INTRODUCTION

This book is not intended to be a scheme of work, but is a manual of ideas, activities and investigations about the science of materials for teachers to use with primary children. They may add to or offer an alternative to those already being carried out in schools. All the activities have been trialled, although in accordance with good practice should be tried by the teacher before using them with a group of children.

Each chapter begins with scientific background knowledge appropriate for the concepts covered in that section and these are intended to help the non-specialist teacher. There is a suggested vocabulary to introduce to children and a list of science skills.

Key ideas or learning intentions are followed by a variety of activities described in some detail. These are intended to help children to develop an understanding of the concepts by taking part in a practical activity themselves or watching a demonstration. Each set of activities may be targeted at a particular year group. Some ideas however, begin with activities for younger children and continue with those for older children, in order to develop the concept further. Extension ideas are often offered for more able children. The intention is for teachers to select activities that best suit their children, school and classroom circumstances.

Opportunities for the use of ICT to enhance the teaching and learning experience have been indicated where appropriate.

The activities section always includes a list of safety considerations, and in some cases additional reference is made to this within the section. It is a good idea to get into the habit discussing the hazards and risks involved with the whole class, especially for situations which maybe particularly hazardous.

Teachers should be aware of the useful guide 'Safe Use of Household and Other Chemicals' (Leaflet L5p) produced by the CLEAPSS School Science Service. However teachers should be aware that this is only available to subscribers to CLEAPSS.

Cross-curricular links

Where possible, links to other areas of the curriculum have been made and in all cases there are references to the Numeracy Strategy and the non-fiction Literacy Strategy for England and Wales. In addition, poems from the star* project have been included. This project on Science, Technology and Reading is funded by The Design Council, Esso and the Royal Society of Chemistry, with support from the Institute of Physics and the Association for Science Education. These poems have been given literacy references in number form only for the age of the children for whom the science activities are appropriate. This and other curriculum information can be found detailed on the following website; www.chemsoc/networks/LearnNet/thats-chemistry.htm

star* Project

Science, Technology and Reading is the star* project and includes a unique collection of poems especially written for it by Michael Rosen. The poems deal with specific scientific concepts in an everyday context and where appropriate, some have been included in this book. They are intended as an exciting introduction to a science lesson, offering the concept in its everyday context, a requirement of the Programme of Study for Science in the National Curriculum. In addition, they offer an opportunity to take a cross-curricular approach, by being referenced to the National Literacy Strategy, where they may also be used.

Literacy

Poetry and stories star* poems have been selected and included for all of the chapters. In addition, other poems and stories have been suggested in the resources section on pages xvii-xx, to link particular scientific concepts with the language curriculum.

Non-fiction Throughout the primary school, children are expected to experience non-fiction writing, which will often have a cross-curricular theme with a specific genre. Some suggestions have been made for this and is dependent on the suggested activities in the chapter and the age of the children carrying them out.

INVESTIGATIONS AND SCIENTIFIC ACTIVITIES

Most of the ideas presented may be carried out in a variety of ways. These include demonstrations by the teacher, investigative and explorative activities and part or whole investigations.

Practical activities such as researching a topic, illustration (eg following instructions for crystal growing), observation, surveys, learning skills (using a thermometer), and handling secondary data are not investigations. They are valuable scientific activities, which may carry specific, skills-based learning intentions. Most of the time, however, they can be incorporated into investigative and explorative activities where pupils are encouraged to make increasingly more choices and decisions for themselves. This is a valuable way of learning scientific and key skills, and building children's confidence to eventually carry out a full, independent investigation.

Investigations involve a set of scientific skills such as identifying a problem or need, planning the process and equipment, carrying out the task, observing and recording results and concluding from the results. This is time-consuming, so children should experience it when it is most appropriate, not all the time. Suggestions for investigations have been made in the book where they are particularly suitable.

Not all investigations are of the type where variables are the focus. Scientists carry out a variety of investigations where the skills of planning, carrying out the task, recording results and concluding are needed. Whilst the investigation must be carried out in a scientifically 'fair' way, changing maybe one variable, the focus maybe on another skill, depending on what is appropriate eg pattern finding. Children should experience a varied diet of investigations. The following give examples of other different investigation types:

(1) **Classifying and identifying,** eg which materials are magnetic? What is this small creature, its name and type?

