Interpreting children's performance and using the results

WORKSHOP LEADER'S NOTES

Aims

The activities in this module are designed to promote discussion of how information about children's skills, attitudes and ideas is used in teaching. Through discussion of specific examples, general strategies for helping the development of skills, attitudes and ideas are identified.

Objectives

1. Further recognition of how formative assessment can be used in teaching.
2. Knowledge of ways of using assessment to help children's development of scientific process skills and attitudes.
3. Knowledge of ways of using assessment to help children's development in understanding scientific ideas.

Task D1

This provides an example of a practical activity in which the teacher sought to set up the work so that he could find out the children's ideas and skills and then develop these.

Organisation: Participants working in groups of about five or six.

Materials needed: Task D1, Resource 9.

Time: Allow at least 25 minutes for participants to read Resource 9 and to work in groups to produce agreed answers to the questions. Then allow 30 minutes for a plenary discussion.

Instructions: Tell participants to:

- Make lists of the process skills, attitudes and ideas that the teacher attempted to gather in each of the three phases of the lesson (eg children's skill in observing, raising questions).
- Identify where the teacher used the information, if he did, either at the time or in his planning for the future.
- Consider whether there were opportunities missed and what other information could have been collected.

Task D1

The lesson on fabrics in Resource 9 is described as having three phases:
exploratory phase
investigation phase
reporting and reflecting

(i) Identify the information relating to assessing skills, attitudes and understanding that the teacher could gather about the pupils in each of these phases.

(ii) Identify where the teacher used information from assessment immediately in the progress of the activity and in his planning.

(iii) What other information might the teacher have gathered and used during this lesson?

Plenary discussion

Ask one group to report their answers to sub-task (i) for each phase of the lesson. List the skills and ideas reported down the left hand half a large sheet of paper:

Phase	Information about	How the information was used
Exploratory phase	.....	
	.....	
	..... etc	
Investigation phase	.....	
	.....	
	..... etc	
Reporting and reflecting phase	.....	
	.....	
	..... etc	

Add to this list from other groups. Discuss any patterns in the information in each phase. Then go to another group and complete the right hand column of the chart with answers to sub-task (ii). Ask a different group for answers to sub-task (iii) and add to the chart as necessary.

Points to emphasise

- There are likely to be overlapping types of information gathered in each phase, but there are patterns which can help in planning to gather information, for example:

	Children's ideas about the fabrics
Exploratory phase	Skill in explaining (hypothesising) Skill in raising questions Skill in predicting
Investigating phase	Skill in observing Skill in planning and conducting investigations Skill in interpreting (drawing conclusions)
Reporting and reflecting phase	Children's ideas about the fabrics Skill in communicating

- If not raised by the participants, ask what opportunities they think there were for assessing attitudes? There is a point to make about being very tentative about assessing attitudes from one lesson. Attitudes are shown in the consistency of behaviour on several occasions. However, this does not mean that information should not be gathered about attitudes, rather that it should be considered in the light of what the children do on other occasions.
- Raise the matter of feasibility of the approach used by this teacher in different contexts. Would it be possible to teach in this way with a very large class, for example, leaving aside for the moment the extra materials that would be needed?
- It was partly to keep the description of the lesson from becoming too long that there is not much information abut what the teacher actually did in using the information. The next two tasks take us into this detail.

Task D2

Organisation: Participants working in groups of about five.

Materials needed: Task D2, Resources 1 and 5. Large sheets of sugar paper or flip-chart paper and marker pens.

Time: Allow at least 45 minutes for participants to work in groups to produce agreed answers to the questions and then 45 minutes for a plenary discussion.

Instructions: Tell participants to:

- Read or look again at the account in Resource 1 (if they have already used it in Module A) and at Resource 5.
- Draw up a table, as in the task handout on a large sheets of paper.
- Decide whether there is evidence of achievement of child C in relation to each skill and attitude in Resource 5 and, if so, identify roughly what C has achieved. Use the labels of the statements in Resource 5 as a short-hand to put these in the table.
- Don't spend too much time on (i) since (ii) is the main task.
- Where there is evidence, consider what the teacher might do to help the child's further development in these skills and attitudes.
- Complete the table by entering suggestions for action by the teacher.

