Guidance

Curriculum and Standards

Key Stage 3
National Strategy

Strengthening teaching and learning in science through using different pedagogies

Unit 2: Active questioning

Science subject leaders, KS3 science coordinators and science teachers

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Strengthening teaching and learning in science through using different pedagogies

Unit 2 Active questioning

DfES 0698-2004 G

How to use this study unit

This study unit offers practical suggestions for you to use in the classroom when considering using active questioning techniques. All the strategies suggested have been tried and tested by teachers in their classrooms. They draw upon both academic research and the experience of practising teachers. You may have looked at *Teaching and learning in secondary school materials* (DfES 0423-2004). While there are similarities with these materials, you will find that this unit gives science specific advice that will be immediately relevant for use in your laboratory.

Your science consultant can help you work through this unit but it would be better to twin up with a colleague who also wishes to enhance the quality of their questioning. The unit is structured so that the tasks listed towards the beginning are simple and quick to implement. More challenging activities come towards the end. The unit contains case studies and tasks for you to undertake. It also contains 'reflections' which will help you revisit an idea or your own practice. It includes practical tips and tasks which will help you consider the advice or try out new techniques in the classroom. The summary of research is contained towards the back of the unit and will offer some suggestions for further reading. The final page invites you to reflect on the experience of having tried out new materials and set some personal targets for the future. You can work through the materials in a number of ways:

- Start small; choose one class to work with. Ask another teacher or your subject leader to help by providing a sounding board for your ideas.
- Work with your science consultant on developing and planning your approach to questioning with one class. After three weeks meet together to review how it is going. Discuss which strategies have been the most effective with one class and plan to use these with other classes.
- Find another science teacher to pair with and team teach. Design the activities together and divide the teacher's role between you.
- Work with a group of teachers in the department. Use the unit as a focus for joint working, meet regularly to share ideas and then review progress after a few weeks.
- Identify the sections of the unit that are the most appropriate for you and focus on those.

There is space provided in the unit for you to write notes and make comments about the activities. You may find it helpful to keep a journal of events. For some tasks you may want to make a video recording of yourself in action so you can make a realistic appraisal of your performance. You could add this, along with any other notes and planning that you do as you work your way through the unit, to your CPD portfolio.

Active questioning

Contents

Introduction

Questioning is a subject that has been tackled in a number of Key Stage 3 Strategy science training materials. This unit aims to bring together the research, methodology, tips and tactics that have been previously looked at into one document for you to work through.

Asking questions is a part of science teaching which is often 'instinctive'. Science teachers rarely have an opportunity to observe each other asking questions or to reflect on their own practice. This unit provides a good opportunity to work with another teacher or your Key Stage 3 science consultant. The unit is designed to support readers to reflect on and analyse their questions and develop techniques that will:

- challenge pupils' thinking;
- enhance pupils' learning;
- assess their understanding.

Task 1

Why is questioning important in science?

Collect ideas with your teacher partner as to why questioning is so important to science teaching.

Record your ideas on a flipchart and then summarise the outcomes.

You may have come up with some of the following points:

- questioning is an immediate way for teachers to assess pupils' level of understanding;
- questioning can challenge pupils' scientific ideas and identify their misconceptions;

- questioning can be used to facilitate the learning of pupils in a variety of situations. For example:
  – engage the pupils with the content of the lesson;
  – whole-class starters and plenaries;
  – interaction with groups;
  – discussions with individuals about their work.

This unit will extend your repertoire of questioning techniques to enable you to be a much more focused question asker.

The purposes of questioning

Science teachers ask questions for many different purposes. Perhaps the most common reason is to interest the pupils and challenge them to think carefully about what they are learning. Often questioning is used to check pupils' understanding of a concept or procedure. This is especially true at the beginning of a new unit of work where pupils' prior understanding is an important building block for how the unit will be taught. When questioning is used effectively it will stimulate recall and mobilise existing understanding in order to make new understanding and meaning. It helps pupils to extend their thinking from concrete and factual to being more analytical and evaluative. Certain questions will promote reasoning, problem solving, evaluation and the formulation of hypotheses.