(2) **Exploring.** Observations of an event over a period of time, eg germinating seeds or the development of frog spawn.

(3) **Pattern seeking.** Observing, measuring, recording, then carrying out a survey to see if there is a pattern, eg do tall people have the longest legs?

(4) **Making things or developing systems.** This maybe a combined science/technology investigation, eg designing and making a traffic light system.

(5) Investigating models, eg does the mass of a candle increase or decrease when it burns?

Many non-investigative activities may be turned into investigative ones if it is appropriate to do so by changing the task title. For example an illustrative activity such as making carbon dioxide using Alka-Seltzer and water can be made into an investigation by posing the question, 'Does the amount of Alka-Seltzer used affect the amount of carbon dioxide made?'

This type of activity presents opportunities for information collecting and handling using ICT.

ORGANISATION

The classroom organisation of science activities depends on a variety of factors, including the number and ages of the children in the class, the size of the room, number of adults helping, the available resources and the specific activity being carried out. Clearly one teacher and thirty 10 year old children, carrying out a 'burning materials activity' is not advisable for many reasons, not least of all the safety factor. For activities like this, it is advisable to carry them out in small, closely supervised groups where the children work in pairs. A classroom assistant or parent helper is very useful, even if not essential, for times like this.

The current pressures of curriculum delivery tend to dictate whole class teaching, which is probably what will happen for most science activities, especially with older children. Class rules about moving around, collecting, sharing and using equipment need to be established for science, as for any other practical subject. Children participate and learn best when they work in very small groups of two or three, but this could be part of a larger group of six, working at one table, who share a tray of equipment.

It is not always necessary for all the children to do all the same activities when dealing with a key idea in science. Differentiation dictates that some children will not be able to do this anyway. If, for example, children are testing materials or looking at factors affecting a scientific process such as dissolving they do not all need to do all the same tests. It is better to do two tests really well, where scientific skills are developed, than attempt to rush through more. The important factor would then be the plenary session at the end, which would bring all their ideas together in a whole class discussion and group presentation. This also addresses various aspects of the language curriculum.

DIFFERENTIATION

It is generally accepted that most children will be able to carry out a simple whole investigation independently by the time they leave primary school. Some, however, will not.

Children gradually develop the skills to do this and investigations can be differentiated not only by changing the task but also by the amount of teacher input that is given.

For example, an investigation into the factors that affect dissolving may be differentiated in many ways:

(1) Limit the number of factors that are investigated for less able children.

(2) When investigating each factor, some children may plan, choose apparatus etc for themselves, others may need help for all or some of this.

(3) You may wish to use the investigation as an opportunity to focus teach a skill to a group of children, such as improving their results chart or teaching them how to draw a line graph.

Helping in any part of an investigation does not negate its value or mean that the investigation cannot be assessed. Children may do a part investigation independently and receive help with the rest. For example, a child may need help planning an investigation, but be able to carry out the task and record results independently. It may not be possible to assess a complete investigation for some children.

(4) Some investigations are not appropriate for all the class eg investigating the saturation point of a solid in water, but may be used as an extension activity for some able 9-10 year old children.

TABLES, CHARTS AND GRAPHS

Charts and graphs help to make sense of a list of measurements and enable children to visually see the results of their scientific investigations. It also helps them to see the effect that variables have on each other. They need to develop the skills of reading and constructing charts and graphs.

There are conventions for tables, charts and graphs, all of which should be given clear, appropriate headings.

Tables should be drawn in column form. The left-hand column is for the **independent variable,** which is the one you choose and change, and the right-hand column is for the **dependent variable,** which is the one you observe and measure.

Any units used should be in the column heading not in the column.

There can sometimes be confusion about plotting variables on a graph and deciding which variable goes on which axis. The **independent variable**, which is chosen by the experimenter, goes on the horizontal or **'x'** axis, and the **dependent variable** , which are the readings to be made, go on the vertical or **'y'** axis.