Task D2

(i) Read Resource 1 (or look at it again if you have already done so) and decide what you can tell about child C's achievement in the skills and attitudes in Resource 5. If you don't think there is any evidence, leave a blank. Complete the first column of a table such as that below.

(ii) Suggest what the teacher should do to help C's development of the skills and attitudes for which there is information about achievement. Give as much detail as you can.

	Achievement shown	Action by the teacher
Observing		
Explaining (hypothesising)		
Predicting		
Raising questions		
Planning and conducting		
Investigations		
Interpreting (drawing		
conclusions)		
Communicating		
Respect for evidence		
Flexibility		
Critical reflection		

Plenary discussion

Ask groups to display their posters and allow time for each group to consider the other groups' work and to look for similarities and differences. To start this off suggest they ask themselves questions, such as:

> *Are there similarities in what people have suggested for developing observation for developing interpretation.....etc.*

Then use these in structuring the feedback, considering each skill in turn. Introduce points from the background information during the discussion, as indicated below.

Points to emphasise

- Not all practical activities give an opportunity for all the process skills to be assessed. In practice a teacher has to look across several activities to assess the full range. If some are never found, then the teacher should look at the activities and see if they are providing oportunities for development of all the skills. (For example, are the children often following instructions and so never having the chance to plan an investigation for themselves?)
- The identification of patterns in developing process skills helps teachers to have strategies at hand that (s)he can apply in any activity. Thus it is important to think in general terms. (The background information summarises these and if possible the participants should be given copies to read after completing the module)
- If the detail for each skill seems too much to deal with at once, there are general points which apply across all the skills about what teachers can do to help development:
  - Providing opportunity to use process skills in the exploration of materials and phenomena at first hand.
  - Providing opportunity for discussion in small groups and as a whole class. (Tasks which are designed to require children to share their ideas, to listen to others, to explain and defend their ideas necessarily involve them in thinking through what they have done, relating ideas to evidence, considering others' ways of approaching a problem in addition to their own.)
  - Listening to their talk and studying their products to find out the processes which have been used in forming their ideas.
  - Encouraging critical review of *how* activities have been carried out. (During and after completing activities children should discuss how they have carried out parts of, or the whole of, an investigation and be encouraged to consider alternative courses of action and the extent to which these may be improvements.)
  - Providing access to the techniques needed for advancing skills. (In order to increase the accuracy of observation and measurement, for example, the use of instruments needs to be taught as the need for them arises. Other techniques, such as those used in the drawing of charts and graphs, and the knowledge of conventions in diagrams, are required for communication. Knowing how to use these instruments and conventions is not the same as using them appropriately, so there is more to using these skills than the basic knowledge.)

Task D3

This task focuses on the assessment of the pupils' understanding of scientific ideas and on how to develop it. It is parallel to task D2 and is conducted in a smiliar manner, but with a focus on ideas rather than skills.

Organisation: Participants working in groups of about five.

Materials needed: Task D3, Resource 10.

Time: Allow at least 20 minutes for participants to work in groups to produce agreed answers to the questions and then 30 minutes for a plenary discussion.

Instructions: Tell participants to:

- Study carefully each example and agree the extent to which there is evidence of achievement of the understanding which is indicated in the stated aim.
- Be very specific about what action the teacher should take. Say exactly what questions might be asked or what particular further activity would be provided (avoid vagueness such as 'give more examples...')

Task D3

Look at the examples of children's writing and drawings in Resource 10.

For each one consider:

- the evidence in relation to whether the child has understood the idea that is stated as the aim
- what action the teacher should take to help further development.

Complete the following table

Example	Evidence related to aim	Action by the teacher
A		
B		
C		

Plenary discussion

Ask one group to give their responses for Example A. Ask other groups for points of difference. Resolve conflict in relation to the evidence by asking for reasons. Question the group closely to provide a detailed indication of what the teacher's action might be.

Repeat with different groups reporting for the other examples.

After collecting all the specific ideas, bring them together and draw out the strategies that could be used in other situations (see below).

Points to emphasise

- It is not just children's 'wrong' answers that provide information to help in teaching. Both the child's correct answer in Example A and the unusual one (the horn) should be followed up by questioning to find out the child's reasoning.
- There are too many ideas to list a separate action for each one so it is important to identify general strategies that can be appied across the range of ideas. These are described in the background information under the headings:
  Helping children to test their ideas
  Extending children's experience
  Discussing words
  Providing alternative, more scientific ideas
- Although these suggestions have been made in relation to individual children or pairs, the strategies suggested can be used in relation to groups and large classes.