The kind of question asked will depend on the reason for asking it. Questions are often referred to as 'open' or 'closed'.

Closed questions, which have one clear answer, are useful when a quick check of knowledge is required, for example, 'What unit do we use to measure force?'

If you want pupils to develop higher-order thinking skills then more open-ended questions are needed. This will allow pupils to give a variety of acceptable answers. During class discussions and debriefings, it is useful to ask open questions such as 'What do you think might affect the size of the current in this circuit?'.

Questioning is sometimes used as a mechanism for bringing the pupils' attention back on task, for example, 'What do you think about what Kevin said Jane?' or 'Do you agree with that Phil?'

The list given in the review box is not exhaustive but will help you to categorise the purposes for asking your own questions.

Review

Why ask questions?

- To extend pupils' thinking from the concrete to the more abstract.
- To check prior knowledge and understanding of key ideas.
- To clarify misconceptions.
- To challenge pupils to apply the key ideas to a range of observations and findings.
- To lead pupils through a sequence which establishes their understanding of certain enquiries.
- To promote the use of thinking skills, for example, reasoning, evaluation.
- To develop a systematic approach to scientific enquiry and problem solving.
- To promote pupils' thinking about what they have learned and how they have learned.

Task 2

Self-review

60 minutes

Read the research summary which is located on pages 14 to 16 at the end of this unit. If you can locate a copy of *Inside the Black Box* Black, P. and William, D. (1998), Kings College London (this was given out during the *Science training unit Assessment in Science 2002*), read this too.

Think about the lessons that you have taught recently. How does your questioning compare with the research findings? Look at the section headed 'What is effective questioning'. Highlight those strategies that you currently employ regularly in one colour and those that you use occasionally in another.

Make a note of those areas you wish to improve.

Now plan a lesson for the next week. Make a note in your lesson plan of the questions that you will ask.

Now try and analyse the questions in the following way, using a grid as suggested below – an example has been given for you.

Teach the lesson (it would be really helpful if your teacher partner could observe the lesson and make notes for you, or you could make an audiotape of yourself, and then allow some time to evaluate it with your partner) even if they were not able to observe you.

Question asked	**Open or closed?**	**Purpose**	**Evaluation of pupils' responses** (impact on their learning)
What do we call the process that a green plant uses to make food?	Closed	To test recall	Helped the pupils to remember the word photosynthesis

Planning effective questioning

The sort of questioning used in many classrooms is often instinctive. This can lead to some questions that are not well judged or productive for learning. The trick to effective questioning is to plan for it beforehand. There are some common pitfalls associated with asking questions that need to be avoided. The following checklist also provides some solutions.

Issue	Solution
Not being clear about why you are asking the question.	Reflect on the type of lesson you are planning. Is it one where the pupils will need to recall lots of facts and assimilate specific information like formula? If this is the case then you will plan to use more closed questions which relate to knowledge. If it is a lesson where you will require the pupils to think about a new concept or interrogate data, then you will need to plan for open questions which will lead to synthesis and analysis.
Asking too many closed questions that only require a short answer.	It will help to plan open questions in advance (more of this in task 3). Another strategy is to ask the pupils to respond with an answer of a given length to encourage deeper thought, e.g. 'I will not accept an answer less than ten words'.
Asking too many questions in a short period of time.	Asking questions on a complex issue such as global warming can lead to complex questions. As these questions are often oral it is difficult for pupils to hold all the information in their minds at once and they need the issue 'chunked' to aid understanding. Work out the issues for yourself first and focus each question on one issue only at any one time. It will also help to use concrete language and as few words as possible.
Asking difficult questions with no build up.	The sequence of questions needs to be planned in advance building-in increasing difficulty. Sequencing the questions allows pupils to move to higher levels of thinking.
Asking superficial questions.	It is possible to ask lots of questions which do not get to the heart of the issue being discussed. Pupils may be very good at naming woodland species but this will not help them to produce a pyramid of biomass.
Asking a question and then answering this yourself.	We have all done this! Usually the cause is not giving pupils sufficient wait time (a case study on this follows later). Tell the pupils that you will give them X amount of time to think about an answer before you will expect one. Be very strict with yourself and count to at least three slowly before taking an answer.
Asking 'guess what I have got in my head' type questions.	This is when you ask an open question, but have a very definite response in your head. If you ask an open question, the pupils will give you many different responses and become frustrated when their answer is not the one you are looking for. This would be planned for more effectively by asking a direct 'closed' type question.
Not involving the whole class.	Usually this occurs when you are in a hurry to obtain a response and therefore only ask the pupils who you know will give you the response that you are after. One way to avoid this is to use whiteboards where all pupils write their answer to a closed question and then on the command 'show me' they all hold them up so that you can see their responses. Another tactic is to adopt a 'no-hands-up' policy where you pick the pupils who you wish to →