In the science activities in this book, most of the graphs used are bar charts or line graphs.

(a) **Bar charts** are used when the **independent variable** is not numerical. The bars can be in any order, equal width and should not touch. Lines, paper strips and materials etc can be used instead of bars.

(b) **Column graphs** are very similar to bar charts but are used when **either or both variables** are whole numbers, the second variable being discreet numbers and not continuous. The columns should be in order of increasing or decreasing size.

(c) **Histograms** are for continuous survey data (any number) where the data has been grouped in numbers, eg weight, 0-10 kg, 10-20 kg, 20-30 kg. This is represented as a column similar to a column graph, but the columns are touching.

(d) **Line graphs** are also for continuous data where two variables are used eg time and temperature of dissolving. The points of the data are marked with an 'x' and the 'best fit' line or curve drawn through the points. Usually in science the points are not individually joined up, although this is common practice in other subjects. The units used are part of the axis label and not next to the data numbers. More than one line can be drawn on a graph, if the same two variables are used, to compare a third variable eg rate of evaporation of different liquids. Colours can be used to differentiate the lines.

(e) **Pie charts** are used for survey data as an alternative to Venn diagrams, column graphs, histograms and bar charts. There should be no more than six categories in order to avoid it becoming too complex, with the data key next to the chart. The sections should be in rank order beginning at '12 o'clock.'

Many graphs and charts can be produced using ICT packages.

STANDARD UNITS OF MEASUREMENT

These are the metre, m, the unit of length; the kilogram, kg, the unit of mass; the second, s, the unit of time; and the cubic metre, m^3, the unit of volume. As the use of litres is common in everyday life children should know both.

1 litre = 1 dm^3

1 ml = 1 cm^3

1 dm^3 = 1000 cm^3

The unit of temperature used is the degree Celsius (°C) which is **not** a standard unit.

HEALTH AND SAFETY

Any situation in school is potentially dangerous and the ultimate responsibility rests with the employer. However there is an expectation that the employee will behave in a certain way as to minimise the risks. All schools should have a school safety policy, which includes references to science activities to which teachers should adhere. In addition, most local authorities belong to CLEAPSS (Consortium of Local Education Authorities for the Provision of Science Services) and follow their guidelines. They recommend the use of the ASE booklet 'Be Safe' which offers advice for most primary science activities and are extremely helpful if additional advice is needed. (The telephone number and website is at the end of this section). However advice is only available to subscribers.

All countries in the UK make specific reference in their curriculum documents to children of all ages recognising the hazards and risks to themselves and others when taking part in a science activity. This therefore means that this awareness needs to be taught, together with strategies for dealing with specific hazards. Practical activities of any sort where children are moving about and using equipment are potentially hazardous and all such activities should be preceded by a brief discussion with children. Specific situations where risks are greater and particular strategies are used, such as the wearing of goggles will also need discussion with the children. It might also be a good idea to get them to design their own safety symbols to put in the margins of their work to highlight the need for safe working, and to use them regularly when they are needed.

All the activities in this book can be carried out safely in schools. The hazards have been identified and any risks from them reduced to insignificant levels by the adoption of suitable control measures. However, we also think it is worth explaining the strategies that are recommended to reduce the risks in this way.

Regulations made under the Health and Safety at Work Act 1974 require a risk assessment to be carried out before hazardous chemicals are used or made, or a hazardous procedure is carried out. Risk assessment is your employers responsibility. The task of assessing risk in particular situations may well be delegated by the employer to the head teacher/science co-ordinator, who will be expected to operate within the employer's guidelines. Following guidance from the Health and Safety Executive most education employers have adopted various nationally available texts as the basis for their model risk assessments. These commonly include the following:

Safeguards in the School Laboratory, 10th edition, Association for Science Education, 1996

Topics in Safety, 2nd Edition, Association for Science Education, 1998 (new edition available in 2001)

Hazcards, CLEAPSS, 1998 (or 1995)

Laboratory Handbook, CLEAPSS, 1997

Safety in Science Education, DfEE, HMSO, 1996

Hazardous Chemicals Manual, SSERC, 1997.

