Improving learning through questioning
How can we ask questions that improve thinking and reasoning?
A PROFESSIONAL DEVELOPMENT MODULE

Introduction
The effective use of formative assessment lessons depends on the quality of feedback given by teachers to students. One important way of moving students’ thinking forward is to prompt them to reconsider their reasoning by asking carefully chosen questions.

This unit contains a selection of professional activities that are designed to help teachers to reflect on:

• characteristics of their questioning that encourage students to reflect, think and reason;
• ways in which teachers might encourage students to provide extended, thoughtful answers, without being afraid of making mistakes;
• the value of showing students what reasoning means by ‘thinking aloud’.

The activities described below are given here as a ‘menu’ of suggestions to help the provider select and plan. They are presented in a logical order, building up knowledge and expertise.

Any planned professional development program should offer opportunities for teachers to try new pedagogies in the classroom and then report back and reflect on their experiences. Activity D is therefore essential in the program.

Activities
Activity A: Reflect on the questions we ask ................................................................. 2
Activity B: What types of questions develop thinking and reasoning? ............................................. 4
Activity C: Observe and analyze a lesson .............................................................................. 6
Activity D: Plan a lesson, teach it and reflect on the outcomes ................................................. 8
Activity E: Solve a problem, "thinking aloud" ......................................................................... 10

Acknowledgement:
In preparing this material, we acknowledge the permissions given by the Bowland Charitable Trust to adapt the professional development resources, Bowland Maths, that they had previously funded us to produce for the UK. This includes many of the handouts and most of the video extracts. Additional resources were also adapted from Improving Learning in Mathematics, a government funded program in the UK. The original sources are:

Draft Feb 2012 © 2012 MARS, Shell Centre, University of Nottingham
Activity A: Reflect on the questions we ask

Time needed: 15 minutes.

Give teachers time to discuss the following questions in pairs or small groups. Ask them to record their collective ideas on a copy of the handout. Then hold a plenary discussion to collect and share ideas. As teachers suggest different purposes, ask them to give particular examples.

Teachers ask many different types of questions and they serve many different purposes.

- What different types of questions are there?
- What different functions do these questions serve?
- Which types of questions do you use most frequently?
- What common mistakes do you tend to make when asking questions? What are their effects?

We ask questions for many possible reasons, including the following eight:

- to interest, engage and challenge;
- to assess prior knowledge and understanding;
- to stimulate recall, in order to create new understanding and meaning;
- to focus thinking on the most important concepts and issues;
- to help students extend their thinking from the factual to the analytical;
- to promote reasoning, problem solving, evaluation and the formation of hypotheses;
- to promote students’ thinking about the way they have learned;
- to help students to see connections.

The following is a list of some of the more common mistakes that teachers make:

- Asking too many trivial or irrelevant questions.
- Asking a question and answering it yourself.
- Simplifying the question when students don’t immediately respond.
- Asking questions of only the most able or likeable students.
- Asking several questions at once.
- Asking only closed questions that allow one right/wrong possible answer.
- Asking ‘guess what is in my head’ questions, where you know the answer you want to hear and you ignore or reject answers that are different.
- Judging every student response with ‘well done’, ‘nearly there’ or ‘not quite’. ‘Well done’ can discourage alternative ideas being offered.
- Not giving students time to think or discuss before responding.
- Ignoring incorrect answers and moving on.
Handout 1: Thinking about why we ask questions

What different types of questions are there?

What different functions do your questions serve?

Which types of questions do you use most frequently?

What common mistakes do you make when asking questions?
What are the unintended effects of each of these mistakes?

<table>
<thead>
<tr>
<th>Common mistake</th>
<th>Unintended effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Activity B: What types of questions develop thinking and reasoning?**

*Time needed: 20 minutes.*

Give teachers time to discuss the following issues. Ask them to record their collective ideas on a copy of **Handout 2**.

- What types of questions promote thinking and reasoning?
- Give some examples that you have recently used.
- Reflect on the implications of these ideas for your own practice.

Afterwards give them copies of **Handout 3**. This contains a summary of some research findings into questioning. This shows that effective questioning displays the five characteristics:

- The teacher plans questions that encourage thinking and reasoning.
- Everyone is included.
- Students are given time to think.
- The teacher avoids judging students' responses.
- Students’ responses are followed up in ways that encourage deeper thinking.

Invite teachers to discuss the research findings in small groups.

- Which of these principles do you usually implement in your own teaching?
- Which principles do you find it most difficult to implement? Why is this?
Handout 2: What types of questions develop thinking and reasoning?