	respond rather than the brave few who put up their hands. One of the advantages is that you can differentiate the questions appropriately so as to aid inclusion.
Dealing ineffectively with wrong answers and misconceptions.	There is always the worry that you will ruin a pupils self-esteem by correcting them or telling them that they are wrong. If responses are handled sensitively this will not happen. Preface your response with phrases such as 'that was a good attempt Jack, you have got the first bit spot on' or 'Joli made a good attempt at that answer. Molly can you help her out with the middle bit.' Any misconceptions that pupils hold must be dealt with at the time, otherwise they will become very difficult to alter later.
Not treating pupil's answers seriously.	It is tempting to dismiss answers that are a bit off the wall. These are often associated with a misconception that needs challenging. It is important not to cut pupils off and move on too quickly if they give a peculiar answer.

Case study

In the article *Feedback in questioning and marking: the science teacher's role in formative assessment* by Paul Black and Christine Harrison appearing in School Science Review, June 2001, 82 (301) they outline how development work in formative practice in school classrooms was undertaken by researchers and twelve science and twelve mathematics teachers was undertaken in two LEAs (Medway and Oxfordshire). Part of this research was into increasing the wait time of teachers when they asked questions of their pupils. The following are some extracts of what the teachers said:

Teacher 1

Increasing wait time after asking questions proved difficult to start with – due to my habitual desire to 'add' something almost immediately after asking the original question. The pause after asking the question was sometimes painful. It felt unnatural to have such a seemingly 'dead' period but I persevered. Given more thinking time the students seemed to realise that a more thoughtful answer was required. Now after many months of changing my style of questioning, I have noticed that most students will give an answer and an explanation (where necessary) without additional prompting … a pause is an effective way of indicating that more information is required. Occasionally, I find myself making the most ridiculous facial gestures to indicate that I want more information. The student looks for my response, none arrives and the realisation hits them. Additional thinking occurs, followed by an explanation.

Teacher 2

I knew I had to find a way of increasing the time and decided the best way of leaving space was to ask them to discuss in pairs, then write down their thoughts in the back of their books. I needed to stop interfering so I sat at the front … Collecting responses at first was better than I expected. More students volunteered answers and the answers were deeper. My follow-up questions were planned and much more open (often more comparative and reflective) and exciting discussions started. Wrong answers slowly stopped being a problem as students got used to the idea that I was very unlikely to express an opinion during these sessions.

Using questions to promote higher-order thinking

All teachers use questions in the hope that they will promote pupils' thinking. We formulate questions of different kinds and often in a lesson will ask questions of different degrees of difficulty. In addition, we need to ask questions of differing degrees of cognitive complexity in order to challenge pupils to develop their thinking. Questions should be linked to the lesson objectives to ensure that the questions planned are closely linked to pupil outcomes.

In many Strategy training materials reference has been made to Bloom's taxonomy (see summary research). It is a useful tool to use in both planning lesson objectives and in planning questions of increasing challenge. The taxonomy classifies educational objectives into groups according to the level of cognitive complexity and the kind of thinking that is required to meet the objectives.

Bloom made the assumption that the objectives could be placed hierarchically, from knowledge (least complex) to evaluation (the most complex) – the one that requires higher-order thinking. Those of you who are familiar with the CASE project will also be familiar with this idea and the work of Piaget.

Both ideas assume that in order to gain higher-order thinking skills lower steps must be completed. For example, pupils need to acquire knowledge before they can understand it or apply it to a new situation.

