

MONOGRAPH 3

Resources for science and technology teaching and teacher training

3.1 Overview

A wide range of resources is available that science and technology teacher educators can use and introduce to their trainees to assist with the teaching and learning process. These include conventional things like tools, equipment and consumable supplies, printed materials and human resources. They 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 students 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.

3.3 General considerations in identification, selection and use of resources

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 students be grouped?
- What resources may be needed to investigate problems and questions raised by student teachers?

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 in their 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, 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 student? Will the resource hold students' attention for a reasonable amount of time?
- **Comprehensiveness.** Does the material explore concepts etc. in enough depth and breadth? Does it allow learners to organise information as well as gather information? Do textbooks contain questions, advance organisers, illustrations, summaries, glossaries?
- **Relevance.** Are the contents appropriate to the students' needs, interests and abilities?
- **Validity.** Will the resource bring about the learning outcomes hoped for? What evidence is there of this?
- **Usability.** Can the resource be used by students and science educators? Is equipment simple to use and reliable? Is it flexible?
- **Variety.** Does the resource provide experiences which are not otherwise possible?

3.4 Manufactured materials

These consist of equipment and chemicals, needed specifically 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 is given as Table 1.

Magnifying lens	Potassium permanganate
Measuring cylinder	Formalin
Clinical thermometer	Alcohol
Laboratory thermometer	Ammonia
Torch cell	Dilute acids
Insulated wire	Chisel
Fuse	Steel plane
Electric switch	Hammer
Ball bearing	Pliers
Pulley	Clamp
Standard weights	Calliper
Spring balance	Screw driver
Plastic tubing	Hand drill and bits
Meter rule	Assorted tiles
Funnel (plastic)	Spanner
Bar magnet	Wire cutter
Baking soda	Tin cutter
Iodine	Iron saw

Teacher educators should be familiar with materials in manufacturers' catalogues and their availability for use in schools. They should liaise closely with the Ministry or Department of Education in selecting 'good' resource materials to ensure that a common message is being given to teachers and pre-service trainees. In many countries, 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 trainees.

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 students, they should not train the student teachers in their use unless they are available in the schools.

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 students understand the procedures to be followed. Such procedures might include:

- award of contract or tender by the institution or a central tender board;
- order against a budget, where schools are provided with a budget for this purpose;
- order from a resource centre – as in Nigeria.

3.4.2 Storage and maintenance

It is also important for science and technology teacher educators to teach their 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 practice with regard to storage in schools, and discuss these with the 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 students may see them and want to use them, thus reducing the possibility of teachers forgetting to use them.

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 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 in maintenance to teachers.

3.4.3 Safety

Teaching about the proper and safe use of manufactured resources is another responsibility of the science and technology teacher educator. Teachers 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 trainees are fully aware of possible dangers from chemicals they may use.

3.4.4 Equipment pools and lending systems

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 have been

developed. In some countries schools are grouped into ‘clusters’, which share human and material resources. Other countries have established ‘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 the equipment.

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. It makes teaching more relevant to students by relating it to their real everyday lives.

Locally available materials are those available either free or cheaply from the immediate environment. They include: wood, clay, iron filings from the blacksmith, pith, soil, grains, plants, empty bottles and bottletops, comb, wax, nails, sawdust, coal, common salt and limestone and locally produced manufactured items such as magnets, balloons, paper clips, plastic bowls and candles. Many of the items generally available in children’s homes, such as bulbs, knives, clothes pegs, razor blades, pieces of fabric, are also valuable resources.

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 trainees to collect such items and in turn advise the trainees to ask children to collect. However, enthusiastic children may collect too many things, so teachers should be advised not to ask every child to bring the same things. Asking children 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 pre-service teachers to gain practice in adapting locally available materials for teaching situations and illustrating their use in making teaching more meaningful.

3.5.2 Local technologies

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. Science and technology teacher educators should use these experiences during training and help their trainees to utilise similar experiences. It should be emphasised to them that local technologies have the potential to make learning more relevant and meaningful for the children 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 students to social concerns which need to be addressed. Such interaction can allow students 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.

