Introduction

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 4 is therefore essential in the program.

Activities

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Acknowledgement:

This material is adapted for PRIMAS from:
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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' '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

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<th>What common mistakes do you make when asking questions?</th>
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<td>What are the unintended effects of each of these mistakes?</td>
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ACTIVITY B: WHAT KINDS OF QUESTIONS PROMOTE INQUIRY?

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 shown.

- What types of questions promote inquiry-based learning?
- Give some examples that you have recently used.
- Handout 3 describes some characteristics of effective questioning. 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 kinds of questions promote inquiry-based learning?

What types of questions seem to encourage inquiry-based learning?

Give a few examples that you have recently used.

Now look at Handout 3

This describes five principles for effective questioning. Reflect on the implications of these ideas for your own practice.

Handout 3. Five principles for effective questioning

1. Plan to use questions that encourage thinking and meaning

   Really effective questions are open-ended. It is helpful to plan sequences of questions that build on an existing student’s idea.

   A good question for a group of students might be:

   - What do you already know that might be useful here?
   - What sort of apps might be helpful?
   - Can you think of any other similar ideas?
   - What do you think the answer might be?
   - What is it that we are trying to find out?
   - What are you trying to prove?

2. Plan to use questions that enhance thinking and learning

   - What will you do after you have finished the activity?
   - What did you learn about the activity?
   - What new ideas have you thought of?
   - What questions do you have about the activity?
   - What other ideas do you have about the activity?
   - What is the purpose of the activity?
   - What are the important parts of the activity?
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ACTIVITY C: OBSERVE AND ANALYSE 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 the **video clip of Gwen's lesson** and consider the following questions:
- Which of the following principles can you see Gwen using in her lesson? Give examples.
  - **Plan questions that encourage thinking and reasoning.**
  - **Ask questions in ways that include everyone.**
  - **Give students time to think.**
  - **Avoid judging students' responses.**
  - **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 emphasising 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 others' 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

4. Observing a Lesson

Sharing petrol 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 euros towards the cost of petrol.

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:

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<tr>
<th></th>
<th>Anne</th>
<th>Ben</th>
<th>Chris</th>
<th>Dan</th>
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<tr>
<td>2 miles</td>
<td>£8</td>
<td>£20</td>
<td>£32</td>
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Method 2:
Assume that, altogether, people will need to pay £10 per mile. Costs are shared out as follows:

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<th>Ben</th>
<th>Chris</th>
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<tr>
<td>Last 2 miles</td>
<td>£5</td>
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<td>Next 3 miles</td>
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<td>Anne pays</td>
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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 organise 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 Petrol 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.
  - Plan questions that encourage thinking and reasoning.
  - Ask questions in ways that include everyone.
  - Give students time to think.
  - Avoid judging students’ responses.
  - Follow up students’ responses in ways that encourage deeper thinking.
- What will you do differently next time?
5. Planning for effective questioning

Plan how you will arrange the room and the resources needed
Arrange students so that they can see and hear one another as well as the teacher. You may need to rearrange chairs in a U-shape so the students can move and "stick" closer together. Or maybe you will move to the back of the room so that the question is the focus of attention and not the teacher.

Plan how you will introduce the questioning session
Silence will be hard for you to bear in the classroom but the students may find it confusing or even threatening. Explain why there will be times of quiet, for example:

Plan how you will establish the ground rules
If you are using "No hands up" then you will need to explain this to students. Some teachers have had to ask their students to sit on their hands so that they remember not to put their hands up. The students will be allowed to put their hands up to ask a question, or if a hand-shouts up remember to ask them what question they would like to ask. The students may also be used to going short answers so you could introduce a minimum length rule e.g. "your answer must be five words in length or a minimum...

Plan the first question that you will use
Plan the first question and think about how you will continue. You cannot plan this exactly as it will depend on the answers that the students give but you might, for example, plan:
- to take one answer and then ask others what they think about the reasoning given
- to take two or three answers without comment then ask the next person to say what is similar or different about those answers

Plan how you will give thinking time
- will you allow 3-5 seconds between asking a question and expecting an answer?
- will you ask the students to think -- pause -- think, giving 30 seconds for talking to a partner before offering an idea in whole class discussion?
- will you use another strategy that allows the students time to think?

Plan how and when you will intervene
Will you need to intervene at some point to refocus students' attention or discuss different strategies they are using? Have one or two questions ready to ask part way through the lesson to check on their progress and their learning.

Plan what questions you could use for the plenary at the end of the lesson
Try not to pass judgments on their responses while they do this or this may influence subsequent contributions.