Background information

Using information to help children's process skill development

At a general level, the following are some of the main ways of helping children to develop their process skills:

- Children have to use process skills in order to develop them; to use their own senses and to gather evidence from which to raise questions, form hypotheses based on existing ideas, and so on. Being told about what it means to observe, interpret or investigate is not the same as doing these things.
- It is useful to design activities which require children to share their ideas, to listen to others, to explain and defend their ideas. This necessarily involves them in thinking through what they have done, relating ideas to evidence, considering others' ways of approaching a problem in addition to their own.
- During and after completing activities children should discuss how they have carried out parts of or the whole of an investigation and encouraged to consider alternative courses of action and the extent to which these may be improvements. This will enable the children to recognise the skills which they need to improve.
- In order to increase the accuracy of observation and measurement, for example, the use of instruments needs to be taught as the need for them arises. Other techniques, such as those used in the drawing of charts and graphs, and the knowledge of conventions in diagrams, are required for communication.

The further points below look in more detail at what can be done in relation to particular skills.

Observing

Opportunity to use the senses as ways of finding out requires objects to explore objects and phenomena. An 'interest' or science table in the classroom is one way of providing this as well as serving other purposes. It is always a good idea to set out objects relating to a new topic two or three weeks ahead of starting it in order to create interest. During the topic work items can be added to the display. The table enables children to use odd moments as well as science activity time for observing and so increases an important commodity in the development of this skill. Time is significant here more than perhaps for other skills. Children need time to go back to things they may have observed only superficially or when a question has occurred to them that suggests something they want to check.

Some children also need invitations to observe. Cards placed next to objects or equipment displayed can encourage observation and action. 'Try to make this bottle make a high and a low sound' placed next to a bottle three-quarters full of water encourages interaction. 'How many different kinds of grass are there here?' placed next to a bunch of dried grasses encourages careful observation. The correct use of a magnifying glass can also be taught through a card with a drawing on it.

When observations have been made, there should be opportunities created for them to be shared. Making a point of spending a few minutes in whole class discussion of what has been noticed about things on the science table, for example, may draw the attention of some children to things they have missed and emphasise the role of the table in the class activities.

Raising questions

Whilst the aim of the development of questioning skills in science is to help children raise questions which are investigable, the starting point towards this is raising questions of any kind. To indicate too soon that science is concerned with certain kinds of questions and

not others might deter the raising of questions. So the teacher should see asking questions of any kind as the first step to progress in this skill. These may be questions which ask for names, for information, for explanations; they may be philosophical or may address aesthetic values, or they may be answerable by investigation or be capable of being turned into questions which can be investigated. It is important to take all the questions seriously and to indicate to the children which ones can be answered if they do something to find out.

Children will readily ask questions in terms of 'how' or 'why' which are often not easy to answer. 'How do worms move without any legs?' 'Why are wood lice (slaters) hard on the outside and soft in the middle?' By helping the children to turn these into investigable questions by such means as posing related questions ('Well, can we find out if the worms move as easily on different surfaces, very shiny ones or rough ones?') they gradually realise that these questions are more effective in obtaining answers. With encouragement and the example of the teacher they will gradually begin to realise that there are certain kinds of questions which are answered by investigation.

Thus the ways in which teachers can help children's progression in this skill include:
- taking children's questions seriously so that they see for themselves how each kind is answered
- posing questions themselves in investigable form in science
- helping children to clarify their questions so that they can see how to find an answers
- giving invitations for children to raise questions ('What would you like to find out about ...?')