Look at the Appendix on pages 19 and 20 which interprets the taxonomy in a science context. Analysis of questions asked by teachers indicates that very often they only ask questions that come into the first two categories (knowledge and comprehension). You can see that this would limit pupils' ability to attain higher-order thinking as the questions do not challenge them to use the higher-order skills of application, analysis, synthesis and evaluation.

It is helpful to develop a bank of department questions to focus on the more advanced categories of thinking.

Task 3

Developing higher-order questions

The list given below represents some closed questions that are often used by teachers.

Working with your teacher partner, look at the questions and the stems and examples given in the Appendix and brainstorm some higher-order questions that will challenge pupils in these contexts. Display your list in the department base or prep. room and ask other colleagues to add to the list.

It is a good idea at each department meeting to spend 5 minutes looking at one science context and brainstorm lots of questions. This very quickly leads to a department bank to draw on if you are stuck for inspiration.

Closed lower category	Open/higher category
Where in the digestive system is the duodenum?	How is the duodenem structured to help it work effectively?
How many micro-organisms can you name that cause disease?	
Name three types of rock.	
What do we mean by renewable energy?	
Which does sound travel best through? Solid, liquid or gas.	
What is air pollution?	

Questioning in scientific enquiry

Asking questions at various levels of demand and framing the lesson objectives can equally well be made progressive in the context of scientific enquiry. We may say things like 'I don't know what to do with 8J. They do the experiment but they can't analyse results or evaluate at all'. This could be because the way we frame the questions does not allow the pupils to show what they can do. Some research reported in *Secondary Science Review* March 2000, 81 (296) *Teachers' questions – types and significance in science education*, looked at the identification and classification of types of questions used in science lessons. It also looked at how question types related to a particular teaching approach.

The table on the following page is adapted and reproduced from this report.

Classification of question types and corresponding mental operations

	No.	Description of questions	Type of mental operations	Example of questions
lower-level thinking	1	Recalling facts, events or remembering and repeating definitions from previous lessons. Included are questions that begin with *what, when, where*	Recalling episodes	Do you remember the middle bit of the last lesson?
	2	Describing the elements of an experimental situation, *identifying* variables and providing simple relationships	Judging	How do these bulbs vary? Which bulb is the brightest?
	3	Questions that basically begin with *how*. Description of the procedure and the establishment of fair testing through a experiment.	Justifying judgements (justification of procedures)	How did you test whether the length of a tube affects the pitch of the controlled note? How did you establish a relationship between …?
	4	Questions seeking *proof/evidence*	Justifying judgements (justification of judgements)	Does this prove that width makes a difference? What evidence have you got for that? Can you see a pattern in growth over time?
higher-level thinking	5	Recognising the *pattern* in a data set or describing the *trend* of a graph. (This category refers only to visual representations of data.)	Judging	Can you see a pattern in this probability table?
	6	Questions beginning with *why*, seeking for a reason behind the procedure followed	Justifying judgements (justification of arguments or explanations)	Why is this a wise decision? Why is that fair?
	7	*What if* questions	Hypothesising	What would be the problem if …? If I already have two heads in a throw, what would be the chance of another head in the next throw?
	8	Giving *predictions*	Hypothesising	Having in mind the previous result, could you tell me how far the next roller ball will go?
	9	Reaching *conclusions*	Reframing	What is the whole point of sampling?

You can see that this hierarchy largely reflects the one outlined by Bloom. The fundamental part of planning enquiry work is that some of the questions you use must be of a higher order. Otherwise pupils will stay in lower-order thinking mode and not be challenged to aim for or demonstrate higher-order thinking skills.

Task 4

Planning an enquiry — **60 minutes**

Working with your teacher partner, look at your current scheme of work and pick out an enquiry that you are going to teach soon. This need not be a whole investigation – it could be some skills development or research work in the context of Science 2, 3 or 4.

Think about how you are going to set up the enquiry and plan some higher-order questioning.

Think about when you are going to ask these questions.

- Will you ask a 'big' question to set up the enquiry?
- Will you focus primarily on questions that will stimulate the pupils to enhance, for example, their evaluative skills?

Teach the lesson and evaluate how successful your new questioning technique was in the motivation and learning of the pupils.

