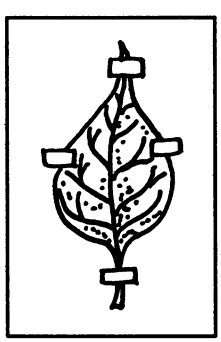
Flowers



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.

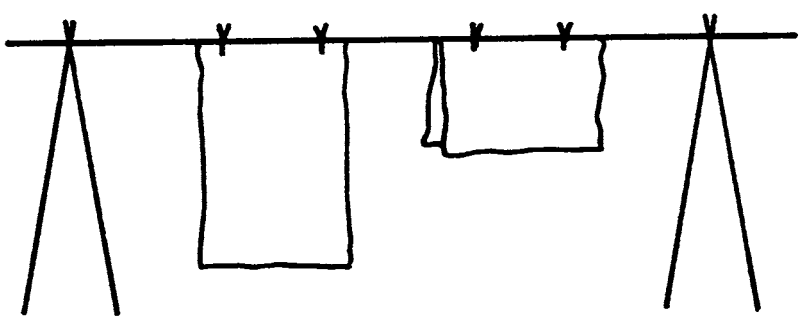
Learning Objective
Compare the rate of evaporation of liquid when the exposed surface area is large with the rate when it is very small.

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.

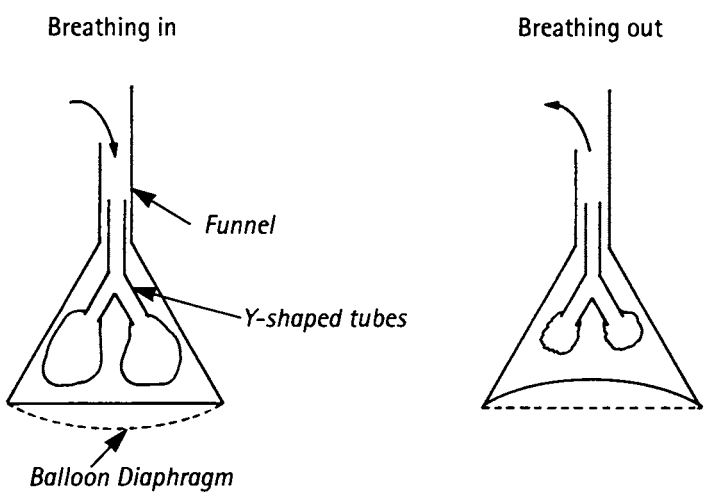
When asked 'How do lungs expand or contract', the responses given were analysed. These indicated that a large number of trainees had misconception about the mechanism of breathing and the role diaphragm plays in the process. The teacher trainees were then asked to perform the following activity. A funnel, 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.

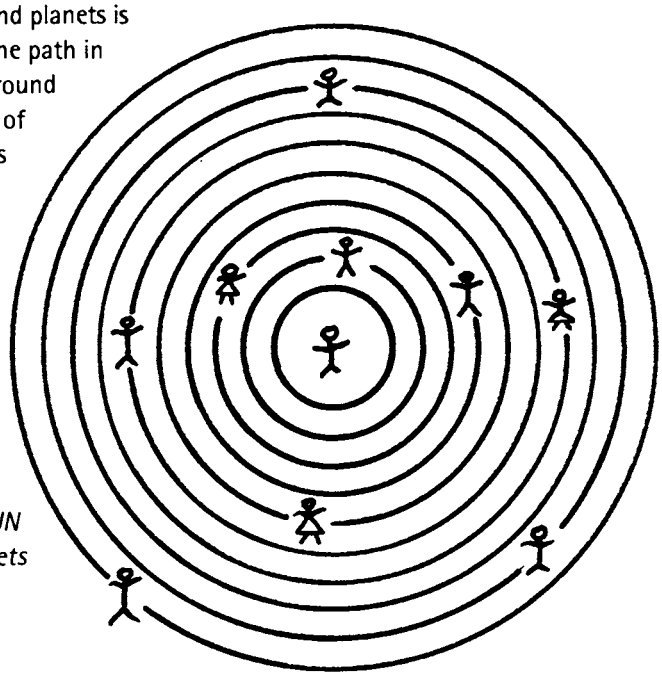
It is important in the problem-solving inquiry approach that the teacher educator provides a situation where the student teachers are made to think, plan, execute using science processes and draw conclusions. Teacher trainees should be given many problems to solve at their own level, so that they come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



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

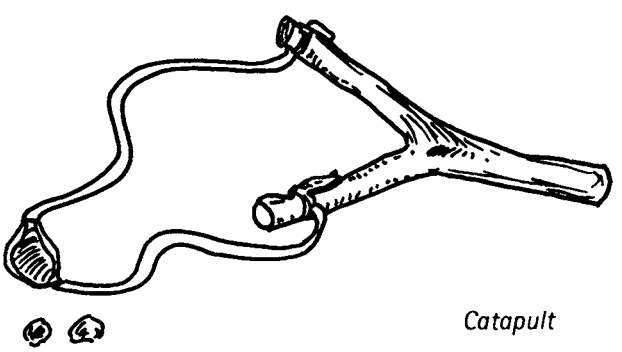
One day Newton was sitting under an apple tree in a garden. He saw an apple falling down from the tree. A thought came to his mind that there should be some reason behind falling of the apple on the ground and not going upwards. So he came to a conclusion that there is a force exerted by the EARTH which 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

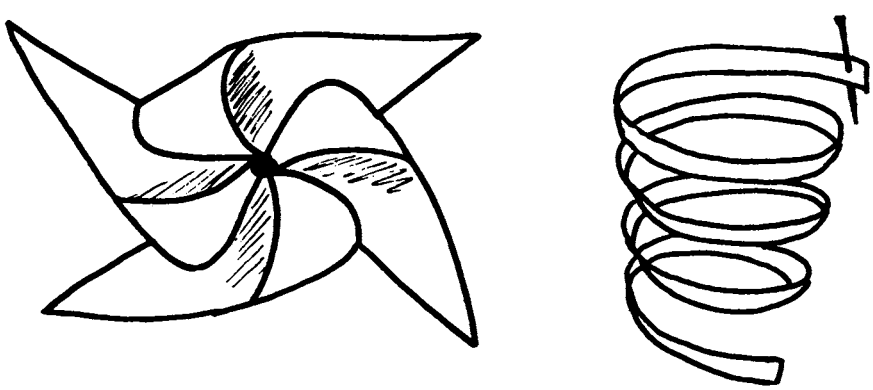
Toys are not teaching methods but are an invaluable resource to help develop scientific ideas. A simple bow and arrow can be used to develop ideas of elasticity, force, action and reaction, etc. Teachers trainees should be encouraged to ask learners to bring their own toys or construct simple toys objects/models 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.