If your employer has adopted one or more of these publications, you should follow the guidance given there, subject only to a need to check and consider whether minor modification is needed to deal with the special situation in your class/school. We believe that all the activities in this book are compatible with the model risk assessments listed above. However, teachers must still verify that what is proposed does confirm with any code of practice produced by their employer. You also need to consider your local circumstances. Are your students reliable? Do you have safety glasses for everyone?

Risk assessment involves answering two questions:

How likely is it that something will go wrong?

How serious would it be if it did go wrong?

How likely it is that something will go wrong depends on who is doing it and what sort of training and experience they have had. In most of the publications listed above there are suggestions as to whether an activity should be a teacher demonstration only, or could be done by students of various ages. Your employer will probably expect you to follow this guidance.

Teachers tend to think of eye protection as the main control measure to prevent injury. In fact, personal protective equipment, such as goggles or safety spectacles, is meant to protect from the unexpected. If you expect a problem, more stringent controls are needed. A range of control measures may be adopted, the following being the most common. Use:

- a less hazardous (substitute) chemical;
- as small a quantity as possible;
- as low a concentration as possible; and
- safety screens (more than one is usually needed, to protect both teacher and students).

The importance of lower concentrations is not always appreciated, but if solutions are suitably dilute they are classified as irritant rather than corrosive.

Throughout this resource, we make some reference to the need to wear eye protection. Undoubtedly, chemical splash goggles, to the European Standard EN 166 3 give the best protection but children are often reluctant to wear goggles. Safety spectacles give less protection, but may be adequate if nothing which is classed as corrosive or toxic is in use. It is recommended that corrosive or toxic materials are **not** used in primary schools.

CLEAPSS

Teachers should note the following points about CLEAPSS:

At the time of writing, every LEA in England, Wales and Northern Ireland (except Middlesbrough) is a member, hence all their schools are members, as are the vast majority of independent schools, incorporated colleges and teacher training establishments and overseas establishments.

Members should already have copies of CLEAPSS guidance in their schools.

Members who cannot find their materials and non-members interested in joining should contact the CLEAPSS School Science Service at Brunel University, Uxbridge, UB8 3PH. Tel: 01895 251496, fax: 01895 814372, email: science@cleapss.org.uk or visit the website http://www.cleapss.org.uk.

Schools in Scotland have a similar organisation, SSERC (Scottish Schools Equipment Research Centre), 2nd Floor, St Mary's Building, 23 Hollyrood Road, Edinburgh EH8 8AE. Tel: 0131 558 8180.

Chemicals used in this book

Chemical	Hazard
Aluminium potassium sulfate	**None**
Borax (sodium tetraborate decahydrate)	**None**
Dilute hydrochloric acid 0.5 mol dm^{-3}	**None**
Iron(III) oxide	**None**
Iron filings	**None**
Plaster of Paris (anhydrous calcium sulfate)	**None**
Poly Vinyl Acetate (PVA) glue	**None**
Sodium hydrogen carbonate	**None**
Universal Indicator solution	**None**

Hazard and risk in teaching

Discuss with children the hazards of an activity – what might go wrong? Then discuss the risks – how likely is it that something would go wrong? How many people could be affected? How badly would each be affected? (One hand chopped off would be a big problem; a minor cut on a hand would be a small problem; a class set of minor cuts on hands would be a medium problem). Then discuss the control measures – how can we make it less likely that something does go wrong?

The word 'danger' can be used when you want to talk generally, but to be precise then hazard, risk, etc are the correct terminology.

So, as an example, for elastic bands, the hazards might be :

(a) Breaking, thus dropping a heavy load on your toe;

(b) Breaking, contracting and flicking something into your face or eye;

(c) Being misused to fire pellets at each other.

The chance of (a) actually happening may be zero (if you are not using heavy loads). Or considerable if you are! The number of people affected may depend on whether the whole class is doing this or just one group. How serious the injury might be would depend on the type of shoes being worn, how heavy your load really is, etc. Whether it will drop onto toes or not may depend on whether there is a bin underneath to keep toes out of the way (a control measure). The chance of (c) happening will depend on many factors such as the control exercised by the teacher and the normal behaviour of the class.