This is another occasion when it would be good for you to be observed teaching the lesson and jointly reflecting on it.

Classroom tactics for effective questioning

Creating a climate where pupils feel safe to make mistakes This is very important if pupils are going to build the confidence to speculate and take risks. It is important that pupils' contributions are listened to and taken seriously by both the teacher and the class. You should model this by ensuring that you make appropriate responses to contributions and are not critical. It is also important that you do not allow the class to ridicule wrong answers. Boys in particular do not like to be shown to be wrong. You could also model making mistakes yourself to show that it's acceptable to be wrong.

Using a 'no-hands' rule This tactic can contribute to creating a supportive classroom climate. It ensures that all pupils are likely to be asked for a response and makes the questioning process more inclusive. If you only ever ask people with their hands up, it limits who is included and can leave some pupils disengaged from the process. The 'no-hands-up' tactic also lets you direct and distribute questions where you want and to pitch a question at the appropriate level to extend the pupil you are asking. If you are asking conscripts rather than volunteers, you need to have a range of back-up strategies in case the pupil is unable to answer. Such strategies could include allowing them to say 'pass' or to seek help from a friend or tell them you will return with the same question in a few minutes so they have some more time to think about it.

Probing When pupils respond to a question, probes are useful follow-ups and can be used to seek more information, to clarify responses or to get pupils to extend their answers. Questions such as 'Can you tell me more about that?' or 'What do you think the next step would be?' are useful probes that extend pupils' thinking.

Telling pupils the big question in advance This helps to reinforce the main ideas and concepts and gives pupils time to prepare for the question as they work through the lesson. You could also provide signals to help pupils recognise the range of possible responses to the question being asked and to help them to select the most appropriate one.

Building in wait time Research suggests that if the teacher waits about three seconds, both before a pupil answers a question and also before speaking after the pupil has answered, there are substantial benefits in the classroom. It is likely to:

- encourage longer answers;
- encourage a greater number and variety of responses;
- encourage more confidence and 'risk taking';
- encourage pupils to ask questions in return.

Allowing time for collaboration before answering Asking pairs of pupils to consider the question for a set period of time before seeking answers leads to more thoughtful and considered answers. It can also promote engagement by giving pupils a very immediate context for their work.

Placing a minimum requirement on the answer Saying something like 'You are not allowed to answer this in less than fifteen words' will begin to produce longer responses.

Dealing with answers

Dealing well with pupils' answers is a very important aspect of effective questioning. The over-use or inappropriate use of praise should be avoided and pupils should be made aware if their answer is not correct. This is particularly true if the answer reveals misconceptions.

If the answer is correct you must acknowledge this but you should avoid effusive praise. If the answer is a particularly good one, you might indicate why it is so good or ask other pupils what they think. If the pupil is hesitant, they will need a greater degree of affirmation than someone who is confident in the answer.

If the answer is incorrect because of a lack of knowledge or understanding, you could simplify the question or provide a series of prompts to encourage the pupil to try a better answer. If this doesn't work, then you could try to clarify the underpinning knowledge or provide a partly correct answer for them to try completing. This can help to clarify misconceptions and can also involve other pupils in the discussion.

If the answer is partly correct you should acknowledge the parts which are correct and then use prompts to deal with the incorrect parts.

If an answer is a result of speculation you should accept all answers as being of equal worth, then collaborate on finding which are more likely to be correct. The way you ask the question in the first place should indicate that all answers are acceptable at this stage. Asking, at the start of an investigation, 'What factors might affect the rate of photosynthesis?' is much better than 'What factors affect the rate of photosynthesis?'

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Reflection

Which of these tactics could help you improve own practice?

Task 5

Classroom assignment: putting it into practice

30 minutes

Choose two or three tactics from the above list. Try them out in a lesson and assess how successful they were. To begin with you may feel self-conscious about doing these new things, but in time with perseverance they will begin to come naturally. The pupils may also find the approaches unusual or novel so you will need to reassure them that this is helping their learning.

As you try out a new tactic, keep a lesson log of strengths and weaknesses of each one. What works well quickly with some classes may need longer to embed with others.