Handout 2: What types of questions develop thinking and reasoning?

What types of question seems to encourage inquiry-based learning?

Give a few examples that you have recently used.

How look at Handout 2

This handout has four principles for effective questioning.

Reflect on the implications of these ideas for your own practice.

Handouts for Teachers

Improving Learning Through Questioning

5.1

Handout 3: Five principles for effective questioning

Handout 3: Five principles for effective questioning

1. Plan to use questions that encourage thinking and reasoning

- What do you already know that might be useful?
- What do you think might need to be taught?
- What can you use to inquiry-base this teaching?
- What is known and what is unknown?
- What are the key questions we need to answer?

2. Ask questions in ways that include everyone

- Use a ‘yes’/‘no’ question. After a few hints, people have given up some of their own questions and ask others. When students have not volunteered answers, they already have the answer they seek. Yes ‘hands up’ responses encourage students to answer and give everyone the opportunity to respond.
- Avoid judgmental or ambiguous questions. Better for students to answer their own questions. When you ask an ‘open ended question’, you open the floor to all students, but you stop others from asking questions.
- Avoid questions that demand answers from everyone. Think about when students say ‘no’. Can you see a question being asked of everyone?
- Allow students to ask questions of each other. Think about when students say ‘no’. Can you see a question being asked of everyone?
- Arrange the room to encourage participation. Think about when students say ‘no’. Can you see a question being asked of everyone?

3. Give students time to think

Avoid judging students’ responses. Interestingly, Brown (1992) found that ‘teacher judgmental comments, even positive ones such as “Well done!”,’ were negatively affected students’ cortical performance even with the immediate and unspoken encouragement. ‘Talk to yourself way students are able to do this.”

- Encourage students to ask questions of each other. People naturally ask questions of each other.
- Allow students to ask questions of each other. People naturally ask questions of each other.
- Encourage students to ask questions of each other. People naturally ask questions of each other.

6. Avoid judging students’ responses

Avoid judging students’ responses. Interestingly, Brown (1992) found that ‘teacher judgmental comments, even positive ones such as “Well done!”’ were negatively affected students’ cortical performance even with the immediate and unspoken encouragement. ‘Talk to yourself way students are able to do this.”

- Discourage students to ask questions of each other. People naturally ask questions of each other.
- Encourage students to ask questions of each other. People naturally ask questions of each other.
- Encourage students to ask questions of each other. People naturally ask questions of each other.

<table>
<thead>
<tr>
<th>Rationale</th>
<th>Teachers</th>
<th>Improving Learning Through Questioning</th>
</tr>
</thead>
</table>

**PD Module Guide**

Improving Learning Through Questioning

5
Activity C: Observe and analyze a lesson

Time needed: 30 minutes.

Work on the problem shown on Handout 4.
• Compare the two solutions. Which do you consider better and why?

Now watch Activity C Video: ‘Gwen’s lesson’ and consider the following questions:
• Which of the following principles can you see Gwen using in her lesson? Give examples.
  o Plan questions that encourage thinking and reasoning.
  o Ask questions in ways that include everyone.
  o Give students time to think.
  o Avoid judging students' responses.
  o Follow up students' responses in ways that encourage deeper thinking.
• What do you think students learned from the lesson

• Plan questions that encourage thinking and reasoning.
Gwen has carefully planned the lesson so that the focus is not on answers but on reasoning. She begins the lesson by emphasizing that lesson will be focused on the quality of students’ thinking, reasoning and explaining, and on listening to each other. This message is reinforced throughout by her interactions with students:
“Do you want to explain to me why that is fair?”; “How are you thinking of the journey? Can you explain to me ...?”; “How are you going to work out ...?”; “What else is there that might help you? That’s all I’m going to say. Keep thinking.”

• Ask questions in ways that include everyone.
Gwen has introduced a ‘no hands up’ rule, so that she can choose who will respond to her questions and so that students continue to think while responses are made. She tries to encourage a range of responses and asks students to comment on each other’s responses.

• Give students time to think.
Gwen gives students time to think individually before discussing, so that they all have something to share.

• Avoid judging students’ responses.
Gwen collects the students’ initial ideas and writes these on the board. She asks follow-up questions for clarification (“Just explain a little bit more about that.”) and thanks them for their contributions, but does not judge responses with ‘Well done’, or ‘That's not quite right.’