Hypothesising

A hypothesis is an attempt to explain some observation, happening or relationship. There are things to avoid as well as to encourage in helping the development of this skill. To be avoided is the idea that a hypothesis has to be 'right', that is, it depends on knowing all about what is happening. This impression can be conveyed through the questions which are asked of children. If the question is framed as 'Why do some leaves turn brown in autumn?' then it is difficult to answer unless you know, or think you know the reason. On the other hand, the questions 'Why do you think some leaves turn brown?' or 'What do you think could be the reason for leaves turning brown?' stimulate the generation of an explanation from existing ideas. (See Module C on teachers' questions)

The development of confidence in ability to suggest explanation is helped by asking for several possible alternatives in situations where there is not necessarily an obvious answer. For example, why are there patches of different coloured grass on the field? There are multiple possible reasons, which could be brought out by asking 'what else could be the reason?' as each suggestion is accepted. Each one has to be possible in terms of the evidence: different kinds of grass; something in the soil under the patches; drainage varying from one place to another. But a suggestion that more rain fall on the patches might be rejected because of evidence that there is nothing to cause such difference.
Trying to explain a shared observation such as this enables children to feel that they have the ability to make sense of the things around them. Which of the suggestions may be most likely, would require more evidence and investigation, but their ability to attempt explanations is not dependent on the result.

Young children's hypotheses will be in the form of attempts to explain specific events in their experience rather than in terms of broad statements of principles which explain a whole range of phenomena (such as referring to the conditions needed for the growth of plants to explain the patches in the grass). However, the ability to suggest explanations in specific terms is the foundation of later development in applying broad principles and theories. Meanwhile the skill of using existing ideas, limited though they may be, in attempting explanations plays an important role in testing and developing these ideas.

Predicting

Opportunities to make predictions can be created both in relation to patterns found in observations and in relation to hypotheses which are put forward to explain observations.

In the case of *patterns found between two variables* the prediction is based on the evidence of some association between one thing and another, but without necessarily assuming that it is an association of cause and effect. The simple relationship between hand size and foot size is an example of association where there is no sense in suggesting that one thing causes the other, that having large hands causes large feet; rather there is another variable which is causally related to both of them. Nevertheless, the association, whatever its basis, can be used in predicting (within limits) the foot size of someone from their hand size.

Not all patterns are simple and the process of predicting from them is best encouraged through the more obvious relationships such as the sound that is made when a thin strip of wood (or a ruler) is held at one end and twanged at the other. The note varies with the length which is free to vibrate. Once observations have led to the pattern being established, children can predict whether a particular length will give a higher or lower note and then try it out. In such situations it is useful for them to discuss how they make their predictions since this helps them to become conscious of using the pattern they have noticed in the observations. They should recognise that this is different from a guess.

Predictions based on hypotheses depend on previous experience and ideas derived from it rather than the interpretation of findings from an investigation or observed events. Hypotheses do suggest explanations in terms of cause and effect and constitute some theory of why things are as they are. It is the test of a true theory that it can be used. For example the hypothesis that the leaves turn brown 'because of the cold' is a theory that cold brings about the change. Although not quite accurate, this theory can be used to make a prediction about the circumstances in which leaves will turn brown, which is a test of the hypothesis and the idea on which it is based. Again, it is important for children to be helped to make predictions in simple cases and think about the way in which they arrive at a prediction.

Children often implicitly use patterns or hypotheses in making predictions but fail to recognise that they in fact do so. A girl who had investigated how far a wind-up toy travelled after different numbers of turns, asked to make a prediction of how far it would go for a certain number of turns said that she guessed. Further probing, however, led to her explaining, 'I thought that it would be a bit more than for 3 and a bit less than for 5', suggesting that she was implicitly using a relationship of 'more winds means further'. Becoming aware of the pattern she was using enabled her to predict other distances with more confidence and indeed satisfaction. Discussion played a central part in bringing about this awareness.

Investigating

The process of investigating is taken here to be what happens between having a question to investigate or a prediction to test and obtaining observations or data to be interpreted. Too often children's experience of these steps in answering questions is of following instructions such as:

> "*(To find out if ice melts more quickly in air or in water a room temperature) you'll need to use the same sized ice-cubes. Make sure you have everything ready before you take the ice cubes out of the tray. Put one cube in the water and one close to it in the air. Then start the clock...*"

Here the children will have no problem in doing what is required, but they will have no idea of why they are doing it. If they did, they might challenge the need for a clock in this activity!

A diet weighted with such activities does not give children the opportunity to carry out planning and thinking about what they are doing. There must, therefore, be opportunities for children to start from a question for investigation and to think out and carry out their own procedures for answering it. This is asking a great deal for young children and for older ones unused to devising investigations and they will need help which subsequently can gradually be withdrawn.