6. A lesson plan on "Sharing Petrol Costs"

The following suggestions describe one possible approach to using the problems with students.

This may take one or two lessons, depending on the class.

1. Introduce the problem, and give time for individuals to think 5 minutes
Issue each student with just one of the three problems.
Explain that in this lesson you are expecting everyone to think through it and to contribute:

Today I am going to make sure you have plenty of time to think. I will give you a problem and I want you to think about how to get started with it for a few minutes. I will then ask for your ideas. There is more than one good way of doing this! No hands up, I will tell you when I want answers and who is to answer. Now here's the question I want you to think about...

Explain how students are expected to start work on the problem:

Read through the problem. How can we get started on this problem? What is known and what is unknown? What assumptions should we make? Remember I don't want answers yet; I want to know your ideas for getting started. You have exactly 1 minute to think starting now!

2. Collect initial ideas on the board 5 minutes
After the "thinking time", pose the problem again then use the alternatives to questioning to generate discussion.

Record this part of the discussion if possible.

Right let's get started, what did you think about, Ann?

Does anyone have any comments on Ann's ideas?

Can I see that, what else might we think about Sarah?

We're talking about three good ideas so far; does anyone have anything really different?

Note that these questions are general and strategic. Do not comment on the specifics of the response at this stage, even if students press you to tell them what is 'best' or who is 'right'.

Instead, simply record these ideas on the board, and get the students to do as they explain. That way the ideas will be there for the class to consider as they start to solve the problem. Remind them that although they have heard several strategies that will help them get started, that they should choose just one of them to start with. Explain what students should do when they are stuck:

If you get stuck, think about the ways of tackling the problem we have talked about. Maybe you could try another one? Remember this lesson is about thinking and reasoning things out; so sit quietly and think about what you could do, then you could talk to a friend about what you are thinking. You are on your own, get going!

Now set a target, reminding them to think about the reasons they make decisions as they work:

Right, now I'm going to give you twenty minutes to work on the problem by yourselves. Then I'm going to ask you some questions about what you have done and why you think the ideas you tried worked or didn't work.

3. Students work on the problem 20 minutes
Allow students time to engage with the problems. When they ask questions, ask them a question that offers strategic guidance rather than technical help. For example:

Which way did you decide to use to start? Why?

What have you found out? How did you do this?

What didn't work? Why? What might work?

Think things out for yourself or between you - only call in the professionals when you have tried everything else.

4. Whole class discusses the approaches being used 10 minutes
When most students have made significant progress with the problem, ask the students about the way that they are working. (It may be helpful to record this part for later discussion).

We are going to review progress so far. I don't want answers I want strategies and ideas. I want to know what you have done so far. What have you tried that didn't work? Why didn't it work?

What have you tried that seems to be successful? (I see pause for thinking)

Right let's start with the first question - what did you try that didn't work and why?

When exploring the unsuccessful ideas remember to ask "What was the unhelpful idea here? What would have made it work?" You are making sure that the students know it's fine to make mistakes and take wrong turns when solving problems but it's the successful ideas that you want, so after a few minutes ask them...

What assumptions made the petrol money sharing much easier?

Can you justify your ideas?

The idea is to provide models that will help students to make more progress on the problem. Make sure that the students listen to the ideas given. Ask the next student to comment on how similar or different their idea is to those offered previously, rather than take isolated answers.

5. Students have a second go at the problem 10 minutes
Encourage students to return to the problem and continue working on it using some of the ideas that have been shared.

6. Whole class reports on their reasoning 10 minutes
Ask students to take turns at presenting their reasoning to the class.

What ideas did you have that worked? Tell us why they worked.

Focus on the thinking rather than the answers. Make sure they know there is no one right answer to these problems. Ask questions such as:

What was it about Sam's ideas that enabled her to solve the problem easily?

What did Josh do that was particularly inventive or different?

What ideas did Niki have that you could use?
ACTIVITY E: SOLVE A PROBLEM, "THINKING ALOUD"

Time needed: 20 minutes.

Teachers usually present science and mathematics as though they are a set of tidy results and procedures. Students often don’t recognise 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 recognise that it is perfectly natural to get stuck, make mistakes, backtrack and look for alternative strategies. It is therefore helpful 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 realise 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. We have included one such video on the resource.

- 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 that have been 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.
SUGGESTED FURTHER READING

**Effective collection of questions for mathematical thinking**

**More effective questions for promoting mathematical thinking**

**Questioning to enable effective learning and assessment for learning**

**Questioning in the mathematics classroom, what really happens and what could happen?**

**Is questioning really important?**

**The questions that make pupils think mathematically**