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

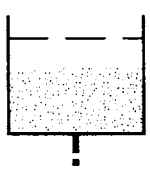
In India, leaves and fruits of some plants are frequently used to control some common diseases.

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.

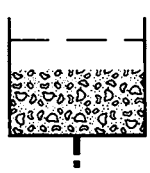
Drawing water from a well

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.

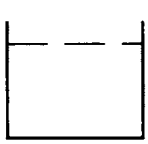
SIMPLE TECHNOLOGIES ARE USED IN WATER FILTRATION



Water sand and collects the sediments sand



Water charcoal traps the germs and charcoal



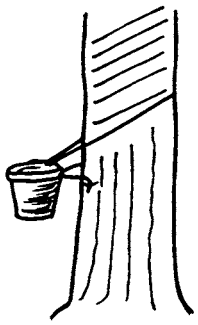
pure water

Making clay pots

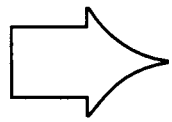
In villages potters have been making clay pots for many years. They have learnt to choose suitable soils and to control the drying and baking processes to reduce cracking.

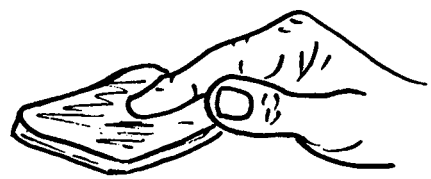
The fact that evaporation causes cooling is used in keeping water cold for a long time using specially designed porous clay pots.

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

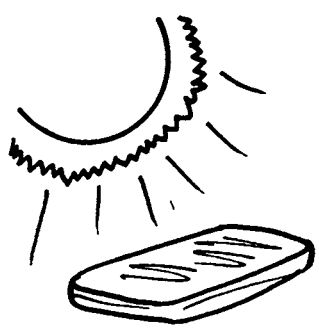


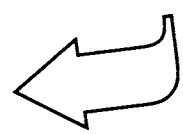
Collect some latex from rubber trees



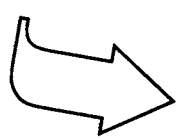


Spread latex over a cut piece of rubber that is going to be e used to mend the puncture.

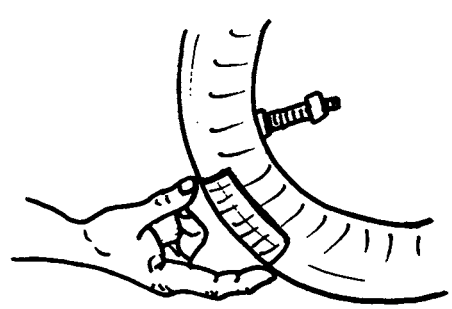




Leave the rubber piece in the sun for four minutes.
The white appearance of the latex turns into a clean and sticky film

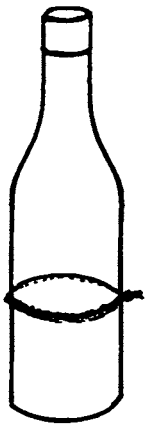


Stick the rubber piece over the puncture

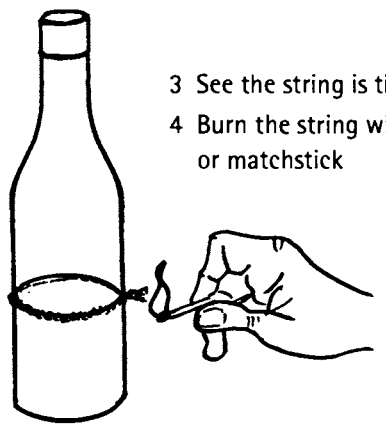


2 Cutting the base of a glass bottle

1 Dip a piece of string into some paraffin or kerosene

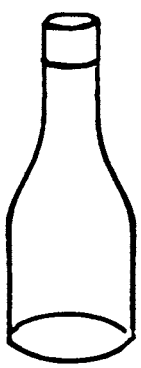


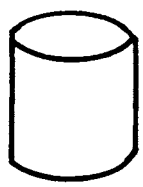
2. Tie the string around glass bottle at the position you wish to cut



3 See the string is tight

4 Burn the string with the candle or matchstick





5 The bottle will be cut into two portions

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

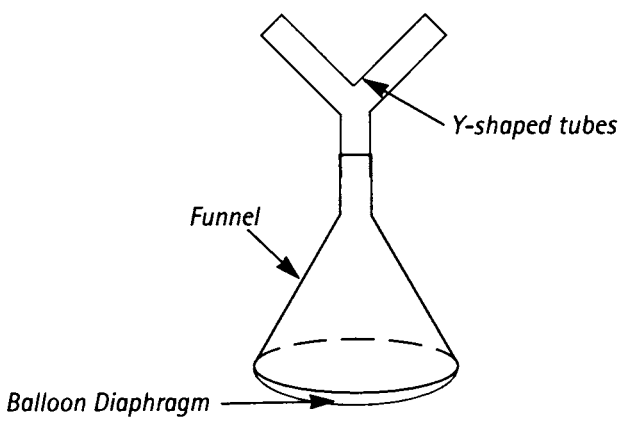
Material required
A balloon diaphragm, a funnel and a plastic tubing.

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.