Young children's experience should include simple problems such that they can easily respond to 'How will you do this?' For example, 'How can you find out if the light from the torch will shine through this fabric, this piece of plastic, this jar of water, this coat sleeve?' Involving children in planning is part of setting an expectation that they will think through what they are going to do as far as possible.

For older children, help in planning can begin, paradoxically, from reviewing an investigation which has been completed (whether or not the children planned it themselves), helping them to go through what was done and identifying the structure of the activity through questions such as

- What were they trying to find out?
- What things did they compare (identifying the independent variable)?
- How did they make sure that it was fair (identifying the variables which should be kept the same)?
- How did they find the result (identifying the dependent variable).

When planing a new investigation the lessons learned from reviewing can be recalled, where perhaps variables were not controlled or initial observations taken when they should have been. Planning continues throughout an investigation and indeed the initial plan may change as the work progresses and unforeseen practical obstacles emerge. However it is important for children to recognise when they do change plans and to review the whole planning framework when a change is made. Writing plans down is a useful activity because it requires forward thinking, actions carried out in the mind. Children become more able to do this the more experience they have to think through and call upon in anticipating the results of certain actions. The teacher's role is thus to provide time and a structure for planning and gradually to set the expectation that children think through what they do even it they do not write formal plans on paper for every investigation.

Interpreting results and drawing conclusions

For children to develop ideas as a result of collecting information and evidence to test their ideas they have to interpret what they find. That is, they must go further than collecting individual observations and to look for patterns, relate various pieces of information to each other and to ideas. For example, children measuring the length of the shadow of a stick placed in the ground at different times of the day children must go beyond just collecting the measurements if the activity is to have value for developing ideas. Important outcomes of this activity are recognising the pattern of the decreasing and then increasing length of the shadow and the possibility of using the pattern to make predictions about the length at times not measured, or the time of day from the measurement of the shadow, and the development of ideas about how shadows are formed. They all depend on *using* the results the children obtain, so the development of the skills required is important. The central part of the teacher's role is to ensure that results *are* used and children don't rush from one activity to another without talking about and thinking through what their results mean.

It was noted earlier that children often make predictions on the basis of patterns without apparently being conscious of doing so. Teachers can help to foster this consciousness by discussing simple patterns, such as the relationship between the position of the sun and the length of the shadow (or the equivalent in a classroom simulation using a torch and a stick). The starting point must be the various ways in which children will express their conclusions, including:

'The shadow is shortest when the sun is highest'.
'The shortest one is when the sun is high and the longest when it is low'.
'Its length depends on where the sun is'.
These are working towards recognising that:
'The higher the sun the shorter the shadow'.
Which says all that the previous statements say and more besides. Time for discussion of how to express a pattern is essential for the development of this skill.

Communicating

In the course of their science activities there is the potential for children to experience a range of different kinds of communication for different purposes and audiences. These should include:

Modes:	writing, speaking, drawing, making, keeping notes and listening, reading, looking
Audiences:	for themselves, other pupils, their teacher, other adults
Purposes:	in order to sort out ideas, tell others about what they have done present observations, findings and conclusions.

This is a wide range to cover and clearly not all will be part of every activity. It is useful, however, for a teacher to plan this part of children's activities so that all are included appropriately and regularly. 'Appropriately' means that it should serve the purposes of the activity and not become meaningless ritual. The routine 'write about what you did' can kill any creativity in communication, as well as being a deterrent for some children.

A personal note-book can be a very helpful aid to recording and to later interpretation and reporting. At the least it is an aid to memory and at best a means of having a dialogue with oneself which assists reflective thinking. It is useful for children to use a note-book but they will need help. The help has to be given very subtly, though; if there is too much checking-up on what is written, the note-book becomes just another exercise book which is 'marked' by the teacher.

Discussion of the best way to present information is the opportunity to introduce techniques for graphical representation or to talk about how to select the best way of presenting information. Work already displayed on the wall can be used as examples of how to and how not to do this. Children are usually willing to criticise their own work after some time has elapsed. It is also a good idea to have one or two examples of commercial posters (such as those about the nutritional value of different foods or showing types of clouds) to show different ways of providing information.

Looking at posters and books is the other side of formal communication, that is, using secondary sources of information. Children need opportunity – suitable reference sources and time to use them – and some help in locating and selecting information.