• Follow up students’ responses in ways that encourage deeper thinking.
For example, Gwen invites students to elaborate: “Can you just say that again?”; asks students to think aloud: “Can you explain your thinking Alex?”; cues alternative responses: “Bethany, what do you think is best out of Hannah’s suggestions?”; “Girls, can you see how that might help you? ... How might that help you?”.
Handout 4: Observing a lesson

Sharing gas costs

Each day Dan’s mum drives him to school.
On the way, she picks up 3 of Dan’s friends, Chris, Ben and Anne.
Each afternoon, she returns by the same route and drops them off at their homes.
At the end of a term, the four students decide to pay a sum of $100 towards the cost of gas.
How should they share out the cost?
Find some reasonable solutions and say which you think is best and why.

Two reasoned methods are shown below. Which do you consider better?

Method 1:
This is to share the cost in the proportion to the road distance people live from school:
2: 5: 8: 10. So:
Anne pays $8
Ben pays $20
Chris pays $32
Dan pays $40

Method 2:
Assume that, altogether, people will need to pay $10 per mile. Costs are shared out as follows:

<table>
<thead>
<tr>
<th></th>
<th>Anne</th>
<th>Ben</th>
<th>Chris</th>
<th>Dan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last 2 miles $20</td>
<td>$5</td>
<td>$5</td>
<td>$5</td>
<td>$5</td>
</tr>
<tr>
<td>Next 3 miles $30</td>
<td>$10</td>
<td>$10</td>
<td>$10</td>
<td>$10</td>
</tr>
<tr>
<td>Next 3 miles $30</td>
<td></td>
<td>$15</td>
<td></td>
<td>$15</td>
</tr>
<tr>
<td>First 2 miles $20</td>
<td></td>
<td></td>
<td></td>
<td>$20</td>
</tr>
</tbody>
</table>

Anne pays $5
Ben pays $15
Chris pays $30
Dan pays $50
Activity D: Plan a lesson, teach it and reflect on the outcomes

Time needed:
• 15 minutes discussion before the lesson.
• 1 hour for the lesson.
• 15 minutes after the lesson.

Choose a problem to try with your class.
Use the prompts on Handout 5 to plan a lesson that will promote thinking and reasoning.

• How will you organize the classroom and the resources?
• How will you introduce the questioning session?
• Which ground rules will you establish?
• What will be your first question?
• How will you give time for students to think before responding?
• Will you need to intervene at some point to refocus or discuss different strategies they are using?
• What questions will you use in plenary discussions during or towards the end of the lesson?

Because teachers will be focusing on the questions that they use and the way that the students answer those questions we suggest that they audio-record some whole class questioning lesson for discussion in Activity 5.

A sample lesson plan using the ‘Sharing Gas Costs’ problem is shown on Handout 6. This may be used as a model for teachers to follow.

After you have tried out your lesson with your own students, discuss the following issues:

• Which questions appeared to promote the most thoughtful and reasoned responses from students? Why was this?
• Which questions didn't work so well? Why was this?
• Which of the following four principles did you use? Give examples.
  o Plan questions that encourage thinking and reasoning.
  o Ask questions in ways that include everyone.
  o Give students time to think.
  o Avoid judging students' responses.
  o Follow up students' responses in ways that encourage deeper thinking.
• What will you do differently next time?
### Handout 5: Planning for effective questioning

<table>
<thead>
<tr>
<th><strong>Handout 5: Planning for effective questioning</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plan how you will arrange the room and the resources needed:</strong></td>
</tr>
<tr>
<td>Arrange students so that they can see and hear each other as well as the teacher. You may encourage students to sit in a circle so the students who are more shy or quiet can participate. For example, you may move to the back of the room so that the question is the focus of attention and not the teacher.</td>
</tr>
<tr>
<td><strong>Plan how you will introduce the questioning session:</strong></td>
</tr>
<tr>
<td>Always be ready for your role - the role of the facilitator - in the session, you may need to add in students' roles to the session. You may need to look at some hands in such a way that you are aware of the hands. The students will be allowed to take the hands up to ask a question, or to hand them up to another student. The students will be given a question that they have been given and then be able to answer questions.</td>
</tr>
<tr>
<td><strong>Plan how you will establish the ground rules:</strong></td>
</tr>
<tr>
<td>Always be ready for your role - the role of the facilitator - in the session, you may need to add in students' roles to the session. You may need to look at some hands in such a way that you are aware of the hands. The students will be allowed to take the hands up to ask a question, or to hand them up to another student. The students will be given a question that they have been given and then be able to answer questions.</td>
</tr>
<tr>
<td><strong>Plan the first question that you will use:</strong></td>
</tr>
<tr>
<td>Always be ready for your role - the role of the facilitator - in the session, you may need to add in students' roles to the session. You may need to look at some hands in such a way that you are aware of the hands. The students will be allowed to take the hands up to ask a question, or to hand them up to another student. The students will be given a question that they have been given and then be able to answer questions.</td>
</tr>
<tr>
<td><strong>Plan how you will give thinking time:</strong></td>
</tr>
<tr>
<td>Always be ready for your role - the role of the facilitator - in the session, you may need to add in students' roles to the session. You may need to look at some hands in such a way that you are aware of the hands. The students will be allowed to take the hands up to ask a question, or to hand them up to another student. The students will be given a question that they have been given and then be able to answer questions.</td>
</tr>
<tr>
<td><strong>Plan how you will intervene:</strong></td>
</tr>
<tr>
<td>Always be ready for your role - the role of the facilitator - in the session, you may need to add in students' roles to the session. You may need to look at some hands in such a way that you are aware of the hands. The students will be allowed to take the hands up to ask a question, or to hand them up to another student. The students will be given a question that they have been given and then be able to answer questions.</td>
</tr>
</tbody>
</table>