This example can be adapted to meet your individual needs.

Tactic	**Pupils' responses:**				
	first try	**second try**	**third try**	**fourth try**	**fifth try**
Using no hands					
Increasing wait time					
Giving the big question in advance					
Allowing pupils time to collaborate					
Placing a minimum requirement on the length of an answer					

Alternatives to direct questions

Sometimes teachers use questioning when other teaching strategies, such as explanation, would be more appropriate. Below are some alternatives to questioning which could be used as additional tools to develop pupils' learning.

Explore a statement Rather than asking pupils a direct question, give them a statement and invite them to discuss, perhaps first in pairs and then in fours, what it means. The statement could be correct, false or ambiguous, for example, 'There is no gravity in space', 'Erosion is a process that is happening all the time.'

Paint the picture This is particularly useful for exploring abstract ideas. Ask pupils to draw how they picture an idea they have in their minds. You might say, for example, 'So the energy in the battery is transferred around the circuit to the bulb and then to the air by light and heating. What is in your head? What mental model do you have for this? Draw it.'

Invite pupils to elaborate Phrases such as 'Would you say a little more about that?' or 'I'm not sure what you mean' are useful in getting pupils to expand and develop a comment.

Speculate about the subject under discussion Saying things like 'I wonder what would happen if …' can help pupils to think around an issue in a different way.

Make a suggestion You could offer alternative ways of carrying out a task. This may be more practical during small-group work than with a whole class.

Offer extra information Providing extra information during a problem-solving activity can be useful in stimulating pupils' thinking.

Reinforce suggestions from pupils Try developing a comment made by a pupil by saying something like 'That was really good because …'

Clarify ideas Saying something like 'We can tell that this is the case because …' helps to reinforce learning by focusing sharply on the main issues under consideration.

Repeat comments and summarise When you want to reinforce important points that have been made, it helps to restate or summarise them in a slightly different form.

Task 6

Alternatives

Plan some alternatives to using direct questions.

Pick a group of pupils to work with and try them out. Evaluate how effective these were in terms of pupils' understanding and engagement.

Summary of research

Effective questioning

Research evidence suggests that effective teachers use a greater number of open questions than less-effective teachers. The mix of open and closed questions will, of course, depend on what is being taught and the objectives of the lesson. However, teachers who ask no open questions in a lesson may be providing insufficient cognitive challenges for pupils.

Questioning is one of the most extensively researched areas of teaching and learning. This is because of its central importance in the teaching and learning process. The research falls into three broad categories:

- What is effective questioning?
- How do questions engage pupils and promote responses?
- How do questions develop pupils' cognitive abilities?

What is effective questioning?

Questioning is effective when it allows pupils to engage with the learning process by actively composing responses. Research (Boric 1996; Muijs and Reynolds 2001; Morgan and Saxton 1994; Wag and Brown 2001) suggests that lessons where questioning is effective are likely to have the following characteristics:

- Questions are planned and closely linked to the objectives of the lesson.
- The learning of basic skills is enhanced by frequent questions following the exposition of new content that has been broken down into small steps. Each step should be followed by guided practice that provides opportunities for pupils to consolidate what they have learned and that allows teachers to check their understanding.
- Closed questions are used to check factual understanding and recall.
- Open questions predominate.
- Sequences of questions are planned so that the cognitive level increases as the questions go on. This ensures that pupils are led to answer questions which demand increasingly higher-order thinking skills but are supported on the way by questions which require less-sophisticated thinking skills.

Pupils have opportunities to ask their own questions and seek their own answers. They are encouraged to provide feedback to each other.

The classroom climate is one where pupils feel secure enough to take risks, be tentative and make mistakes.

The research emphasises the importance of using open, higher-level questions to develop pupils' higher-order thinking skills. Clearly, there needs to be a balance between open and closed questions, depending on the topic and objectives for the lesson. A closed question such as 'What is the next number in the sequence?' can be extended by a follow-up question such as 'How did you work that out?'