Using information to develop children's ideas

These are suggestions for ways of meeting individual needs within a group context. They do not propose separate activities for individual children but support from the teacher which is based on knowledge of the development of the children. The ideas that children express and which we see as 'unscientific' need to be taken seriously because they are based on their own reasoning even though this reasoning may be limited and 'unscientific'.

The children's ideas may be:
- based on their inevitably limited experience
- expressed using scientific words but without a grasp of the accepted meaning of these words
- held because there are no alternative ideas which are more convincing to the children.

Consideration of their characteristics leads almost automatically to the action that a teacher may take to help the development of their understanding: helping children to test their ideas more rigorously (which implies the development of process skills); extending experience; discussing words; providing alternative, more scientific, ideas; enabling children to review past experience in the light of any change made in their ideas. We shall consider the teacher's role in relation to each of these.

Helping children to test their ideas

If we think about how children arrive at their ideas it is often the case that they have taken account only of certain evidence and ignored anything that is contradictory, or that they have not compared like with like.

An important part of a teacher's role in science is to set up the expectation that *all* ideas have to be tested, not just the children's but any the teacher proposes or ones found in books. If this becomes routine, then there will be no implied criticism in asking children to 'find a way to see if your idea works'.

Not all tests of children's ideas will be of the kind suggested in books of scientific activities and the teacher should be prepared to be as imaginative as the children in devising ways to address unexpected ideas.

Extending children's experience

It is not always the case that children have ignored evidence; often evidence that they might have used is just not available to them, as it is to adults. For example, it is reasonable to hold the hypothesis that rust may originate inside the body of a metal if a child has only ever seen the exposed surfaces of metal objects. Cutting through a rusted nail may be all that is needed to show that this in not the case. (This could be interpreted as testing the prediction that rust is found inside the metal; indeed all ways of extending children's ideas could be regarded as ways of testing ideas).

The teacher's role is to provide gradually extended experience as a matter of routine. This can be through classroom displays, which are added to as a topic proceeds; through posters and photographs mounted on the walls, information books at the right level, for reference in the book corner; through visits, visitors and full use of the school buildings as resources for observation and activity.

Discussing words

The introduction and use of 'scientific' words is often a cause of uncertainty. The teacher's role is to judge the right time to introduce an appropriate word to describe events or objects that children have already experienced and need to name.

However, children pick up words from other sources and take some delight in trying them out. When children use scientific words, from any source, it is necessary to find out what meaning they have in mind rather than to assume that it is the same as the accepted meaning. A useful way of doing this is to ask the children to show some examples of what the word means: 'Tell me about something that is melting....vibrating....evaporating....etc' . If the example is of something rather different from the meaning of the word (as when evaporating is confused with condensing, for instance) then the correct word can be introduced and the children should become involved in thinking up and demonstrating examples of both condensing and evaporating – or whatever words were confused. Encouraging children to challenge each other's use of words can sharpen their thinking at times when the teacher is not present.

Providing alternative, more scientific ideas

This needs careful judgement even though it may seem the most obvious role for the

teacher to take. The delicacy of judgement is required because it is all too easy to destroy children's confidence in their own thinking and reasoning if their ideas are swept aside by premature presentation of the 'right' ones. The best way of avoiding this is to ensure that more scientific ideas are introduced, not as being 'correct' but as alternatives worth considering, and that these are tested in terms of the evidence available so that everyone can judge the extent to which they 'work' in practice.

As children progress in ways of thinking and experience they can be encouraged to consider alternatives by argument and information from secondary sources and not only from what they can experience directly. Thus, for example, models of the solar system can be used to introduce explanations of the apparent movement of the sun and moon which can over-ride the naive interpretations of direct observations.

Enabling children to review earlier experience in terms of new ideas

When early ideas that children have used to explain things to themselves are changed by the impact of investigating and thinking about new experience, it is important for there to be some review of their understanding of earlier experience. Without this there may be a residue of naive ideas which are still used to explain previous experience. For example, we can all probably recall believing in something like 'the man in the moon', but recognise that this belief was overtaken by more rational views. It would be illogical to believe in a man in the moon and the moon as understood more scientifically. To avoid the equivalent in children's growing ideas the teacher should help them to reflect on previous experience in terms of new ideas. It is helpful to be quite explicit about 'how your ideas about ... have changed' for this legitimises changing ways of understanding things, which is essential for the continued development of ideas.