---

### Handout 6: A lesson plan on sharing gas costs

**Handout 6: A lesson plan on sharing gas costs**

The following suggestions describe one possible approach to using the problems with students. This may take place in two lessons, depending on the class.

**1. Introduce the problem, and give time for individuals to think:**

- **Issue each student with just one of the three problems.**
- **Explain that this lesson is a question time to think about the problem.**
- **Today is going to be a very special day for you.**
- **Tell the students what you think about the problem:**
- **Explain how students are expected to start work on the problem:**
- **Read through the problem.**
- **How can you start thinking about this problem?**
- **What is your understanding of the problem?**
- **Explain the importance of understanding the problem:**
- **Collect initial ideas on the board:**
- **After the ‘thinking time’, pose the problem again:**
- **Use the alternatives to questioning to generate discussion.**
- **Round the part for later discussion (if possible).**

**2. Collect initial ideas on the board:**

- **After the ‘thinking time’, pose the problem again:**
- **Use the alternatives to questioning to generate discussion.**

**3. Students work on the problem:**

- **On average, 20 minutes:**
- **What did students think about the problems?**
- **What did they think about the problems?**
- **What did you think about the problems?**

**4. Whole class discusses the approaches being used:**

- **On average, 10 minutes:**
- **What did students think about the problems?**
- **What did you think about the problems?**
- **How did you think about the problems?**

**5. Students have a second go at the problem:**

- **On average, 10 minutes:**
- **What did students think about the problems?**
- **What did you think about the problems?**
- **How did you think about the problems?**

**6. Whole class reports on their reasoning:**

- **On average, 10 minutes:**
- **What did students think about the problems?**
- **What did you think about the problems?**
- **How did you think about the problems?**
**Activity E: Solve a problem, "thinking aloud"**

Teachers usually present science and mathematics as though they are a set of tidy results and procedures. Students often don’t recognize the invisible, messy processes that go on inside the heads of scientists. One reason why some students are reluctant to persist is that they do not recognize that it is perfectly natural to get stuck, make mistakes, backtrack and look for alternative strategies. It is helpful, therefore, for a teacher to model these processes by tackling a problem from start to finish, thinking aloud and involving the class by careful questioning.

In the professional development session, it is useful for teachers to think through this process by tackling a problem together, ‘thinking aloud’.

Try working out an answer to the following problem, thinking aloud as you do so:

**About how many dentists are there in your country?**

Afterwards think what it would feel like, doing this with a class, not knowing the answer beforehand.

If you are working with a group of teachers, ask two volunteers to tackle the problem publicly, thinking aloud at the front of the room. The other teachers should take the role of the pupils and try to assist when asked to do so.

Afterwards, discuss other possible strategies that might help students realize the mental processes that scientists and mathematicians use every day. These may include, for example:

- Making a video of yourself and some colleagues solving a problem, while thinking aloud and discussing this with your class.
  
  **Activity E Video:** ‘Thinking Aloud’ shows a group of British teachers trying this.

- Students watching or reading biographies of mathematicians and scientists as they tell about their struggles and breakthroughs. See for example, Andrew Wiles’ story on Youtube: [http://video.google.com/videoplay?docid=8269328330690408516](http://video.google.com/videoplay?docid=8269328330690408516)

- After working on a problem, reading solution attempts produced by other students that reveal errors, and the multiple trials and dead ends that have been encountered. Ask the students to work together to find, correct and comment on the ‘errors in reasoning’. They should also comment on where the reasoning was good so that they may use these ideas again.