Overall, the research shows that effective teachers use a greater number of higher-order questions and open questions than less effective teachers. However, the research also demonstrates that most of the questions asked by both effective and less effective teachers are lower order and closed. It is estimated that 70 to 80 per cent of all learning-focused questions require a simple factual response, whereas only 20 to 30 per cent lead pupils to explain, clarify, expand, generalise or infer. In other words, only a minority of questions demand that pupils use higher order thinking skills.

How do questions engage pupils and promote responses?

It doesn't matter how good and well structured your questions are if your pupils do not respond. This can be a problem with shy pupils or older pupils who are not used to highly interactive teaching. It can also be a problem with pupils who are not very interested in school or engaged with learning. The research identifies a number of strategies which are helpful in encouraging pupil response. (See Borich 1996; Muijs and Reynolds 2001; Morgan and Saxton 1994; Wragg and Brown 2001; Rowe 1986; Black and Harrison 2001; Black et al. 2002.)

Pupil response is enhanced where:

- there is a classroom climate in which pupils feel safe and know they will not be criticised or ridiculed if they give a wrong answer;

- prompts are provided to give pupils confidence to try an answer;
- there is a 'no-hands-up' approach to answering, where you choose the respondent rather than have them volunteer;
- 'wait time' is provided before an answer is required. The research suggests that three seconds is about right for most questions, with the proviso that more complex questions may need a longer wait time. Research shows that the average wait time in classrooms is about one second (Rowe 1986; Borich 1996).

How do questions develop pupils' cognitive abilities?

Lower-level questions usually demand factual, descriptive answers that are relatively easy to give. Higher-level questions require more sophisticated thinking from pupils; they are more complex and more difficult to answer. Higher-level questions are central to pupils' cognitive development, and research evidence suggests that pupils' levels of achievement can be increased by regular access to higher-order thinking. (See Borich 1996; Muijs and Reynolds 2001; Morgan and Saxton 1994; Wragg and Brown 2001; Black and Harrison 2001.)

When you are planning higher-level questions, you will find it useful to use Bloom's taxonomy of educational objectives (Bloom and Krathwohl 1956) to help structure questions which will require higher-level thinking. Bloom's taxonomy is a classification of levels of intellectual behaviour important in learning. The taxonomy classifies cognitive learning into six levels of complexity and abstraction:

1. Knowledge – pupils should: describe; identify; recall.
2. Comprehension – pupils should: translate; review; report; restate.
3. Application – pupils should: interpret; predict; show how; solve; try in a new context.
4. Analysis – pupils should: explain; infer; analyse; question; test; criticise.
5. Synthesis – pupils should: design; create; arrange; organise; construct.
6. Evaluation – pupils should: assess; compare and contrast; appraise; argue; select.

From Benjamin S. Bloom Et AL, *Taxonomy of Educational Objectives*. Published by Allyn and Bacon, Boston, MA. Copyright ©1984, Pearson Education. Adapted by permission for the publisher.

On this scale, knowledge is the lowest-order thinking skill and evaluation is the highest. It is worth pointing out that, in most cases, pupils will need to be able to analyse, synthesise and evaluate if they are to attain level 5 and above in the National Curriculum and Grade C and above at GCSE.

Bloom researched thousands of questions routinely asked by teachers and categorised them. His research, and that of others, suggests that most learning-focused questions asked in classrooms fall into the first two categories, with few questions falling into the other categories which relate to higher-order thinking skills.

Summary

If questioning is effective, then pupils should be able to recall ideas, link ideas together and explain their understanding orally. Pupils will also engage with the teacher because they feel comfortable; they are aware of the purpose of the questioning and do not feel threatened by it. As time goes on they become more aware of how they are learning because the questioning not only probes their thinking, but helps them reflect on their own thinking and learning processes.

Next steps

In this unit there have been a number of suggestions for you to pair with another teacher or your science consultant as a means of support while you develop your confidence in developing group talk activities. Here are some ideas to consider in order to take this work forward:

- Start small: choose one class to work with. Year 7 would be a good choice because these pupils still have vivid memories of their primary school where they were used to their teachers questioning technique. However, if you have another class you feel would respond well to this, then use them.
- Ask another teacher or your science consultant to help you. You may have an AST in school who is not a member of the science department but who is well versed in questioning. They would be a good source of help.
- Ask for some protected time before the lesson so that you can check the resources and practise your script.
- Make sure your line manager or head of department/subject leader knows what you are doing. This will enable dissemination to happen much more easily.
- Read some research about questioning from the range of references provided.
- Talk to your pupils about how this technique helps them to learn.
- Share the class with another teacher and you take responsibility for the questioning part of the lesson.
- Ask your science consultant to team teach the lesson with you. You should each take responsibility for trying different questioning techniques.