Production of 'Akpeshie', a local gin in Ghana

Palm wine, a sugary sap tapped from the palm tree, is allowed to undergo fermentation by being left to stand in metal drums for at least three days. During these three days, the sugar in the palm wine is converted to alcohol by the action of yeast that is present in the palm wine as a result of its being exposed to the air.

The drum containing the palm wine is connected from the top by means of small-diameter metal tubing which either passes through another drum filled with water or passes through a pond or slow moving stream to a smaller metal or glass receptacle.

When heat is applied to the drum containing the palm wine, the alcohol evaporates, passes through the tube, and is condensed by the cooling effect of the water in the pond, stream or drum and collects in the receptacle.

The 'strength' of the resulting alcohol is tested by applying a lighted matchstick to a small portion of the product. If the alcohol is 'strong' it inflames; if it is 'weak' it does not.

Repelling mosquitoes

In Swaziland a plant called 'umsutane' is used by some communities to repel mosquitoes. The insects are repelled by its scent. It is rubbed on the body or the leaves placed in strategic parts of the huts overnight.

Jelly pan 'photocopies'

This technique was extensively used when photocopy machines were not available, and is still being used in rural schools in South Africa. 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 *Presentation 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 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. 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 pupils' exercise books*

It is not necessary to tear a page out of a pupil's exercise book. Simply, put a clean page face down on to the jelly pan, smooth over the page, and the drawing is in the pupil's 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!

In many schools in South Africa 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 $2 + 10 = 12$
 $9 + 3 = 12$

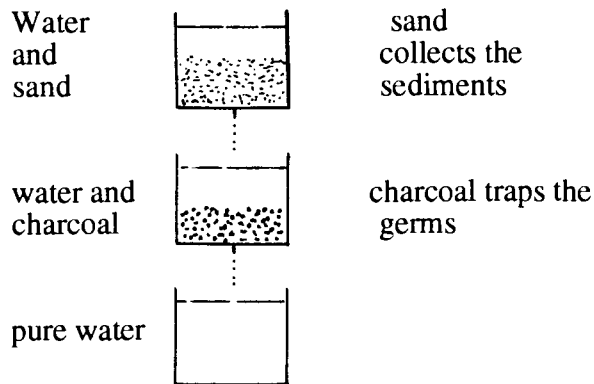
2 In the same way, add three numbers diagonally across:
 $3 + 11 + 19 = 33$
 $17 + 11 + 5 = 33$
 The sum is always the same. Try with any other three numbers diagonally across.

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?

Simple technologies are used in water filtration



Making clay pots

In Malawi, village potters have been making clay pots for many years. They have learned to choose suitable soils and oils, and to control the drying and baking processes to reduce cracking.

Despite the acquisition of technological skills, one elderly woman potter still attributed her success to a superstition:

'Since I started using my granddaughter to light the fire', she said, 'no pot has broken'.

She was referring to the baking of the pots she made. Perhaps the reason why the pots never cracked during baking was due to her mastery of the technology of pot-making.

3.5.3 Other local resources

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

- Visits to different construction sites to study the methods, materials and tools used. Children 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 children 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 a local hospital, health centre, doctor, restaurant, garden, plant shop, railway station, etc., can be very rewarding as a means of linking real-life experiences with school science and technology.

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

3.6 Improvisation of scientific equipment

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 teachers’ scientific process skills, technological skills and a positive attitude towards improvisation and science and technology. 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 feeding bottles;
- measuring cylinders or air pressure pumps from discarded syringes;
- corks from bamboo pith/raffia palm;
- 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;
- formalin (preservative) from the local gin;
- funnels from the top parts of discarded plastic bottles;
- weather instruments - wind vanes and water gauges.

Science and technology teacher educators may suggest other items which could be improvised and are suitable for particular situations. They should encourage teachers 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.

As well as 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 pupils themselves. Improvisation by pupils 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 pupils 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. Teachers 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 magazines or newsletters, such as the newsletter of a local science teachers' association.

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, tape measure, 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 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.

3.6.3 Attitude to improvisation

Many teacher educators and teachers 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, 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 student, which may not be possible with sophisticated and costly manufactured items.
- Improvisation leads to development of problem-solving skills amongst teacher educators and teachers which may be passed on to students.

3.7 Resource centres

Teachers' resource centres have been found to be very useful in some 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 Ministries 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.

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. 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.