Setting professional targets

Reflect on the experiences you have had while undertaking this unit and set yourself two targets to develop over the next year. Below are just a few suggestions of the kind of things you might want to undertake.

Observe an AST and/or leading teacher in science who will be able to demonstrate the use of effective questioning.

Work with your science consultant and plan to team-teach a module using the techniques that you have learned during this unit.

Plan a series of lessons for next term using these techniques and invite a colleague to observe you teaching.

Setting targets

Bearing in mind the guidance given above, reflect on the further steps you are going to take, perhaps by discussing the possibilities with a colleague or your line manager. Set yourself two targets to work towards over the coming year.

Specify:

- the outcomes you will seek in terms of developing effective questioning techniques in your classroom;
- the strategies you will employ to disseminate your good practice to the rest of the department.

References

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Appendix: Interpreting Bloom's taxonomy in the context of science teaching

Too few questions come from the categories, which relate to higher-order thinking skills and are broadly comparable to the science level descriptions.

Reproduced from *Planning and Implementing Progression in the Classroom CPD unit*.

Category	**Useful stems to consider when asking questions**	**Some examples used in science**
Knowledge	Name	Name the parts of the body.
	Identify	Identify the main parts of the circuit.
	Recall	What happens when you add an acid to a metal?
	State	Give me the equation for photosynthesis.
Comprehension	Describe	Tell me what you observed when you added hydrochloric acid to copper carbonate.
	Compare (events and objects)	What is the difference between metals and non-metals? What can you tell me reacts the same as ... ? How is the graph of temperature against time different for insulated and non-insulated containers?
	Classify	How can you classify these plants?
	Explain	How can you use the idea of forces to explain why a boat floats in water?
Application	Interpret	What does the graph of velocity against time tell you about the acceleration and direction of the car?
	Relating	What happens when you connect more bulbs in series?
		How does the energy in the cells transfer to the bulbs?
	Solve problems	How are you going to find out how the change in the wavelength of light changes the rate of photosynthesis?
		How are you going to find out about the impact of the greenhouse effect?
		How are you going to find out how and why the length of the shadow varies during the day?
	Applying ideas	How might your knowledge of plants make sure that each runner bean that is planted will grow really well?

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Category	Useful stems to consider when asking questions	Some examples used in science
		From what you know about the work of Newton, how can you explain the difference between the force of gravity on the Earth and the Moon? Using your ideas about particles, explain why some smells reach you before others.
Analysis	Prioritising	Can you put these statements in the correct order? Which do you think has the greatest impact on staying healthy?
	Inferring	What do your results tell you? From what you know about particles, explain the shape of the graph.
	Logical reasoning	From what you know about how light travels, can you explain how we can see objects that are not sources of light?
	Critical reasoning	From what you know about the work of Jenner, can you prepare to make a presentation either for or against his methods of trialling the vaccine for smallpox?
	Drawing conclusions	Explain, using your knowledge of energy transfer and different materials, what happens when you increase the number of layers of insulation on a hot water tank? Do you think the outside temperature makes a difference?
Synthesis	Reflecting	Donna says that as the temperature increases the particles get bigger. Do you agree? Give your reasons.
	Designing	How could we use our work on electricity to design a lighting circuit for a doll's house?
	Predicting	How are you going to design an investigation to find out the impact of fertilisers on plant growth?
	Speculating	Using what you know about food chains, explain what happens in Antarctica. Where would you find the information to support your prediction? Do you think the shadows on Mars will change in the same way as those on Earth?
Evaluation	Summarising	What reasons can you give for the success of your experiment on ...?
	Judging	Which ideas that you considered gave the most information?
	Evaluating	How good were your results? How well did they support your conclusions? If you repeated the investigation, what would you improve on?

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